Land Management and Sustainable Agricultural Development in West Asia and North Africa: An ICARCA View

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ABSTRACT

The food and agricultural employment needs of the rapidly increasing populations of West Asia and North Africa are pressing hard on a fragile and already degraded soil resource. Lands marginal by reason of steep slope, shallow soil or low rainfall are particulary vulnerable, but current "development" is largely exploitative. There has been little local research. Standard conservation practices could be effectively used in many places; but successful adoption requires local community involvement in identifying acceptable and profitable solutions to generally perceived problems and also a reorientation of government priorities to provide support. The paper summarizes findings (and limitations) of relevant ICARDA research and proposals for new research and regional activities relating to sustainable land management.

Introduction

The region of West Asia and North Africa (WANA) covers 24 countries lying between the Atlantic and Indian Oceans (Fig. 1). It has a total area of 17m km² and a population, 416 million in 1985, growing at the rate of 2.6% annually. Much of the region has a Mediterranean-type climate-moist, cool or cold winters and dry, hot or very hot summers-superimposed on a widely varying relief. Irrigated agriculture is important where sufficient

Fig. 1 The countries of West Asia and North Africa.

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water is available. Otherwise, agricultural potential is controlled largely by the amount of rainfall and by the temperature regime, factors determined by latitude, altitude and continentality. The coincidence of rainfall with cool winter conditions of low evaporative demand favours efficient utilization by crops, and significant agricultural production from annual totals as low as 150 mm is possible in some places. However, crop growth in winter is limited by low values of solar radiation and temperature, as well as by frost in many areas ; and high temperatures during grain-filling are a widespread hazard. Above all, the large and unpredictable annual variability in the amount and distribution of rainfall imposes a wide year-to-year range in growth potential. Under such conditions, soil capacity to infiltrate and store rainwater is a major determinant of agricultural potential ; but in many areas soils are shallow and degraded, much bare rock is exposed on the hillsides, and only valley bottoms have deep soils on alluvial and colluvial deposits. The degree of responsibility of man and his animals for this situation is controversial. Agriculture has a long history in this region. Mediterranean forests have been subject to felling, with little or no regeneration, for millenia (Dregne, 1986), although this may have been due more to the demands of urban populations for wood than to the depredations of sheep and goats (Dresch, 1986). In the northern highlands of Jordan (360-550 mm rainfall), Beaumont (1986) noted that serious soil erosion, though partly the result of steep slopes, had been accentuated by deforestation (for timber and firewood), overgrazing by sheep and goats and the cultivation of cereals. The cumulative effect was large areas completely stripped of soil. Elsewhere, many alluvial areas suffer from the long-term effects of waterlogging and salinization : "present-day Iraq is still trying to recover from damage done more than 1500 years ago" (Dregne, 1986).

It is the present and the future that concern us here. The demands made on an already depleted land resource, for both employment and food, are still increasing rapidly. Little potentially productive land remains unused. Future increases in output must come very largely from intensification and increased yield levels (FAO, 1987) ; and this must be achieved without incurring further reductions in productive capacity. It is not just a matter of devising appropriate technical solutions-many of these exist on paper already - but of making those solutions readily and rapidly available in a form economically attractive to land users and governments. This paper attempts to identify the main issues and possible responsse to them, from the point of view of an international research center. The focus will be on rainfed agriculture, because that is ICARDA's mandate ; but it should be recognized that the broader picture includes many problems facing irrigated agriculture, particularly salinity control and falling aquifers. And, undoubtedly, for long-term sustainability all forms of agriculture will become increasingly interdependent.

The agricultural systems

The main rainfed agricultural systems of the region, their rainfall ranges, soils, crops and economic orientations are summarized in Table 1. At the wetter end of the rainfall spectrum, arable cropping merges into tree cropping, particularly in hilly areas and where soils are shallow, and at the drier end into pastoral systems. In all rainfall zones, there is much steep and rocky land utilized as rough grazing. Wheat is the preferred arable crop. It tends to be more productive than barley in wetter areas but less productive in drier areas. Fairly generally, rotations of wheat with food legumes and summer crops (e. g. melons, maize, sorghum, vegetables) predominate where mean rainfall exceeds 300-350 mm, while barley is the main crop under drier conditions. Further, since few other crops are productive below the 300 mm isohyet, barley is often the only crop : and, increasingly, as demographic and economic pressures build up, barley monocropping is replacing rotations of barley with fallow. Animals are kept almost everywhere, but their economic importance increases strongly with decreasing annual rainfall. In wheat-based systems, crops are the main

Table 1 Summary of rainfall, low-altitude farming systems of winter rainfall areas of West Asia and North Africa

	Rainfed mixed tree and arable crop systems	Rainfed cereal production systems		Steppe-based nomadic or semi-nomadic pastoral systems
		Wheat-based systems	Barley-based systems	
Mean annual rainfall, mm	600 (+) − 350	600 (+) − 300	350 − 150	<200
Main great soil groups* (USDA system)	Chromoxererts Calcixerolls	Xerochrepts Chromoxerets Calcixerolls	Calciorthids Gypsiorthids Xerochrepts	Gypsiorthids Torriorthents Xerorthents
Main crops	-Olives, vines, fig, other fruit -Wheat -Food legumes (faba beans, chickpea)	-Wheat -Food legumes (lentils, chickpea faba beans, pea) -Barley -Summer crops (melons, sorghum, maize, vegetables) -Vines, olives, fruit	-Barley -Wheat -Minor crops (lentils, vetch, olives)	-Barley
Animals	-Cattle -Sheep/goats	-Cattle -Sheep/goats	-Sheep/goats	-Sheep/goats -Camels
Main cash products	Fruit, crops	Crops	Animal products	Animal products

* Also many lithic subgroups (Lithosols in FAO system)

marketable product; but in drier areas, much of the barley is grown as animal feed (green pasture, grain, straw and stubble), and nearly all agricultural income derives from sheep and goats.

Some caveats are necessary. The above summary refers only to lowland areas (<1, 000m) with a broadly Mediterranean climate, and the systems are modified at higher altitudes (and also, in varying degree in the vicinity of urban or major irrigated areas). In any case, nearly everywhere farming systems are dynamic and evolving. They are becoming less subsistence-oriented and increasingly integrated into the market economy, though with wide national and local differences in degree and rate of change depending on communications and market opportunities. Topography also has a major local influence: as a factor controlling soil depth and, therefore, land use and choice of crop, and through its effect on communications.

Soils are predominantly Aridisols, Inceptisols and Entisols, with smaller but agriculturally important areas of Vertisols and Mollisols. Rock outcrops are common, and many soils are stoney and/or shallow overlying bedrock or calcareous or gypsiferous layers. Except in the wettest areas most soils are calcareous and, except where formed on blown sand, have high or moderately high contents of expanding 2 : 1 clays. Many of the more productive arable soils crack when they dry out, which has implications for moisture storage over dry periods. Silt contents also tend to be high, particularly in drier areas, and soil capping impedes rainfall infiltration. Except in Mollisols, organic matter contents are low or very low.

Land management problems

Largely uncontrolled agricultural development threatens soils and natural pastures throughout the region. The rapidity of the population increase over the last hundred years has intensified the utilization of land, increasing its subdivision and forcing the spread of cultivation and unsuitable cultivation techniques on to more and more marginal land, a trend facilitated in recent decades by the widespread adoption of tractors. One result is that in all rainfall zones soils are at hazard to agriculturally-accelerated erosion by water; for example:

1 Tillage, previously limited mainly to relatively flat areas, continues to move onto steeper slopes, usually without any conservation measures. In drier areas this is mainly for barley production. Under higher rainfall, such land is often planted to orchards and vineyards, in which subsequent clean weeding intended to improve infiltration and conserve moisture often has the effect of accelerating erosion.

2 Hill pastures (already reduced in area by expanding cultivation) are increasingly overgrazed. This exposes the soil, encouraging runoff and soil loss ; and the runoff water often causes further damage, by gullying the arable land on lower slopes.

The effects of such erosion are seen in the high sediment load of most rivers. Jaradat and Abu Mushrif (1988) reported that 1.89% of the water mass of the Zarqa river in northern Jordan is suspended sediment, over 90% of the catchment area being subject to sheet erosion and 20% to gully erosion. As yet, serious wind erosion is limited to drier environments. Former natural grazing lands with 200-300 mm rainfall, brought into cultivation only relatively recently, appear to be increasingly at risk. The landscape is usually open and treeless, soils have only weak structure, and broad expanses of barley stubble are heavily grazed in summer by large flocks of sheep. Lewis (1987) described the situation in northern Syria : "Almost uninterrupted cultivation of barley continued. Grain and straw, and even roots when the crop was harvested by hand, were fed to the sheep. The land received no fertilizer and little manure. This type of crop" "mining" is widespread…… throughout the drier areas of the country." Unless management is improved the future of these lands is bleak.

However, the physical effects of wind erosion are more evident in steppe areas, where the vegetation cover has been largely removed by grazing (and for firewood), and broad tracts have been ploughed up for opportunistic crops of barley in favourable years. Blown sand can be seen to be accumulating behind every small obstruction. Such soils often have a gypsic layer at shallow depth, and any delay in controlling erosion brings that layer to the surface (UNEP, 1989).

Loss of natural vegetation is particularly severe in steppe areas. Overgrazing is perhaps the major factor, but it is ploughing which has the most rapid and permanently destructive effect. In Jordan "the tremendous expansion of rainfed cultivation into the pasture land…… has changed the ecosystem, with serious consequences" (Barham and Mensching, 1988) ; and "degradation of Morocco's land resources (is) undoubtedly one of the most serious problems threatening the future productive potential. Cereal production is expanding onto lands that are marginal if not totally unsuitable for cultivation" (Crawford and Purvis, 1986).

Underlying all these problems are immense social and economic forces that must be understood and accommodated before measures to conserve the resource base and establish sustainable agricultural systems can be successful. One major factor is land tenure. In the arable context, subdivison arising from inheritance often results in holdings consisting of several long narrow fields ; and on sloping land these usually run up and down the slope. This arrangement gives an equitable distribution of good and bad land but rules out contour ploughing and most other forms of soil conservation. Most grazing land is, to a degree, common property, although local customs on utilization rights vary. Such customs, which often had an inherent conservation basis, are breaking down in many places, due to population increase and rapid social change. A case in point is the Syrian steppe : "Shayks and tribesmen could no longer regulate grazing, and flocks belonging to men of every tribe, to peasants and to townsmen ranged wherever they wished. Competitive pressure has increased in the last two decades, to the point that sheep are now hurried to take advantage of spring vegetation as soon as it appears, before other flocks can reach it. Palatable vegetation is grazed down to ground level and frequently does not regenerate, and unpalatable species take over" (Lewis, 1987).

A second major factor might be termed "modernization" , a complex of pressures arising from population increase, urbanization and in many countries, increasing affluence and sophistication of food requirements, which drive an increasing commercialization of agriculture. The effects are particularly evident in livestock production. All over the region, a rapidly rising demand for livestock products has promoted large increases in the numbers and sale value of animals. The incentives to increase stocking rates and to plant more barley for feed are considerable, and in drier areas a potentially destructive vicious circle develops. Farmers there have always depended on livestock production for their security, because it is inherently more resilient than cropping to unpredictable variations in rainfall ; but as numbers increase and the grazing deteriorates, the livestock themselves become increasingly dependent on purchased feed and on locally produced barley. Large flocks are now supported in dry range areas all the year round by means of boreholes and transported feed, and more and more formerly communal grazing land is ploughed up in the hope of a private barley harvest. In some places (e. g. Algeria), ploughing the range confers ownership, and this may become an end in itself, irrespective of any harvest (Rashed, E., personal communication).

The picture is not all gloomy. Many trees have been planted on steep slopes and eroded catchments in Syria, and in the steppe there are projects to improve range (e. g. by planting *Atriplex*) and to control moving sand at source by establishing windbreaks and vegetation (UNEP, 1989) ; Jaradat and Abu Mushrif (1988) refer to a number of terracing and soil conservation projects in Jordan ; and many countries have programs of soil conservation. Nevertheless, most of this effort is of a project nature, initiated by governments and external agencies and, in some degree, imposed on land users from above. To become a permanent feature of the farming system such measures must gain general farmer acceptance. Terracing is an indigenous practice in some mountain areas ; but even in Yemen, where it is a major feature of the farming system, many terraces are now falling into disrepair (Tutwiler, R., personal communication). Elsewhere, although the remains of former terracing may often be seen, land-hungry farmers bring steep slopes back under the plough apparently without regard for the future. One small but hopeful sign is the proposal in Jordan to encourage farmers owning adjacent strips of arable to manage the land jointly, so that tillage on the contour and perhaps conservation structures can be put in without changes of tenure.

Issues and possible solutions

What the approach of an international center should be to such problems is problematic. Previous "green revolution" successes have encouraged large investments of faith (and proportions of international and national research budgets) in crop germplasm improvement to the relative neglect of the wider problems-agronomic, agropastoral, socio-economic and, not least in a region like West asia and North Africa, the preservation of the fragile resource base. The question now is to what extent such organizations should keep to their relatively narrow area of expertise, continuing to develop crop varieties and technologies (fertilizers, chemicals, etc.) to overcome each new yield constraint as it arises and hoping that others -national governments and farmers themselves-will find ways to conserve soil, water and vegetation. The alternative, the opening of a new front on resource conservation and sustainable land management, constitutes a radical departure from what has previously been seen as true "agricultural research" and requires a painful rethinking and restructuring of research priorities and operating modes.

Unfortunately, the view that prevails among most farmers (understandably) tends also to be held (more covertly) by national governments and even funding agencies, that "in the long term we are all dead, so give us a quick fix now and let the future look after itself". In this climate, responsible agricultural research must seek a middle way, by which environmentally-safe quick fixes are identified but within a program which seeks, almost by stealth, to develop truly sustainable systems of agriculture. I think we are still struggling to come to terms with this complex assignment.

As already indicated, a major factor underlying many immediate and more long-term problems in the WANA region is a rapidly increasing market demand for animal products and, hence, for feed. This imposes a particularly heavy strain because, within just a few years, a mode of agriculture that had previously been largely complementary to crop production (obtaining most of its requirements from non-arable land and from crop residues) has suddenly become highly competitive for both land and for the products of arable cropping. Current research in northern Syria is providing some possible technical responses to the immediate need:

- Small amounts of phosphate fertilizer greatly increased the yield of herbage, especially the legume component, of a degraded hill pasture: sheep gained weight faster and required less supplementary feed, and stocking rates up to 3 times that of the unfertilized control became possible (Osman *et al.,* 1988).
- Trials on farmers formers' fields have shown that substantial and economic increases in barley yield can be obtained from the use of fertilizers (FRMP, 1990). Working from these data, Cooper and Bailey (1990) calculated that Syria has the barley-growing potential to feed its national flock in 3 out of 4 years without ploughing up any marginal land.
- Long-term rotation trials show that rotations of barley with forage legumes (*Vicia* and *Lathyrus* spp.) outproduce the barley-fallow and barley-barley rotations currently favoured by farmers by 20-60% in terms of dry matter production and by around 100% or more in terms of crop nitrogen output (a measure of feed quality) (Jones, 1990).

And many other ideas offer promise, e. g.:

- Regeneration of degraded steppe through the planting of fodder shrubs like *Atriplex* and *Acacia* species has shown some success (Sankary, 1978), although for large areas low cost techniques for the rapid seeding of subsequently self-seeding species would likely be more practical. These still need to be developed.
- The potential of annual *Medicago* pastures in rotation with wheat is now well established (Cocks and Thomson, 1988), but rotations of appropriately adapted medics with barley in dry areas may ultimately prove to have greater application; and pastures of medic, annual grasses or self-regenerating barley (Hadjichristodoulou, 1990) may provide a practical means to put back into sustainable production many steep slopes and shallow soils that have been unwisely ploughed up.
- The Mediterranean flora is rich in annual and perennial legumes, but except as a component of natural pastures their utilization by indigenous agricultural systems has been limited. A mere handful of species has been utilized as arable food and feed crops. There remains great scope for screening new species and local varieties and for germplasm improvement for both pasture and forage utilization.
- Olives and other tree crops could be intercropped with permanent pastures or annually sown feed crops, provided that the net value of the feed exceeded that of any lost tree-crop production. Erosion control would be a major bonus on sloping land.

Each of these techniques, if developed to the point of successful and economic adoption, has the potential to increase feed supply in ways that minimize competition between food and feed crop production. However, each needs to be critically examined in respect of its likely contribution to more permanent and sustainable agricultural development. Planting permanent pastures on hillslopes and interplanting tree crops appear likely to confer clear benefits on the soil, but the consequences of other innovations are less certain.

For example, it is hoped that the production of more feed from higher-yielding crops of barley and forage legumes on suitable, well-managed arable land and from well-managed pastures will relieve the grazing pressure on unimproved pastures and range and eliminate the need to plough up more marginalland for barley. But this may be too optimistic. The many people now living permanently in the marginal areas require a livelihood. They will not easily be moved out. Moreover, demands for animal products are price-elastic. Improved feed production techniques may reduce prices and stimulate demand and so actually increase the total number of animals. Indeed, if human populations and their prosperity continue to increase, this seems the most likely outcome.

There are further dangers. Innovations like fertilizer use, more drought-resistant varieties and rotation with legumes will certainly increase the productivity and profitability, in the short term, of barley-based farming systems with 200-300 mm rainfall, but we have no evidence yet that they will confer long-term sustainability. Experience on the ground suggests that sustainability is unlikely in these areas unless the more immediately profitable innovations are accompanied by improved techniques of soil and land management (e.g. stubble conservation, planting of windbreaks, contour ploughing and terracing of sloping land). Moreover, innovations that increase productivity in legitimately arable areas will almost certainly increase the profitability of ploughing up marginal land.

ICARDA approach

For the foreseeable future, a major slice of ICARDA's research effort will continue to seek, through improved germplasm and improved crop and input management, incremental gains in the yields of the major food crops, cereals and food legumes; and insofar as the crops are grown on deep, level soils and under at least moderate rainfall, those gains will probably be achieved. Further, if reasonable precautions are taken to avoid build-up of pests, chemical residues and where supplemental irrigation is practiced, salts, such increases should be sustainable. However, they are unlikely to be sufficient. Given the projected population increases, it is virtually certain that the pressures to utilize more intensively the very much larger areas of sloping land, shallow soils and marginal rainfall-for food and feed crops-will continue to mount. Ways can no doubt be found to increase yields there also, but it is difficult to avoid the conclusion that few technical innovations, however yield-enhancing, offer of themselves any certainty of sustainability. Most, if not all, need strong support in three other dimensions:

- postive soil conservation measures;
- positive farmer acceptability;
- positive policy support at government level.

Of soil conservation, the ICARDA view is that time and research budgets are too short for any painstaking quantification of the rate of current damage prior to seeking remedial action; and, further, there are many standard techniques (bunding, terracing, etc.) that could be applied almost immediately with very little local modification. Any new technical research should address situations unique to the farming systems of the region, for which there are no directly applicable "off-the-shelf" technologies. Current research is limited to studies of the long-term effects of different tillage, stubble and straw management treatments on soil physical properties; but proposals (pipedreams) for future work include studies of:

1) Pasture and forage intercropping of olives: soil-water dynamics, effects on olive yields and economics.
2) Land utilization at sites along a rainfall gradient, 250-150 mm, comparing range grazing and arable cropping in respect of biological and economic yields, yield stability and likely sustainability.
3) The integration of conservation measures, e.g. windbreaks, forage-shrub hedges, contour banks- contour ploughing, into the farming system of a dry arable area.

To a considerable degree, all such work is unavoidably location-specific. A big problem for any regional center is how to generalize local results for wider application. ICARDA has been slowly accumulating a base of agro-ecological models and data-handling techniques, and the next step is to add in erosion models. The aim is to build a core of experties able to support national scientists and planners by providing information (or techniques to obtain information) about the intrinsic vulnerability of particular landscapes, soil types and farming systems to resource degradation, and about potential solutions.

For any innovation, the greatest hurdle is always adoption. Farmer attitudes are crucial. All but the richest farmers apply a high discount rate to long-term improvements. No new measure, however large the eventual benefits, will be accepted unless there are also some immediate payoffs. To avoid the failures that so many top-down schemes have suffered, insight into farmers' views of resource management is essential. To this end, ICARDA is currently initiating in several WANA countries studies of local systems of agricultural production and land use in dry marginal areas. The aim is to relate current practices and the limitations of the physical and socio-economic environment to farmer perceptions of their resource base and its degradation. In this way we hope to identify practical and acceptable options for sustainable development.

Government attitudes are also crucial. The adoption of any innovation requires a favourable economic climate; and restrictions on the utilization of vulnerable land need to be based on clear and fair policies, firmly enforced. In many cases, direct government funding, subsidies or compensation payments will be required. These will not be forthcoming unless their necessity is supported by strong, well-researched arguments from the agricultural sector. Unfortunately, the most vocal agricultural lobbies tend to be those of the richest farmers who may occupy the best land or have the most to lose if restriction are imposed. So it is the government agricultural services which must provide the voice for the poorer farmers and herders and for the vulnerable land. This is a weak point in many countries: appropriate expertise (e.g. land-use planning and management) is often lacking, and departments of soil conservation, crops research, animal research and of extension (whose role in these matters is vital) are usually administratively isolated and their actions uncoordinated. This is also a difficult area for intervention by an international center. However, ICARDA hopes soon to recruit a land management specialist, whose role will be to coordinate information and expertise across the region and catalyse actions by national governments.

Conclusions

The prospects for sustainable agricultural development in West Asia and North Africa vary locally according to the nature of the land. We may be reasonably optimistic about the relatively small areas of rainfed land under wheat-based arable cropping; but for irrigated land (not discussed here) there are many hazards ahead; and for the much larger rainfed areas, marginal by reason of their topography or their dryness, the prospects must be judged bleak. Almost certainly, they could be made sustainably productive at much higher levels of output than they provide today, but the road by which this might be achieved is a very difficult one.

Technical solutions will never be enough. The real problems are those that derive from the interaction of man with his environment. It is usually the poorest sections of the population that are driven to utilize the marginal lands; and, although their output may become increasingly important to the national economy, each individual is concerned only with his own livelihood. To him it makes good economic sense to exploit fragile resources for shortterm gain. He often has little other choice. Meanwhile, governments intent on feeding rapidlygrowing city populations, concentrate most of their agricultural development effort into more favourable areas, where returns are quicker, larger and more certain. Informal, non-sustainable 'development' in marginal areas is usually ignored. Where there is intervention, it tends to be imposed with too little consutation; and when it fails, it is the

farmers or herders who are blamed. The following appear essential to real progress:
- in research, combined socio-economic and technical studies in the field, cooperating with local communities to devise acceptable, profitable and sustainable systems of management, backed up at base by appropriate information and modelling systems;
- in government policy making, an appreciation of the potential (in the national interest) of the marginal areas and the need for positive measures (provision of services, incentives and rational controls) to curb the accelerating loss of that potential;
- two-way channels of communication between land users, research and development services and government policy units.

ICARDA's role is to initiate and catalse these activities and to provide support in terms of information, methodologies and liaison between national programs; but perhaps above all at this time, to instill a sense of urgency.

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