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Experience in the Middle East [and Discussion]

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Experience in the Middle East

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The paper considers the possibilities for meeting the hazards in agriculture – scientific, technological and socio-economic. The discussion is divided broadly into three sections, covering the physical situation; other factors (such as population and the availability of both expertise and funds) which need to be taken into account; and pointers to future improvement.

The first section discusses the resource basis, emphasizing the effect which long-term exploitation by man has already had and indicating, mainly from actual studies undertaken, how evaluation of potential can be undertaken. The second section discusses other constraints which have hitherto tended to hold back agricultural development, and the new impetus which, wisely handled, the vastly-increased oil revenues of the area can supply. Finally, a brief survey is presented covering the directions which future agricultural development in the region might take, and some of the key inputs which may be needed.

1. The physical situation

I want to start with an obvious but fundamental issue. Like China, the Indian sub-continent, and perhaps parts of North Africa, most of the 'Middle East' has been occupied by man, often with substantial densities of population, for a very long time. This makes the Middle East a somewhat special area when we come to consider both its problems and its potential.

It is generally agreed that this long-term use by man (and his domestic livestock) has resulted in widespread degradation or deterioration of the resource base. The deterioration which has taken place is of course of different kinds and degrees. In some areas both vegetation and soil have been almost totally lost; elsewhere land has been permanently degraded by irrigation, particularly in Mesopotamia; the rangelands of parts of Syria, Jordan, Iraq and Iran offer examples ranging from recoverable overuse to complete destruction. Such deterioration may develop slowly over a long period of time – which is almost certainly true in the case of the irrigation in Mesopotamia; in other cases deterioration has been rapid during no more than the past two or three decades. Because both vegetation and soil have been lost, the environment has in effect become more arid in many areas.

The two principal resources with which we are here concerned are land and water. In both cases the *unused* or *under*-used resources are limited, at least at the present level of inputs. Put another way, most *land*, if not water, is over-used at existing levels of inputs. Of the major rivers in the region, the Tigris and Euphrates are in a class of their own, but even their unused waters are limited, especially in summer. Actual and projected reservoirs can and will improve this situation, but whether the available water is being most effectively used is quite another matter. I shall return to this subject later. In Iran, the Karun and Kharkheh rivers probably account for something like one-third of the potentially available surface waters, while the rivers in the extreme northwest, and in the Caspian area, account for more than half the remainder. The Euphrates and, particularly, the Tigris flow through vast alluvial plains where

land can readily be commanded by water supplies, but elsewhere the physical relation between land and water is not always so straightforward. In Iran, the Karun and Kharkheh, for example, command substantial areas of alluvial land, but this land all too readily becomes saline – indeed much of it is already saline – and this undoubtedly affects the kind and cost of irrigation development. Otherwise the topography is such that much agricultural land is scattered in relatively small individual areas, so that the development problems are quite different from those of the large alluvial areas.

Groundwater is of course another major source. It is particularly important in Saudi Arabia, and it is significant in many other countries of the region. In Iran the groundwater resource provides about one-tenth of potentially available supplies.

Throughout the region, there are large land areas which produce very little, but most of this land would have little real potential for agriculture even if water supplies were unlimited. These areas include vast stretches of true desert – for example the rocky mountain deserts in Iran, southern Jordan and Saudi Arabia, and the basalt deserts of Jordan. Much of the land of greater potential is in alluvial plains, notably in Syria, Iran and particularly Iraq. Yet even on this land, as I have already indicated, salinity and other hazards present difficulties.

Outside areas whose future turns on irrigated agriculture, there are of course substantial areas where rain-fed agriculture could be improved – the Mediterranean zone of Jordan, for example; the wide sweep of country from Lebanon across Syria and through Iraq from Mosul to Kirkuk; and in Iran, where the area suited to rain-fed agriculture amounts to some 6.5×10^6 ha, compared with 5.5×10^6 ha of land supplied with irrigation water, of which about 3.6×10^6 ha are cropped annually. Little of this rain-fed farming area is managed as it could be, though there is a remarkably well-managed and largely rain-fed agriculture, involving complex and well-maintained terraced fields, in the mountains of the Yemen Arab Republic – something I have, to my regret, not yet seen.

Traditional agricultural methods have relied on what has been described as the 'minimal risk' system, applied even in irrigation in the absence of assured supplies. But however sound such systems may be ecologically, they tend to break down under population pressures and the land then suffers. There are also worrying instances of unwise 'land-mining' operations, using machinery and financed by the now readier supplies of capital. The ploughing of marginal rainfall or 'steppe-zone' rangelands (around 250 mm rainfall) for short-term catch crops of wheat is perhaps the worst example. Once rangeland vegetation, however degraded, is destroyed completely in this way, it is very difficult indeed to re-establish.

One has to conclude that, in sum, the basic resource situation is not too encouraging. There are of course bright spots, and it is certain that very major increases in agricultural production could be achieved through proper management of the resources now available. But major efforts in conservation will be needed, and the social problems involved, in shifting or settling people, or in reducing stocking rates, are very real and difficult to deal with.

2. Some other relevant factors

Population pressure seems bound to increase. In most countries of the region populations seem likely to continue to expand at rates between $2\frac{1}{2}$ and 3 % per annum. At the same time, particularly in those countries with oil revenues, rising incomes will not only generate increased demand for food but are likely to alter the pattern of demand – perhaps especially in relation

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to livestock products. But the trend towards urbanization and industrialization will perhaps begin to ease the direct pressure on land and so make it easier to introduce more rational and eventually more productive methods of land use.

Many countries will probably try to become as self-sufficient as they can in foodstuffs. This is entirely understandable, yet it will make it more difficult either to ease the pressure on over-strained resources or to rationalize production so that it makes best use of the resources of the region as a whole. One would like to feel that the new Arab Fund/U.N.D.P. study on Inter-Arab Integration and Development, due to have started this year, could point the way. This study of course extends beyond the Middle East; a good deal of attention is being directed to Sudan as a future source of food for the Arab world.

The present average yields of crops are small, and have changed all too little over recent years – though there are some encouraging exceptions. The reasons why yields remain small are complex, but they include degraded land, insufficient or untimely water supplies, lack of improved agricultural inputs, uncertainties caused by land reform, and chronic shortages of trained manpower and management. Although they differ in degree in different countries, these problems remain largely unsolved.

Land reform is such a crucial – and politically sensitive – issue that it needs separate comment. In many parts of the Middle East, the pressures for land reform have been great. All too often, however, reforms have been introduced without any understanding of how the old system, however bad it was, actually worked. As a result exploitation of people has sometimes been replaced by even greater exploitation of the land, simply because the old methods of management have been removed – along with the agricultural inputs which they sometimes included.

The main new factor, which may be crucial if it is wisely handled, is the sudden increase in wealth flowing from the increased oil prices. Although the direct effects on individual countries obviously differ widely, the indirect effects are or will be widespread. Properly used, this new wealth offers a very real opportunity to steer agriculture out of its present relatively static state and, in the longer term, to stabilize and renew the resource bases. At the present time there is sadly little coordinated planning, and significant amounts of the new wealth tend to go into wildcat or ill-considered schemes – including the purchase of 'the latest technological developments' which have important prestige value but do not necessarily offer a practical path to development under present socio-economic conditions. The latest technology is not necessarily the most appropriate.

3. Analysing potentialities

The two examples I want to give here draw on experience in Jordan, Iraq and Iran. The first concerns the broad appraisal of land-use potential – or appropriate land use – on a regional or national scale. The second concerns analysis of a particular form of development, in this case irrigated agriculture.

Land-use potential

In appraising regional land-use potential, the first step is to develop what I call 'zoning'. Zoning of land, in this context, establishes what are the 'proper' uses, or range of uses, for different land units, irrespective of the actual uses to which they are now being put. Proper (or optimum) land use describes ways of using land which will permit sustained production

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without physical deterioration of the land. In my view, proper land use includes the preservation of amenities (such as complete protection of areas of great scenic beauty), the protection and management of wild-life in national parks, and the protection of areas of specific scientific interest.

Most countries in the region already possess enough data to develop at least the first stages of a zoning system. Data on climate and soils are of the first importance, plus information on landform and topography. To this one should certainly add present land use (including information on any remaining natural vegetation such as forest and rangeland), since so much of the effort for optimal use of land lies in redirecting or improving the uses to which people put it already. Most areas have substantial soils information: indeed though a great deal of time and money has been spent on soil surveys, surprisingly little of the information from them has actually been used for planning or land management. It is often claimed that attempts to develop a comprehensive zoning system take too long and are too expensive to consider. In fact most of the necessary data are usually available; commonly the problem is that no effort has been made to coordinate or synthesize it for the purpose of making land-use decisions. The wide availability of aerial photography, now supplemented over virtually the whole of the Middle East region by 'Earth Resources Technology Satellite' (ERTS) imagery, also means that a mass of 'remotely sensed' data is available to the planner at minimal expense.

A useful first step is to divide the country into areas which are uniform in landform and vegetation. The types thus distinguished, and the maps of their distribution, can be used in more detailed investigations. We did this in Jordan, though the immediate objective – a 'range classification' of the natural pastures – was much more limited. The survey was however designed in such a way that it could be used as a general land classification which could later be applied to other forms of land use. The survey was supplemented later by work on the bioclimatology and vegetation of Eastern Jordan by G. A. Long, an ecologist from Montpellier: the two studies combined provide the essential basis for comprehensive land-use planning.

The survey covered all of Jordan east of the Jordan River – the greater part of the country. The climate ranges from sub-humid Mediterranean to arid Mediterranean, with large areas of desert classified as Saharan bioclimate, from cool to very warm. (The terminology is that of Emberger.) Climate critically influences land use, but physical conditions have been markedly degraded in the areas more favoured for human occupation. In some areas this degradation has developed over a long period: elsewhere it is relatively recent. For example considerable areas of the remaining oak forest in the south-central highlands were destroyed when the Hejaz railway was built, around 1916, and as a result much of the soil cover was lost.

The survey work in Jordan covered nearly 97 000 km². The team's work in the field was concentrated on collection of sufficient information to distinguish and describe individual ecosystems or biological habitat types; and to identify these, so far as possible, with characteristics recognizable on the aerial photographs. The results could then be extrapolated to cover the whole survey area. Because little time was available for field work it was rarely possible to return to any area, so that all necessary information had to be collected during a single visit. For the same reason, the examination of soils could be no more than elementary. In an area where little basic information on soils or vegetation was available, the opportunity to have a second look can be important for many reasons. It is now clear that these were disadvantages which should be avoided in future studies of this kind. As a general rule, vegetation is one of the most useful indicators of human influences on local conditions. However,

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vegetation which has been used by man for very long periods, as is the case in Jordan, has usually been so deeply modified that it reflects present conditions only. Human interference, in semi-arid or arid regions, nearly always changes vegetation so that the environment becomes even more arid, but relict species may provide evidence of potential. A fully useful classification system should consider not only the present state of the vegetation but the capacity for improvement.

In Jordan we were able to combine a bioclimatic classification with a mapped distribution of ecosystems or habitat types. This had two advantages: in the first place, effective cross-checking became possible and, secondly, the potentialities in the various bioclimatic sub-divisions could also be more fully identified since the level of physical resource degradation – where it had taken place – was also known. In the 'sub-humid Mediterranean' bioclimate region of Jordan, for example, it is still possible to find areas of something approaching climax forest, with soil cover intact. Elsewhere, within the same bioclimatic region, almost all vegetation has disappeared and little more than a bare rock surface, denuded of soil, remains. Unless situations of this kind are recorded, as they were during the survey under discussion, the usefulness of a bioclimatic map, on its own, must be limited.

Since the Jordan survey was done, nearly 20 years have passed. A great deal of additional resource and climatic data has been acquired throughout the region. Moreover, the ERTS satellites, with virtually total and recurrent cover in both monochrome and false colour, provide a wealth of information – admittedly at a very small scale – which can be used to analyse landforms and related features. No country concerned with the long-term future of its land resources and, therefore, with the well-being of its people, should fail to make use of this outstanding source of data. Supplementary work may of course be needed in varying degrees, but none of it is costly in terms of the issues at stake.

The same kind of approach was used later in studying the Diyala river basin in Iraq. The lowest parts consist of a level plain of alluvium, where irrigated agriculture was clearly the most important way of using land. It was in the upper and middle parts of the basin, where choice was widest, that the kind of study under discussion was most appropriate. The stated objectives of the study were clear, and again somewhat limited. They were directed essentially to three questions: the extent of present or potential erosion in the watershed area; the nature of present forest or other vegetation cover and its management in relation to erosion control; and a study of existing agriculture and measures to be taken both to raise production and to reduce erosion. Nevertheless the main elements of comprehensive land-use planning were there.

As a first step, the area was divided into ecological zones based on vegetation characteristics. The zones were designated dry steppe, moist steppe and established forest. The most important ecological boundary was that between dry steppe and moist steppe, two plant formations which differ greatly in their productivity and botanical composition. In moist steppe, rainfall is sufficient to maintain a continuous cover of trees, though most of these have gone as a result of human activities. In true dry steppe the climax vegetation is grassland, since the rainfall is insufficient for trees. The division between these two kinds of steppe approximates to the 300 mm rainfall isohyet, and this was probably where, originally, forest passed into steppe, through a wide zone of steppe-margin woodland. Most of the remaining established forest belongs to a dry type of the Iraq mountain forest characterized by species such as *Quercus aegilops* and *Pistacia khinjuk*. The climate under which forest exists – and would have existed – in the upper Diyala is exceptionally extreme (very hot summers and cold winters). Under pressure, in such

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a climate, ground conditions change drastically in the direction of greater aridity, and an invasion of steppe species into the degraded forest is likely. Once the forest is removed it is very difficult to re-establish: in this region degradation from woodland proceeds straight to annual grassland without the shrub stages which intervene in the Mediterranean region.

The broad ecological zones initially determined were further subdivided according to landform and geological formation. These divisions were very significant. In the moist steppe zone, for example, most of the productive grassland was on conglomerate rocks. The soil, though often not deep, is remarkably stable and resistant to erosion, and hence the conglomerate grasslands can withstand heavy grazing pressures. Nevertheless, the effects of protection from grazing are very marked: perennial grasses became established quite rapidly and, given a source of seed, oak trees would probably reappear. The geological formation known as Fars provides a striking contrast to this relatively stable situation. The Fars beds consist of interbedded sandstones and soft clays. The landscape is composed of bare sandstone ridges and red clay badlands, whereas the conglomerates produce a gentler landscape of rolling rounded hills. Within the Fars formation three landforms can be distinguished: thin soils on the exposed sandstone, clay badlands, and valley bottoms (often quite extensive) with deep alluvial/colluvial soils. The effects of human use, and the potentials for use, are therefore widely different in these two geological formations, although both may occur in the same ecological zone. By analysing and mapping these factors, the necessary information for sound land allocation becomes available.

In Iran, in a broader context altogether, we were particularly concerned with defining the limits for rain-fed agriculture, which could again be related to certain climax forest vegetation formations: Alborz deciduous forest along the Caspian shore and Zagros deciduous forest (an oak–pistachio woodland) for what we have termed 'high-potential' rain-fed farming with average rainfall around 450 mm or more, and steppe forest (a *Pistacia–Amygdalus–Juniperus* woodland) for 'low-potential' rain-fed farming (250–450 mm) or improved range. Selected field traverses were made in an attempt to establish these quite critical zones at the small scale necessary for national-level planning. Subsistence or catch-crop arable farming below the 250 mm rainfall level should be banned and the land returned to managed rangeland use.

Irrigation

Turning to irrigated agriculture, I want to consider the situation in the Tigris/Euphrates plains of Iraq. I have selected this area for two reasons. First, these plains perhaps represent the largest 'high-potential' area in the Middle East. There is also an extremely long tradition of irrigation which has clearly had a major effect on the situation we see today. Not only have substantial amounts of salt accumulated in the soil, which is not surprising under long-continued irrigation without drainage, but in addition the soil structure seems to have deteriorated, which makes irrigation difficult because infiltration and drainage are slow.

The evidence of past use is so clear (the networks of abandoned canals of various periods can be seen on aerial photographs), and the salinity/structure problems are so widespread, that we began to speculate whether the development of salinity in the soil had been a factor in the rise and fall of the ancient city states of Mesopotamia. An archaeological expedition from the University of Chicago became keenly interested in this concept, but the results were inconclusive: a canal system is far more difficult to date than an established settlement.

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Salt in soil can be removed by leaching and associated procedures, but the degraded structure is more difficult to correct. Its nature remains something of a puzzle, though it seems clearly related to the old irrigation systems. Extreme cases show a curious surface relief similar to the Australian 'gilgai', which gives a very characteristic pattern on air photographs. We originally described these soils as 'solonetzic', but the exchangeable sodium values give only very slight support for this classification. It seems that deteriorated structure is not related to any major difference in exchangeable cations. Nor is it wholly a manifestation of dispersion (in the sense that a sodium-dominated clay disperses to give a bad structure). It may be due to a closer packing of soil particles leading to a structure with smaller pores. (Laboratory measurements relating suction pressure to soil water content tend to support this view.)

Whatever the solution, the problem does affect the selection of areas for development and the pattern and intensity of irrigation supply. Almost certainly areas of extremely poor structure should be excluded, and fortunately they are very easy to identify. (Apart from their distinct pattern on the aerial photographs, we found it instructive that local people employed as pit-diggers and auger-borers consistently identified such soils as unusable.) The tendency, hitherto, without a drainage system, has been to spread irrigation supplies very thinly over very wide areas, with cropping intensities as low as 50 % in winter and 10–25 % in summer. It now seems wiser to concentrate on the better land, installing drainage and adopting a more intensive cropping pattern, hoping thereby to lessen salinity, improve structure and greatly increase crop yields. The proof of this particular pudding will of course be in the eating, and most of the meal is yet to come. If this policy succeeds, the consequences will be widespread and important.

4. Pointers to future improvement

It seems inevitable that irrigation must provide the main bases of improved agriculture in the region, simply because of the generally arid situation throughout most of it. Yet, in spite of a wealth of studies and considerable investment, development (in terms of crop production rather than of completed engineering works) has been all too slow, largely because post-construction management, extension, farm-level inputs, regulation of the prices of farm commodities and the establishment of marketing facilities have received little attention. Nor has anything been done about rural infrastructure and amenities. None of these things present insuperable difficulties once the need for them is accepted, and funds are generally available. What can be done, in a harsh environment, with technical ability and skilled management, has been clearly demonstrated in Israel: but political relations have prevented any direct transfer of such success, at least to the Arab countries.

In addition to, or in conjunction with, irrigation, major development in livestock production is possible, provided livestock are integrated with agriculture so that resources are used (and conserved) in a rational way. Rangelands in marginal rainfall zones can be managed as breeding areas, particularly for small stock, and the animals can be finished in irrigated areas or on rain-fed farms in wetter regions. Both Iran and Iraq are beginning to develop large-scale commercial enterprises, mainly so far in dairying and poultry. Unless some reorganization of this kind takes place, the rangelands will continue to deteriorate. In Iran they constitute a vast resource whose effective management is at present largely neglected. In Iraq, Syria, Jordan and Yemen they are less important but nevertheless significant. To rationalize

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livestock production requires major social changes, including changes in political attitudes towards nomads and in the concept of management (including control of stock numbers) among the nomads themselves. No country has yet, so far as I know, evolved a coherent policy in this respect. The tendency is to shy away from such problems, and often to condemn nomadism as primitive without fully appreciating it. In Iran, the rangelands vary greatly in altitude and it is necessary to organize some kind of seasonal rather than year-round use. A nomad or at least transhumant system is still appropriate, provided stocking controls and proper stock routes can be introduced.

Catchment protection is needed almost everywhere in connection with surface storage of water, but it is largely neglected except perhaps in Iran. The upper river catchment areas usually receive more rainfall and provide opportunities for afforestation (and hence timber products) and other tree crops (fruits and nuts) instead of the progressive deforestation and denudation that continues almost everywhere.

Though I have commented critically on *new technology*, it must not be dismissed. But its application and particularly its transferability need careful examination. The use of oil or gas to produce animal feedstuffs could be important, not only to increase livestock production but perhaps also to take pressures off rangelands temporarily so that conservation and improvement could be initiated. A breakthrough in desalination of water, so that its cost becomes compatible with irrigated agriculture, could be of vast importance. Even now, small-scale plants are operating in Kuwait and Abu Dhabi, producing valuable vegetable crops in what is virtually a hydroponic system, and in at least one case, using surplus energy (from gas which would otherwise be burned off).

Then – a vital factor – there is a widespread need for *training* of manpower at all levels, but perhaps critically in upper and middle management. The shortage of managers, perhaps more than anything else, cripples decision-making and the successful implementation of development schemes, as the countries of the region are increasingly recognizing. How to provide such training is a complex question, yet it is extremely important to find an answer.

I have spoken mainly about the evaluation of technical problems and solutions. Of course any worthwhile planning must also consider the economics of different courses of action, and pay proper attention to sociological factors – after all farming is undertaken by people and there are plenty of examples about to illustrate what happens if this is ignored. As a recent article in *The Ecologist*† put it: 'Scientists and development planners work out elaborate schemes for rural regeneration, but peasants and goats seldom seem to find it in their own interest to assume the profile of the computer cards they are dealt.' But although it is possible to see rather clearly what is happening and what should be done, it remains difficult to bring about the appropriate action. It is difficult to get the decision-makers to see the problems in the round: to provide for effective management and farm-level inputs on an irrigation scheme rather than merely complete the engineering works; easy to get decisions to build a dam and very difficult to get anyone to pay more than lip-service to watershed management; and even more difficult to get those in power to consider rationalizing land use for the long-term productive management of their country's resources. One is faced constantly with the old problem of short-term expediency in preference to long-term benefits. One can understand the difficulties the decision-makers face in such choices, while remaining seriously concerned about what will happen unless they are faced. There seems little real awareness of the

† E. Eckholm 1976. The politics of soil conservation, **6**, no. 2, February 1976.

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importance of conservation – and I use the term in a positive sense, implying sound resource management and sustained production – and without this it is difficult to see how even the best-conceived plans can be put into effect.

Fundamentally, countries in the Middle East, like many other countries, must devote a great deal more attention, and a greater share of their budgets, to agriculture – a fairly basic change in thinking and priorities.

In a part of the world that still lives to a great extent on the exploitation, the mining, of non-renewable natural resources, such basic changes in attitude are slow in occurring. But I think they *are* taking place, and that is perhaps the most hopeful note on which I can end.

Discussion

T. Riney (*Department of Forestry and Natural Resources, Kings Buildings, University of Edinburgh*). In commenting on Mr Robertson's paper I would like to mention two points. In 1972, in response to a request from the F.A.O. regional office in Cairo, a three-man team, comprising a sociologist, economist and ecologist, visited Iraq, Iran, Sudan and Libya to identify the marginal land problems in each of these countries. These countries were selected by the Cairo office as being representative of the region. In terms of an analysis of the environmental problems our findings were essentially the same as described by Mr Robertson. It may be of interest to know that, although we recognized the core of the problem as a man-mismanagement–environment problem, we gave priority to a social constraint: lack of coordination of aims and activities existing between different government departments. Working with responsible officers in each country, this difficulty was suggested by the officers themselves as the main bottleneck to progressing towards effective stabilization of their marginal lands and toward eventually developing more appropriate forms of use or management. Two countries added the additional qualification 'of course before we can coordinate we must first communicate' and communication between departments was very poor indeed. We recommended that, in considering future assistance to the region, solving this sociological constraint should have high priority: either as a prerequisite to other normal kinds of assistance; or as an integral part of future projects and programmes, that is to say building into future projects special mechanisms for achieving such coordination as would be prerequisite to making the project a success.

The second observation involves recognition of the extent nomadic traditions are long-standing and widespread and the possible significance of comparatively recent breaks in these traditions. In Iraq of special interest to us was the pattern of utilization by pastoralists. There a traditional nomadic and semi-nomadic pattern had continued for 3000 years, this pattern having spread and being essentially the same as shown by nomadic pastoralists in the Sahara. It seems important to understand on the one hand the reasons for the down-grading trends often associated with such changes as has been mentioned by other speakers. On the other hand, more infrequently but equally important is understanding why the maintenance of a stable environment has been possible in spite of rather sudden breaks with tradition. It seems to me that using a 'uses and limitations', or 'dangers and benefits' approach to research studies directed at understanding breaks in the nomadic tradition and their consequences, could provide the kind of basis of understanding which might accelerate the process of profiting from past experience – a process apparently little appreciated in developing resources in semi-arid lands.

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D. C. P. Thalen (*International Institute for Aerial Survey and Earth Sciences* (*I.T.C.*), *Enschede*, *The Netherlands*). A remark has been made in the discussion that the use of the Middle Eastern Rangelands has not changed over the last 3000 years. I have to disagree, especially taking the last 30 years in comparison to the long period before. My information is based on a few years field work in the desert areas of Iraq and on literature data. A major change in the use of the arid and semi-arid ranges has taken place over the last decade, due to new mechanical means allowing the drilling of wells and reaching remote areas with 4-wheel-drive terrain cars. This change has caused an enormous increase in grazing pressure. In this respect a parallel can be drawn with Mr Perry's picture of the Australian rangelands following the settlement. Statistical data on the total number of sheep in Iraq may illustrate this. The first data are from the thirties giving figures of about 4–5 million. This is followed by an increase to about 10–11 million in the mid-sixties. These figures have in some publications been extrapolated to about 14 million in 1973. Recent, in my opinion reliable, data show that the figure for 1971 should be around 6 million. This fits in Mr Perry's picture for Australia of an increase in livestock number when opening up new areas, followed by a sudden drop when the resources had been over-used and a gradual stabilization afterwards at a lower level under proper management of the already degraded resources.

In my opinion in the Middle Eastern rangelands we have gone through the first two phases in the last 30 years or so. It is time to be concerned about the third phase, that of proper management based on survey and research data.

J. A. Allan (*School of Oriental and African Studies*, *Malet Street*, *London WC1E 7HP*). It has been suggested by Mr Robertson that man has mismanaged water and soil in such a way that the soil has become unusable because of saline–alkali degradation. Professor Jolly has further enquired whether the process can be reversed so that degraded areas can be reclaimed. I am not as familiar with the Tigris–Euphrates area and its irrigation systems as I should like to be, but I should be surprised if the position there is not similar to that which I have encountered in other semi-arid areas in northwest India. There the climate and geomorphology are such that the development of saline–alkali soils is a 'naturally' occurring phenomenon, and it is likely to be a condition which has affected progressively more and more of the area during past millennia. Could I enquire whether the irrigated lowlands of Iraq show evidence of similar trends which irrigating man should recognize in managing water, and how this might affect approaches to soil reclamation in such areas?

V. C. Robertson. It is probably true that development of saline-alkali soils is a naturally occurring phenomenon in a situation like the Tigris–Euphrates plains, where drainage is naturally poor and salts are distributed at times of flood. It would be a very slow process, however. 'Irrigating man' can, however, greatly speed this process by increasing the application of salt in irrigation water and by building up the level of groundwater which may itself be saline. These factors must be taken into account in designing irrigation schemes, so that salt build-up is prevented (by use of suitable 'leaching' factors) and groundwater levels controlled by properly designed drainage systems.

E. B. Worthington (*I.B.P.*, *c/o The Linnean Society*, *Burlington House*, *Piccadilly*, *London W1V 0LQ*). With reference to the extensive ancient irrigated areas of Iraq, deserted through soil salinization, and the idea that these areas had been used successively on a system which might be

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compared with shifting cultivation, was there evidence that the salinated irrigated areas, like areas of rain-fed agriculture, recovered within measurable time?

V. C. Robertson. We obtained no evidence that salinized irrigated areas could recover, though theoretically some recovery is possible if cessation of irrigation allows high water-tables to drop and salt to be leached out of the upper soil by the limited rainfall. There is some direct evidence that such recovery occurs in the Indus plains of Pakistan.

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