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Overview No. 3

Overview of Physical and
Socio-Economic Environmental
Situations in North Africa

PROGRAM FOR INTERNATIONAL DEVELOPMENT
CLARK UNIVERSITY
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OVERVIEW OF PHYSICAL AND SOCIO-ECONOMIC ENVIRONMENTS IMPACT SITUATION IN NORTH AFRICA

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Overview Paper

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1. INTRODUCTION

Any assessment of the environmental impact of development in North Africa must take into account two salient factors, namely the high degree and widespread extent of aridity prevailing in the area and the long history of human use of the region's ecosystems. Much of the region experiences hyperarid conditions and even the subhumid portions of the area suffer seasonal aridity and periodic, frequent drought. Productivity is, to a considerable extent, moisture limited and even the best-watered districts are by no means risk-free, secure habitats. Moreover, except in the moister regimes of rivers and mountains, ecosystems with their own array of environmental problems, pervasive aridity tends to lengthen the period required for recovery after disturbance. In consequence, any environmental impact tends to have an enhanced effect because both the expense and the time period required to rectify the adverse effects are greater.

The lengthy record of sedentary occupation of the Middle East has serious implications for the region's environment. To the best of our knowledge, both agriculture, at least as it pertains to seed crops and herd animals, and urbanization arose in this area. The impress of settled agriculture on the landscape is rich and dramatic. It runs the gamut from deforestation to massive hillslope terracing and from successful, stable irrigation civilizations to progressive salinization, siltation and population collapse.

In the process, massive changes have been instituted in the physical environment and hardly a piece of untrammelled, virgin

land survives today. The legacy of this historical process of resource development has been to give the region both a cultural richness and diversity and a record of environmental modification perhaps unrivalled elsewhere. For, if the resources of the region were sufficient to nurture and support economic and cultural development during previous epochs, the same claim can not be made today. While agricultural resources still possess considerable potential for future development, human-induced environmental change has constricted many contemporary development options or drastically increased the cost of pursuing them. With only a few exceptions, the mineral resources required to construct a modern industrial economy are lacking.

This overview examines these themes in two contexts, each supported by a series of maps. The first establishes existing conditions through a series of maps that outline the factors of physical and human systems. The physical state factors of geology, climate, soil and vegetation initially examined individually are then summarised in climatic classification and bioclimatic maps. Maps of existing livelihood systems and agriculture, the status of desertification, transport, urbanisation and population change and development introduce some factors responsible for, or summary statements of, changes occuring in the physical environment.

The second section of this overview delineates some of the causal factors underlying future environmental impacts. Each major theme is the subject of a map which, for analytical purposes, can be overlaid. Thus, comparing the desertification potential of an area with the livelihood system of the same area enhances

comprehension of where change is likely to produce environmental impact. Anticipated changes in existing transportation networks or identification of rapidly growing urban areas likewise gives warning of the foci of environmental disruption associated with changing population density.

Crude comparative cartographic analysis of this type offers revealing, first approximation, insights into emerging environmental impacts. No substitute for field investigation, they do forewarn the informed observer of potential danger and permit an initial assessment of impending difficulties.

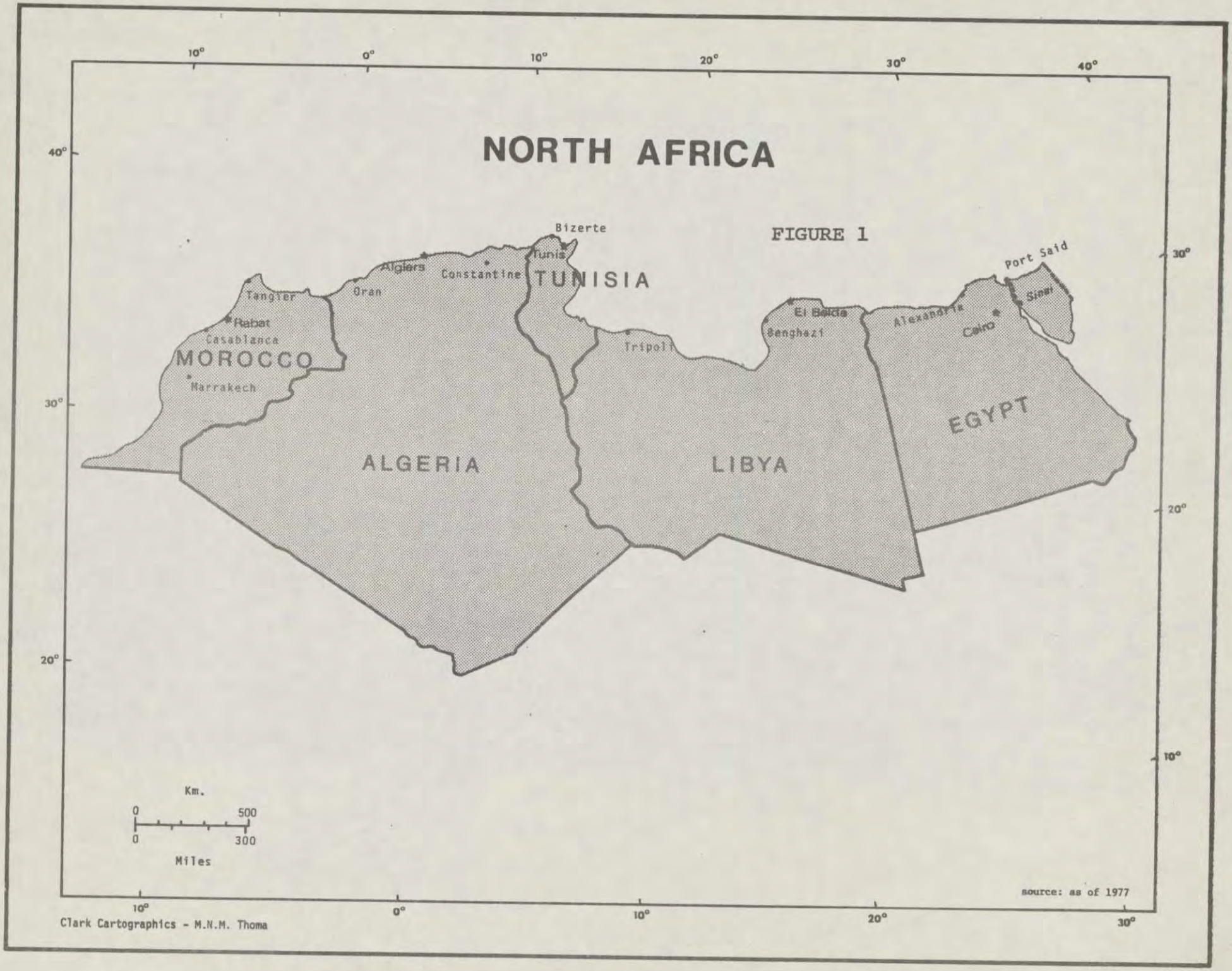
Figure 1 provides a locational key to the area under discussion.

2. EXISTING ENVIRONMENTAL CONDITIONS

Existing environmental conditions constitute a set of state factors that form the first concern of environmental assessment. Those factors that are primarily physical systems are presented in Figures 2-5 and summarised in Figures 6 and 7.

2.1 Solid Geology

The major geological formations of North Africa are presented in Figure 2. Rather than focusing on the geological era in which a stratigraphic formation originates, the map concentrates on the characteristics of these features. Younger sedimentary rocks and alluvial deposits formed during recent, Quaternary periods are sharply contrasted with older sedimentary, crystalline and volcanic materials. The younger formations are significant for several reasons. Often formed in marine environments and subsequently exposed by tectonic movements or marine regressions, these sedimentary basins are the site of substantial petroleum deposits. Oil fields in Libya and Algeria are associated with


NORTH AFRICA
FIGURE 1
Bizerte
Tunis
TUNISIA
Algiers
Constantine
Oran
Tangier
Rabat
Casablanca
MOROCCO
Marrakech
ALGERIA
Tripoli
LIBYA
El Beida
Benghazi
Alexandria
Cairo
Port Said
Sinai
EGYPT
Km.
0
500
0
300
Miles
source: as of 1977
Clark Cartographics - M.N.M. Thoma

Generalized Surface Geology

FIGURE 2

volcanic materials

sedimentary (quaternary)

sedimentary (tertiary)

crystalline (mesozoic, paleozoic, precambrian)

these formations: they are the locus of considerable economic activity and thus a focus for environmental change.

Many of these sedimentary layers are composed of limestone which has great significance for agricultural activity and water supply. Frequently subterranean drainage develops as fissures and cracks are dissolved by water filtering from above. Sinkholes, underground caverns and confused drainage patterns are the result. Rather than surface run-off, subterranean movement can characterise substantial areas. The al-Marj Plain of eastern Libya is one such area in which a large depression with rich agricultural soils is drained by sub-surface flows. Development of supplemental irrigation is difficult in such areas and the provision of storage dams is complicated by storage reservoir loss through seepage into the surrounding rock layers. Conversely, springs of considerable volume and purity frequently appear in localised settings wherever impervious sub-surface layers encourage water concentration and lateral movement.

While many of the geologically recent deposits are of limited agricultural utility, only representing sand and gravel material transported by erosional processes during former pluvial periods, others can be fertile. Where water, applied either by rainfall or artificial irrigation, is available, such deposits can be highly productive. The Kufra Oasis development project in southern Libya, based on the use of subterranean, possibly fossil, aquifers to irrigate sandy material weathered from Nubian sandstone, is a classic example of development in such areas. Such projects have enormous potential for environmental change because, located far from appreciable sources of precipitation, they are

vulnerable to groundwater depletion and soil salinization. Also potentially valuable are areas of volcanic activity where fertile soils could develop if water deficiencies could be overcome.

Less significant for their agricultural potential are the older, often metamorphic, crystalline rocks of the continental interior. Unlike the more recently formed sedimentary deposits, these zones could be the site of significant mineral discoveries. One of the ironies of the geography of North Africa is the disjunct relationship between precipitation and areas with the mineral potential to support industrialisation. Existing deposits on the margins of continental tectonic plates are too small, and many of them have been too heavily worked, to provide reasonable economies of scale for industrialisation.

2.2. Precipitation

No other single factor in the physical environment is as important as rainfall. In its absence, life fails. As it diminishes in amount, temporal variability increases. Precipitation provides the basic energy input for all other components of the ecosystem and is the vital component in energy flow, nutrient recycling and other essential processes. Where rainfall totals are significant and reliable, possibilities for development are good; as rainfall decreases, the management options for dryland resources become increasingly constrained and the potential for environmental disruption increases.

Several implications flow from the critical role played by precipitation. In North Africa, the total area that receives relatively large precipitation amounts is quite small. These

Average Annual Precipitation

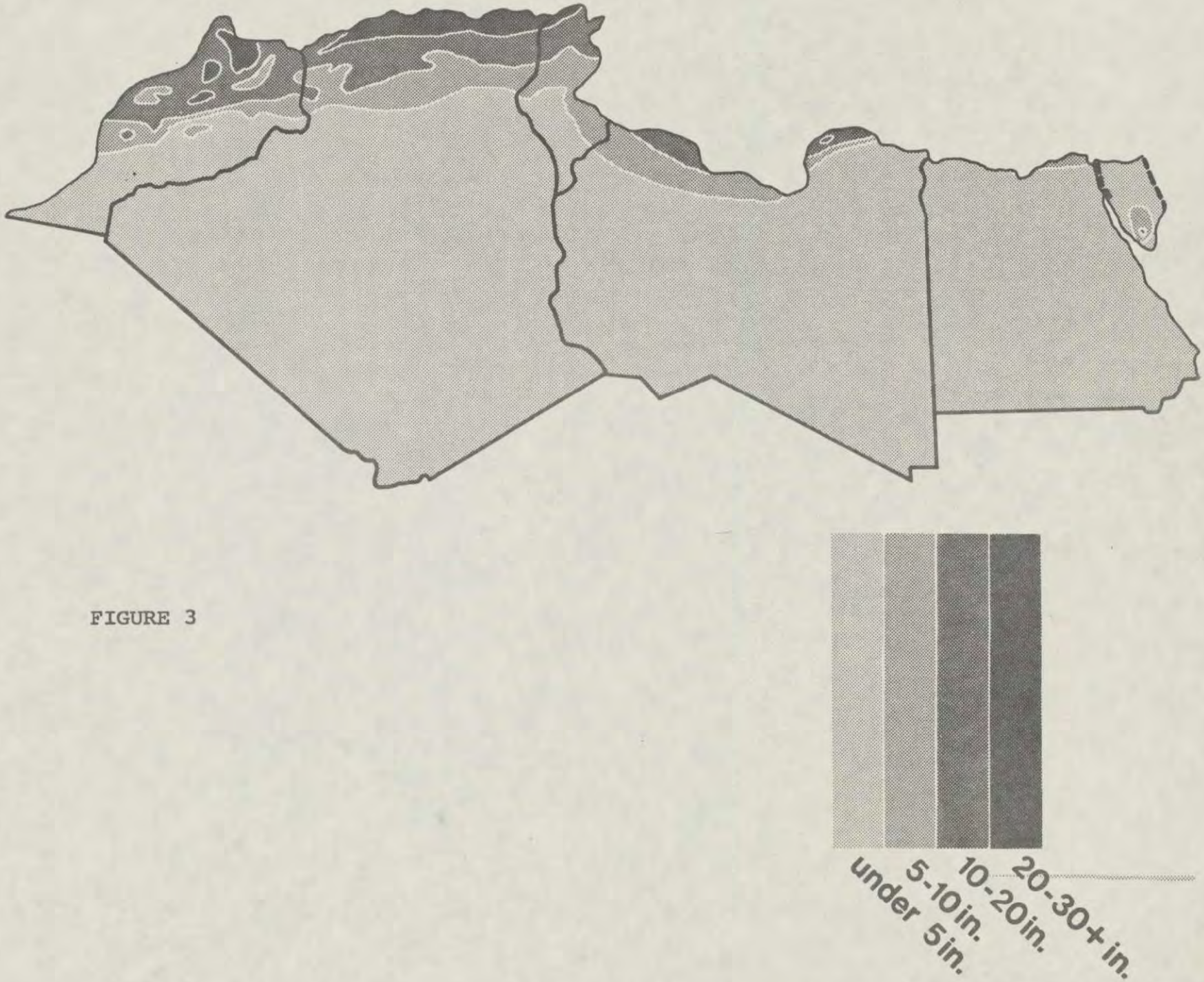


FIGURE 3

districts, Figure 3, are located close to the Mediterranean coast, often in upland areas. While topography promotes orographic precipitation, slope and soil conditions are frequently not favourable to full utilisation of enhanced water supply. Indeed, poor soil management practices, plowing on steep slopes, removal of protective vegetation cover and isolation from technological innovations have often combined to institute gully erosion. The promotion of agricultural development in many of the better-watered upland districts is likely to encounter both degraded environmental resources and resistance to the adoption of new management techniques. Because population totals are already high, pressure on existing agricultural land is considerable. In such circumstances, rural dwellers are likely to select only those portions of aid packages that remove constraints to productivity in the local environment. Unless careful attention is paid to the full range of likely effects, unexpected environmental impacts are likely.

Table 1 gives climatological data for Benghazi, Libya. Note the range of temperature and the seasonality of the rainfall.

TABLE 1.

CLIMATE AT BENGHAZI, LIBYA

MONTH	J	F	M	A	M	J	J	A	S	O	N	D
TEMPERATURE ^{OF}	56	57	60	65	71	75	77	78	76	73	67	57
PRECIPITATION IN INCHES	2.7	1.6	0.8	0.2	0.0	0.0	0.0	0.0	0.1	0.7	1.8	2.6

Precipitation totals decrease sharply as one moves away from coastal and upland districts. This constricts the possibility of

agricultural development to a small portion of the total land surface. Comparison of precipitation with the distribution of livelihood forms indicates a shift from intensive, sedentary agricultural modes of production to more extensive pastoral and nomadic regimes. Only the groundwater oasis settings of the Sahara or the Nile valley are exceptions to the rule; islands of intensive agriculture, they are miniscule, albeit important, specks on the desert sea of sand and rock.

As rainfall increases, variability decreases and reliability increases. It is particularly important to note that variability within a given rainfall regime is as important in the consideration of agricultural production as mean annual totals. Crops grown under arid and semi-arid conditions must be able to either survive prolonged drought or germinate and mature during a short rainy season. The natural oasis of deflation hollows, wadis and perched ground water provide additional water resources.

2.3 Soils

Arid zones of low and irregular rainfall, supporting herbaceous and scrub cover, are generally areas where soil development is slow. The generic properties of arid soils include

a. Slow Evolution

b. Shallowness

c. Highly Evolved Organic Content

d. Ill Defined Structure

e. High Mineral Content

f. Poorly Weathered Minerals

g. Stable Colloidal Structure

h. Concentration of Soluble Compounds at Surface

and i. Hydromorphic Phenomena.

Most soils are formed under desert and semi-desert conditions. (Figure 4.) The Mediterranean soils (red-brown, plateau and steppe) formed under alternating wet and dry conditions are especially important. The nature of the parent rock is considerable in the formation of mature soils, e.g. the contribution of weathered limestone to the formation of "terra rosa", deep red clay, in the Maghreb.

Between the Tellian and High Atlas of Algeria and Tunisia lies a plateau with elevation between 1,000-1,500 meters. It contains a series of intermittent, shallow and salty lakes which disappear during summer and expand during the rainy season. These swampy, hydromorphic soils evolve because of the presence of groundwater through the soil profile, the temporary waterlogging of some horizons or surface floodwater.

In desert areas, extreme climatic conditions produce little weathered soil. Absence of vegetation encourages wind erosion resulting in areas where surface materials are removed (reg landscapes) and areas where aeolian deposits obscure the relationship between solid geology and soil formation.

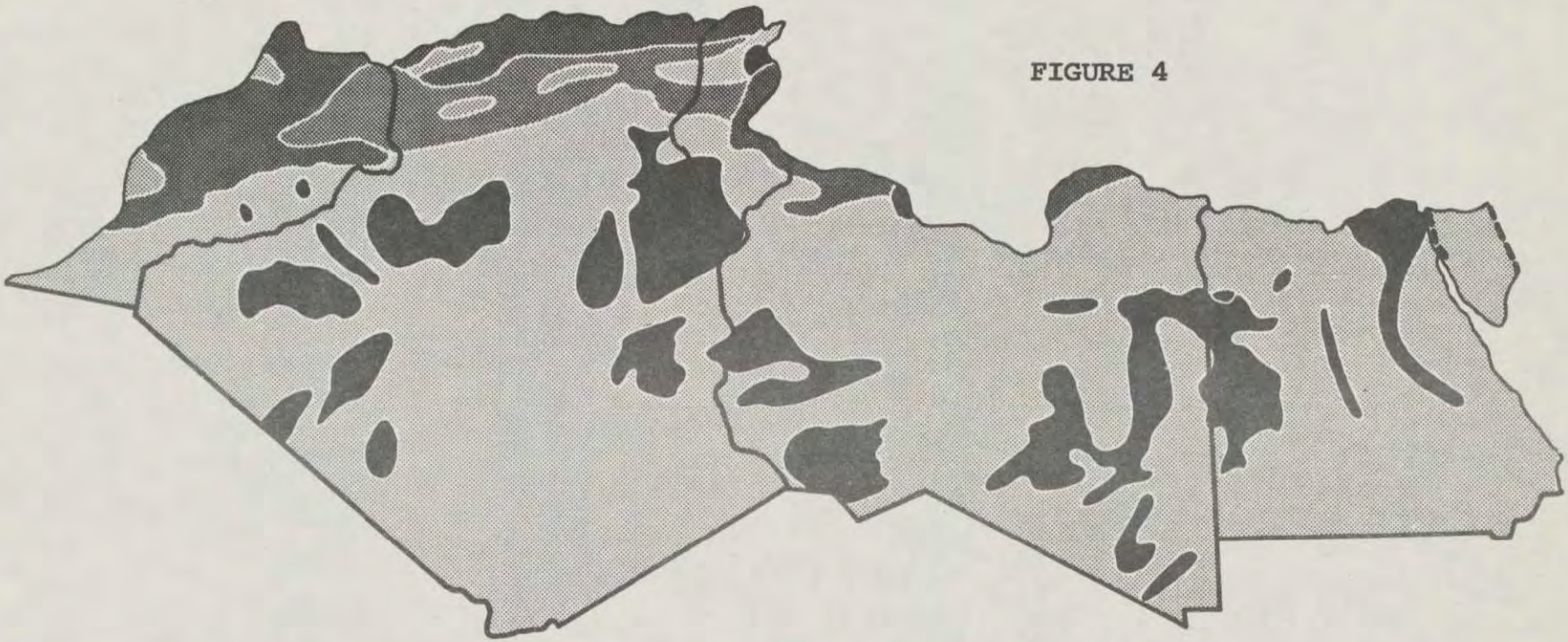
The recent alluvium deposits, both coastal and riverine, are areas of concentrated agricultural activity. The cycle of renewed fertility associated, for example, with the annual regime of the Nile, are the most productive soils in the area.

2.4 Vegetation

The relationship between solid geology and soil type is

Soils

FIGURE 4



recent alluvium

red and brown mediterranean soils

plateau and steppe soils

swamp and/or saline soils

desert soils

dune fields

clearly apparent in North Africa...so too is the relationship between climate and vegetation especially climatic determination of the character and distribution of vegetation. (Figure 5) Vegetation can survive prolonged periods of heat and drought by

a. Completing the growing cycle in the cooler weather, e.g. cereals and grasses

b. Special structural (XEROPHYTIC) adaptations e.g. cork forests

The lengthy human occupance of these areas has meant that little original plant cover remains thus desert encroachment is encouraged even in sub-humid areas.

The Mediterranean scrub and cork oak forests are an adaptation to climatic conditions. Adaptation to high evapo-transpiration during summer months produces evergreens, with sclerophyllous leaves, permitting rapid growth when moisture is available. Years of human occupation have removed much forest and continued intensive grazing, especially by goats, has produced a scrub associtio that is an anthropogenic subclimax community.

Deciduous and coniferous forests tend to occur at higher elevations, e.g. Atlas Mountains. The Steppe locations are transitional zones between humid and arid areas. Although rainfall is not as low and variable as that of the true desert, limited totals make agricultural production marginal. The steppes are used by pastoral nomads except where irrigation/dryland farming is possible. Riverine vegetation on the extensive alluvial plains is a special plant community in which aquatic grasses, e.g. reeds, play an important role. Most riverine areas are heavily settled

Generalized Vegetation

FIGURE 5

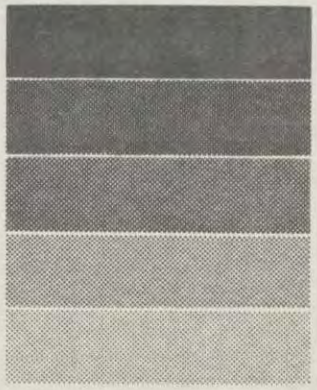
mediterranean scrub and cork oak forest

deciduous and coniferous forest

steppe

riverine

desert shrub



and current agricultural production has destroyed much of the pristine vegetation.

2.5 Climate and Bioclimatic Zones

Climatic classification enables summary statements to be made about the implied physical process. (Figure 6) The letter "B" in the classification designates dry climates (i.e. where evapotranspiration excedes precipitation). There are two main subdivisions of B climates, BS and BW. The BS climates are semi-arid and are known as steppe climates. BS climates can be further divided into BSh and BSk. (The subdivision is determined by average annual temperature...if it exceeds 64.4^{o} F-hot/heiss- or if it is beneath that figure-cold/kalt.) In North Africa, the BSh areas are influenced by the rain-bearing westerlies in winter and the dry sub-topical highs in summer. Approximately 90 per cent of the rainfall occurs between October and May. The area thus experiences a summer drought (BShs)-the final "s" indicating the driest season.

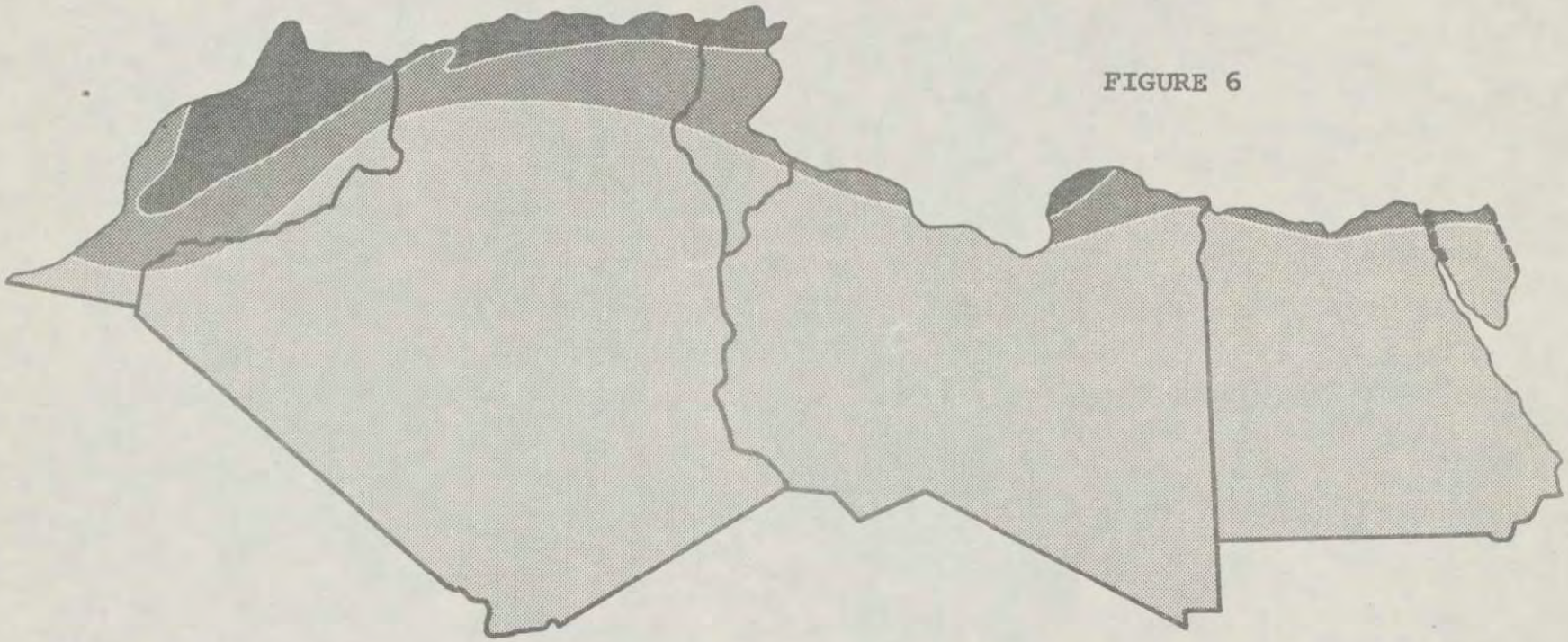
BW indicates an arid desert climate. 64.4^{o}F average annual temperature is also the dividing line between BW climates. The desert areas of North Africa are hot, thus BWh.

Csa are climates where the average temperature of the coldest month lies between 26.6^{o}F and 64.4^{o}F. The warmest month has an average temperature in excess of 72°F. (a) The summer is the dry season. (s) Although there is a similarity in rainfall seasonality between the Csa and BShs, the vegetation cover in the latter zone is broken.

A more complex summary statement about the complex natural

Climate Classifications

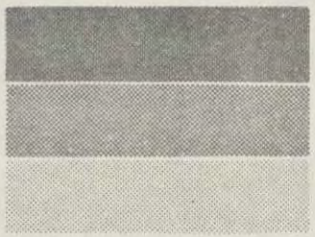
FIGURE 6



Csa mediterranean

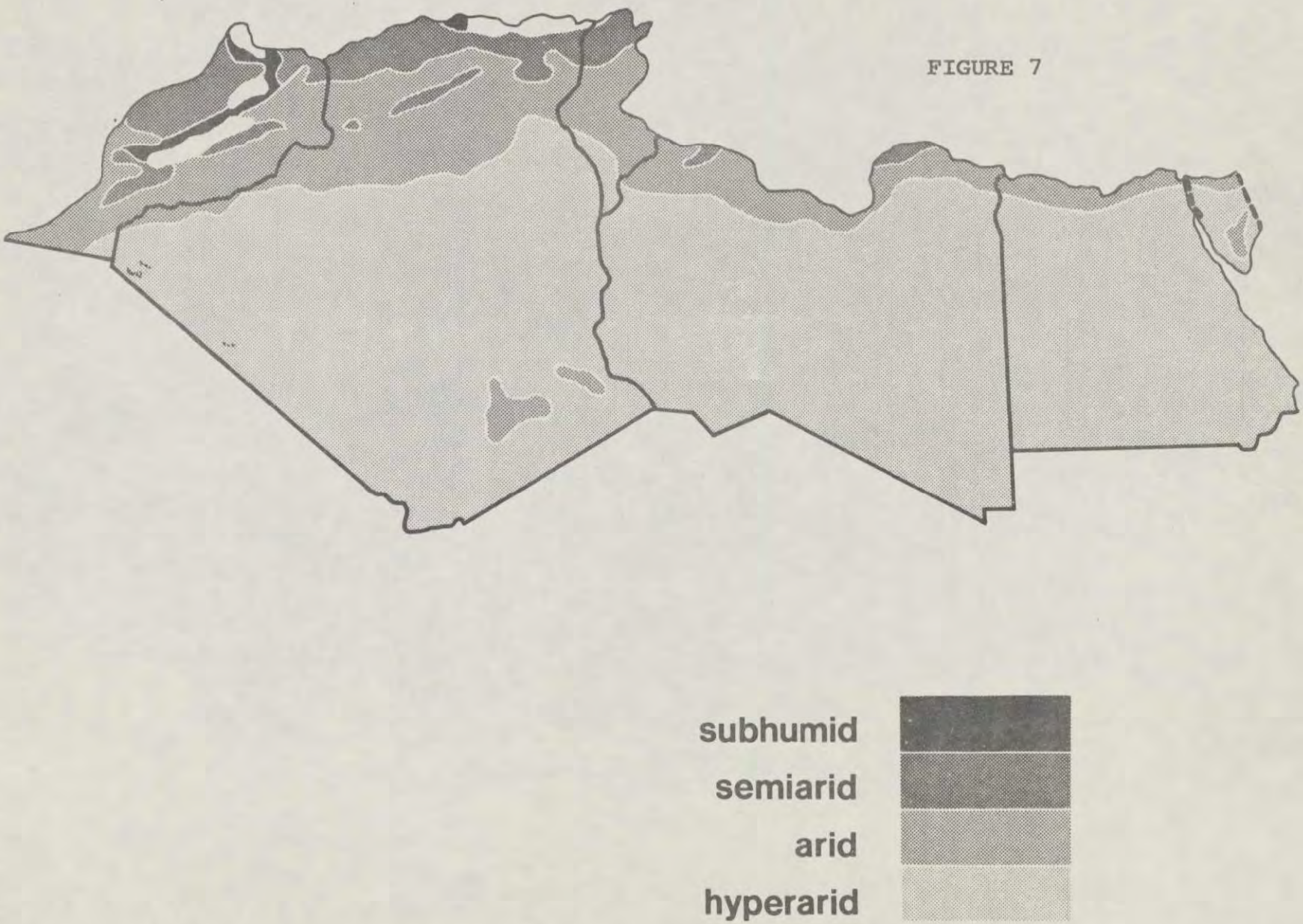
BShs steppe (marked summer drought)

BWh desert (constantly high temperatures)



Bioclimatic Zones

FIGURE 7



systems is found in Fig. 7 -- the bioclimatic maps. Information summarised in this manner includes the geological, climatic, pedological and vegetational data. Such a summary statement initiates discussion on possible agricultural production including measures that can be utilised in increase agricultural productivity. For example, the arid and hyperarid areas contain dry farming and pastoralism -- increased water supply could increase yields but also the threat of salinization; semiarid areas with pastoralism and cereal cropping, could be improved with pasture improvement programs and crop rotation utilizing fodder crops; subhumid areas support intensive activity, such as market gardening but, in areas where productive land is limited, land ownership frequently requires reform. Detailed bioclimatic maps, such as those published by FAO, are an invaluable guide to an understanding of the total physical environment.

2.6 Dominant Life Styles

The relationships between geological structures, climatic factors, pedology and flora and fauna are complex. This complex system is altered by human action. The substance from which human beings derive energy is food. Choroplasts in plants operate in photosynthetic process to transform solar electro-magnetic energy into chemical energy. In the "natural" state, prior to any deliberate or conscious human intervention aimed at raising the productivity of a given piece of land, there is a necessary movement towards equilibrium, the parameters of which are defined by the efficiency of the photosynthetic transformations allied to the particular qualities of the soil upon the substances of which

Dominant Life Styles

FIGURE 6

rural sedentary population

nomadism and transhumance

wasteland

the plant life must call for the substance of its own growth. Agriculture is a series of processes whereby a given area is artificially induced to yield more food for animals and people than it would naturally support. These activities are undertaken with a specific socio-economic formation and produce what can be identified as dominant lifestyles (Fig. 8).

3. EXISTING SOCIO-ECONOMIC CONDITIONS.

Despite the largely rural population, towns dominate the region. The political structure of the urban areas contrasts with rural customary legisltation concerning land, human relationships and religious practices. Modernization has sharpened the functional differentiation between the town and country. The rural sedentary population of the North African coast and the Nile Valley respond rapidly to stimuli from primary urban foci. In contrast, the nomadic and transhumance populations form a distinct entity although their lifestyle is being gradually eroded through sedentarization to which they are frequently forcibly induced or economically reduced.

3.1 Agriculture and Development

Even with the growth of oil exports and the establishment of petrochemical industries, agriculture remains the important sector in the North African economy. The vital role of agriculture must be understood against the occupational structure of the population. The location of the population reflects the natural conditions and consequent landuse patterns. Some countries, Egypt in particular, have reached the limits of cultivable, arable land given the present socio-economic formation. Agricultural technology

reflects a range from the "traditional" to the modern technologies. Egypt, with a macedoine of technologies, a small land frontier, less than 2 acres of land per capita, 52 per cent of the population in agriculture and only 28 per cent of GNP from agricultural activity, is indicative of the problems facing agricultural development in these regions.

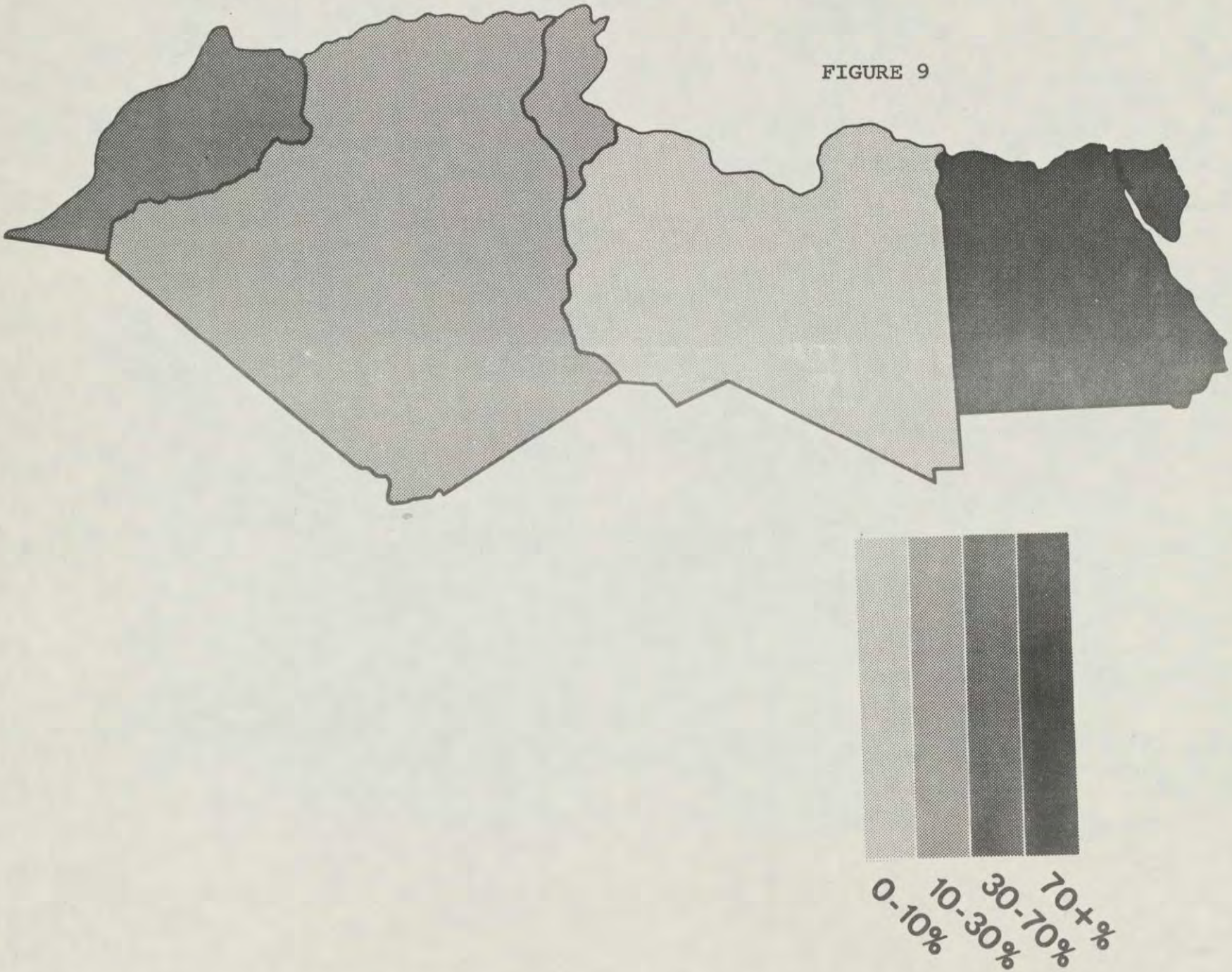
Agricultural export expansion requires stable prices, a clear indication of demand for a specific agricultural product and adequate transport facilities. Such conditions rarely exist. Despite crop diversification, a strategy that lowers market and environmental risk and enables balanced subsistence diets to be maintained, cereals dominate agricultural production. Nutritional levels are low, despite the dietary inputs of milk products and fruit, leading to vulnerability to endemic and epidemic disease, e.g., typhoid.

Figure 9 indicates the contribution by agricultural sector to export trade. These figures disguise the relative importance of industrial crops to export trade. Over 50 per cent of the total exports from Egypt are accounted for by industrial crops, especially cotton. The other North African countries have less than 5 per cent of total exports from industrial crops. Libya without oil would be severely restricted in developmental options.

The status of desertification, the summary term to describe the lowering of land capability for agricultural production because of human action, indicates that the areas most likely to suffer from diminishing land capability are precisely those that are important for agricultural production. Increasing land

Contribution by Agricultural Sector to Export Trade, 1971

FIGURE 9



degradation means lower productivity, decreased food resources for an increasing population, increasing food imports and a consequent balance of payments problem. (Figure 10) Drought probability, although varying with latitude, further exaccerbates the problem. (Figure 11) The combination of the possible disruptions from both the physical and human milieu contains sufficient elements to be described as an ecological timebomb. Recurrent drought in such a fragile environment could lead to substantial political change.

Linkages between rural and urban populations have always existed...it is essential for the functioning of the two systems. Transport is, however, poorly developed in many areas. Figure 12 shows an accumulative measurement that indicates the integration of the population and communication networks as a ratio.[1] The lower scores indicate a higher degree of integration. Development plan expenditure by sector is also included which shows the little emphasis placed by Tunisia, Libya and Algeria on agricultural development.

3.2. Rural - Urban Interactions

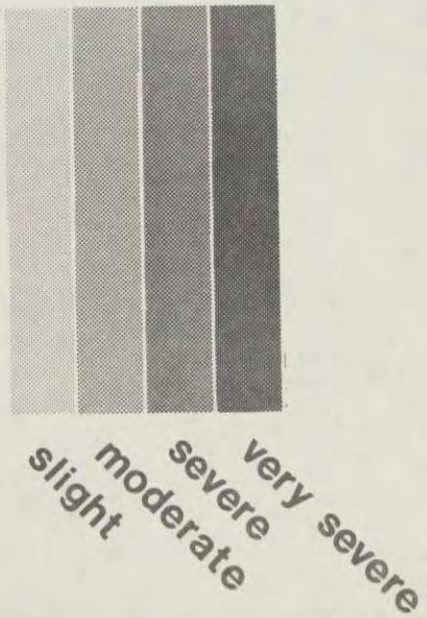
North Africa has experienced rapid urban growth. Table 2 indicates that the urban population has been growing more rapidly than that rural. This trend can be expected to continue for the forseeable future as the urban population continues to grow at a rate 2 or 3 times the rural one.

---

1. Transit scores were obtained by regressing km/100 sq, km road and rail with km/100,000 pop. of each network with motors/1,000 pop. and the total km. of railways.

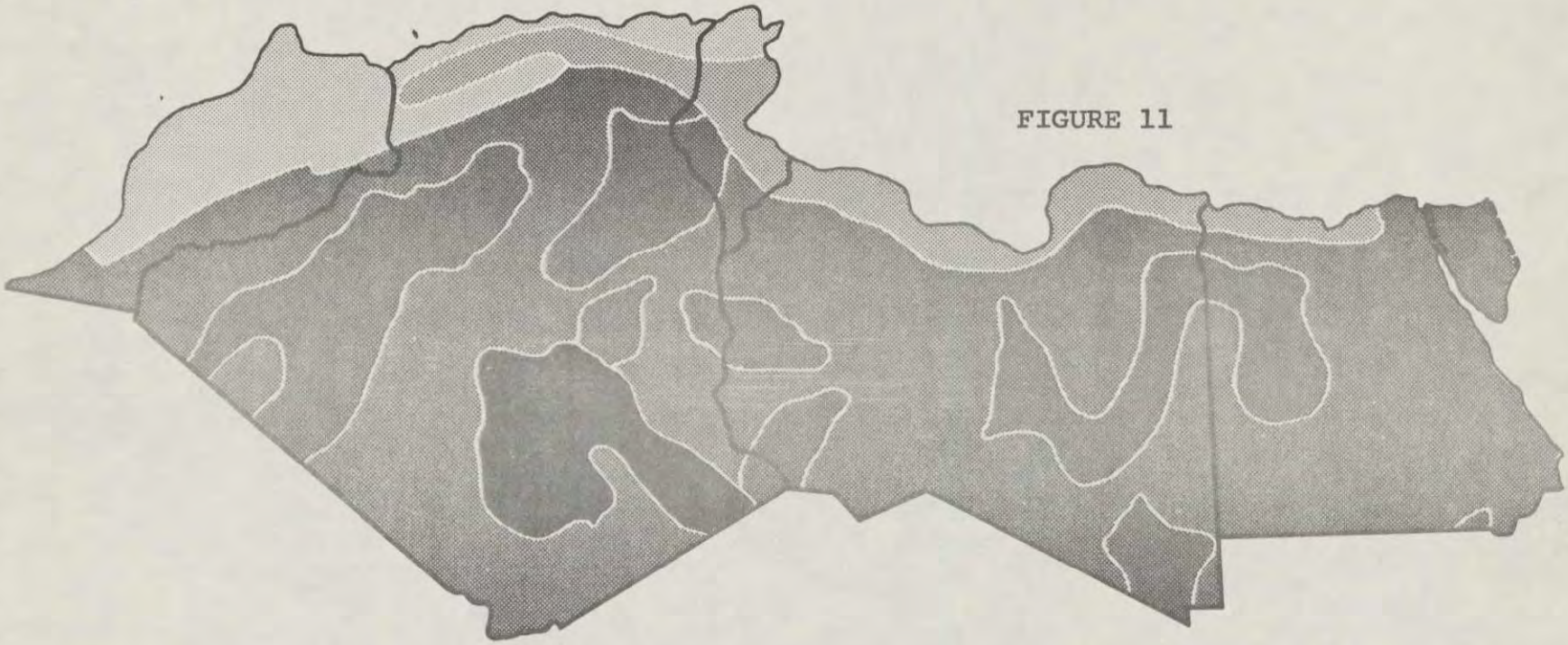
Status of Desertification

FIGURE 10



Drought Probability

FIGURE 11



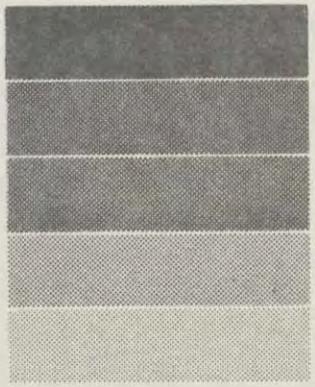
mountain deserts

dune fields

100%

50-75%

> 50%



TRANSPORT AND DEVELOPMENT

FIGURE 12

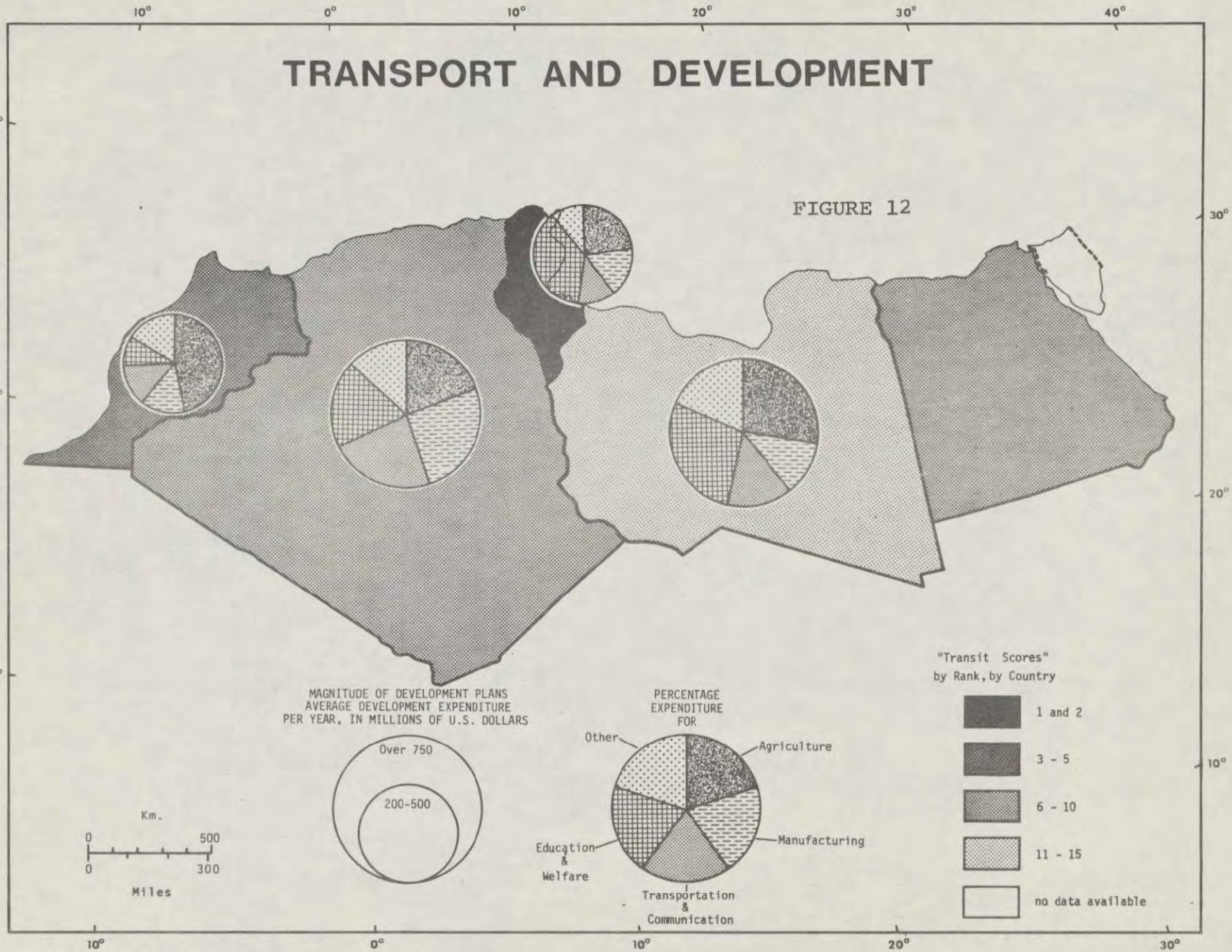


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TABLE 2

Population Growth in North Africa

			1950	1960	1970	1980	1990
EGYPT	Total Pop.	('000)	20,461	25,929	33,329	42,144	52,640
	Urban Pop.	(%)	31.90	37.54	44.36	51.07	57.79
		('000)	6,527	9,734	14,784	21,521	30,421
	Rural Pop.	('000)	13,934	16,195	18,545	20,623	22,219
LIBYA	Total Pop.	('000)	1,029	1,349	1,938	2,638	3,590
	Urban Pop.	(%)	18.66	22.76	27.76	33.36	39.58
		('000)	192	307	538	880	1,421
	Rural Pop.	('000)	837	1,042	1,400	1,758	2,169
TUNISIA	Total Pop.	('000)	3,530	4,221	5,137	6,561	8,629
	Urban Pop.	(%)	25.86	37.27	42.61	51.04	58.78
		('000)	913	1,362	2,189	3,349	5,072
	Rural Pop.	('000)	2,617	2,859	2,948	3,212	3,557
ALGERIA	Total Pop.	('000)	8,753	10,800	14,330	19,828	27,741
	Urban Pop.	(%)	21.4	31.13	44.29	55.18	64.11
		('000)	1,877	3,362	6,347	10,941	17,785
	Rural Pop.	('000)	6,876	7,438	7,983	8,887	9,956
MOROCCO	Total Pop.	('000)	8,953	11,640	15,126	20,384	27,633
	Urban Pop.	(%)	20.62	29.47	34.27	41.81	49.3
		('000)	1,846	3,430	5,183	8,522	13,622
	Rural Pop.	('000)	7,107	8,210	9,943	11,862	14,011

In most countries, centres of all sizes in the urban hierarchy have been growing but the explosive growth pattern is in the largest centres, especially those that had a central function during the colonial period. The differential growth of Tunisian cities serves as a model for the entire region. (Table 3) While smaller centres such as Sousse, Sfax and Bizerte have made impressive gains in size, often at rates greater than Tunis the capital's head-start enable it to retain its primacy in the urban hierarchy despite the differential growth rates. Indigenous in-migration to urban areas counteracts the departure of the European population after Independence thus maintaining trends. Indeed, if the growth of administratively separate but functionally linked suburban areas are included in the metropolitan figures, Greater Tunis contains more than 50 per cent of the urban population living in towns of 10,000 + persons. Some regional centres have accelerated growth rates as the result of deliberate government action, especially through the expansion of tourism, but the dominance of primate urban areas is likely to continue.

In the growing urban areas, many of the environmental problems are concentrated. Some of these problems are social in nature. Males predominate in the urban areas because

a) Females are underennumerated in census

b) Most migration tends to be male.

Although there is considerable migration for urban employment, much of it seasonal, it seems that monetary flows back to the rural areas are largely devoted to increasing subsistence or purchasing new consumer goods. When technological innovations are

TABLE 3

The Growth of Selected Urban Centers in Tunisia

(in thousands)

	1921	1926	1931	1936	1946	1956	1966
BIZERTE	19.1	20.6	23.2	28.5	39.3	49.7	51.7
TUNIS	171.7	186.0	202.4	219.6	364.6	410.0	469.0
SOUSSE	19.8	21.3	25.3	28.5	36.6	48.2	58.2
KAIROUAN	19.4	19.4	21.5	23.0	32.3	34.0	96.2
SFAX	27.9	27.7	40.0	43.3	54.6	65.6	70.5
GABES	16.9	15.1	15.6	18.6	22.5	24.4	32.3

bought to enhance rural productivity, they often result in unforeseen environmental change. Thus, the substitution of deep-delving, tractor powered disk ploughs for the surface scratching, Mediterranean (often camel drawn) plough,can have far more serious consequences than an expansion of cultivated land. The traditional shallow plough confers important benefits. Salient among these is its light disturbance of the surface layer; this disrupts upward movement of soil moisture by capillary action, forces water to move as a vapor (and therefore more slowly) rather than as a liquid, and thereby retards the loss of stored soil moisture. Deep plowing runs counter to these time-tested objectives of dry-land agriculture and can both expose more devegetated areas to erosion and result in rapid loss of crucial soil moisture storage capacity with consequent increased susceptibility to drought.

Often these rural-urban linkages can result in counterintuitive effects. The normal assumption made about population growth is that any increase in rural population leads to an increase in the number of animals, an extension of agriculture into more marginal settings (steep slopes, lower rainfall zones and so on), and a shortening of fallow cycles. Increased environmental disruption is the short-term result and ultimately catastrophic population collapse is envisioned as resource-base productivity diminishes. Conversely, when population growth diminishes, reduced pressure is anticipated.

Yet in the rangelands of eastern Libya this simple disruption model fueled by population growth generally has not accurately depicted local conditions. More detailed examination of the

people-animals-environment model just described reveals a more interesting and complex set of relationships. For in eastern Libya a declining rural population is resulting in more, rather than less, disturbance, at least in the grassy, if not the shrubby, vegetation. Heavy pressure on the grassland resources of eastern Libya has been observed in a number of ecological studies. These show a tendency for woody perennials and unpalatable annuals to increase at the expense of more desirable sheep forage species. This vegetational change reflects the doubling of Libyan urban population that has taken place in the last twenty-five years rather than rural population growth. Indeed, it is the very decrease in rural population that has helped to stimulate environmental disruption.

Herders of camels, sheep, and goats, the rural pastoralists found the need for drought-resistant, subsistence, browsing stock to be less when first males, and then entire families, began to move into urban areas after 1950. The decline of camel and goat herds reflected both reduced subsistence needs and a decrease in the available labor pool to care for the herds. This, in turn, lessened the pressure on perennial woody species and resulted in some expansion in areas distant from rural settlement centers.

At the same time increased numbers of urban residents, possessing enhanced purchasing power in the post-1960 oil boom economy, created heightened demands for more, and better quality, meat. Local preference and prejudice strongly favored domestic lamb and mutton; goat was a distant second, imported meat was distrusted, and camel meat hardly merited consideration. Because

the rural labor pool was depleted due to urban migration, increasing recourse was had to hired shapherds to care for the augmented commercially-oriented sheep herds. These shepherds possessed less knowledge of local resources than did indigenous herders, were cheaper to employ as a result, but also were less venturesome in seeking grazing and water resources. This tended to promote concentrated grazing pressure along tracks and around water sources. The result was an expansion of undesirable and unpalatable species from the standpoint of sheep-herding. Selective reduction in the carrying capacity of rangeland for sheep could logically be expected to follow. But any decrease in sheep herds was likely only to increase the demand for home-grown meat and consequently to encourage herders to employ every available device to increase herd-size. Well-drilling, increased use of mechanization to reach distant pastures, construction of cisterns, provision of fodder reserves for drought years and so on all had the counter-intuitive effect of increasing pressure on existing grazing resources. Maintenance of artificially large herds during drought years served to hinder vegetation recovery when rainfall totals more nearly approximated the long-term average. The underlying motivating force in the system was the series of changes occurring in a subsistence agro-pastoral economy as massive and accelerating rural to urban migration created unfamiliar pressures and opportunities to which local decision-makers responded rationally in terms of their own objectives. These pressures appeared first not in the zones of population concentration but in the vacated rural areas.

3.3 Urbanization

The effects of urbanization are somewhat different depending on the size of the urban center and the economic capacity of the national economy. In both Libya and Morocco, fortuitous mineral resources, petroleum and phosphates respectively, have helped to keep the growth of GNP ahead of population increase. Libya has benefited not only from massive petroleum revenues, but also from a small initial population. Thus, the potential per capita share of the new national wealth was increased and government policy since 1970 has favored relatively equitable income distribution. Not only was initial population larger in Morocco, but also there is some question about the tendency of national averages to mask income distribution inequalities. In Algeria statistics indicate that GNP is at least matching population growth (Fig. 13) and that a policy of spartan self-denial in the present in favor of infrastructure development probably means that existing agricultural and mineral resources will contribute meaningfully to long-term development. In Egypt and Tunisia, in contrast, rapid population growth to date has outstripped productivity gains. The discovery of new mineral resources could alter this picture.

3.4 Environmental Impact of Large Urban Centers

Unequal patterns of growth between nations results in varying capacities for coping with the environmental impacts of rapid urbanization. These impacts can be very considerable, and they attain maximum concentration and intensity in the largest urban areas (Fig. 14). Perhaps the most serious social effect is the

Differential Rates of Change, 1970

FIGURE 13

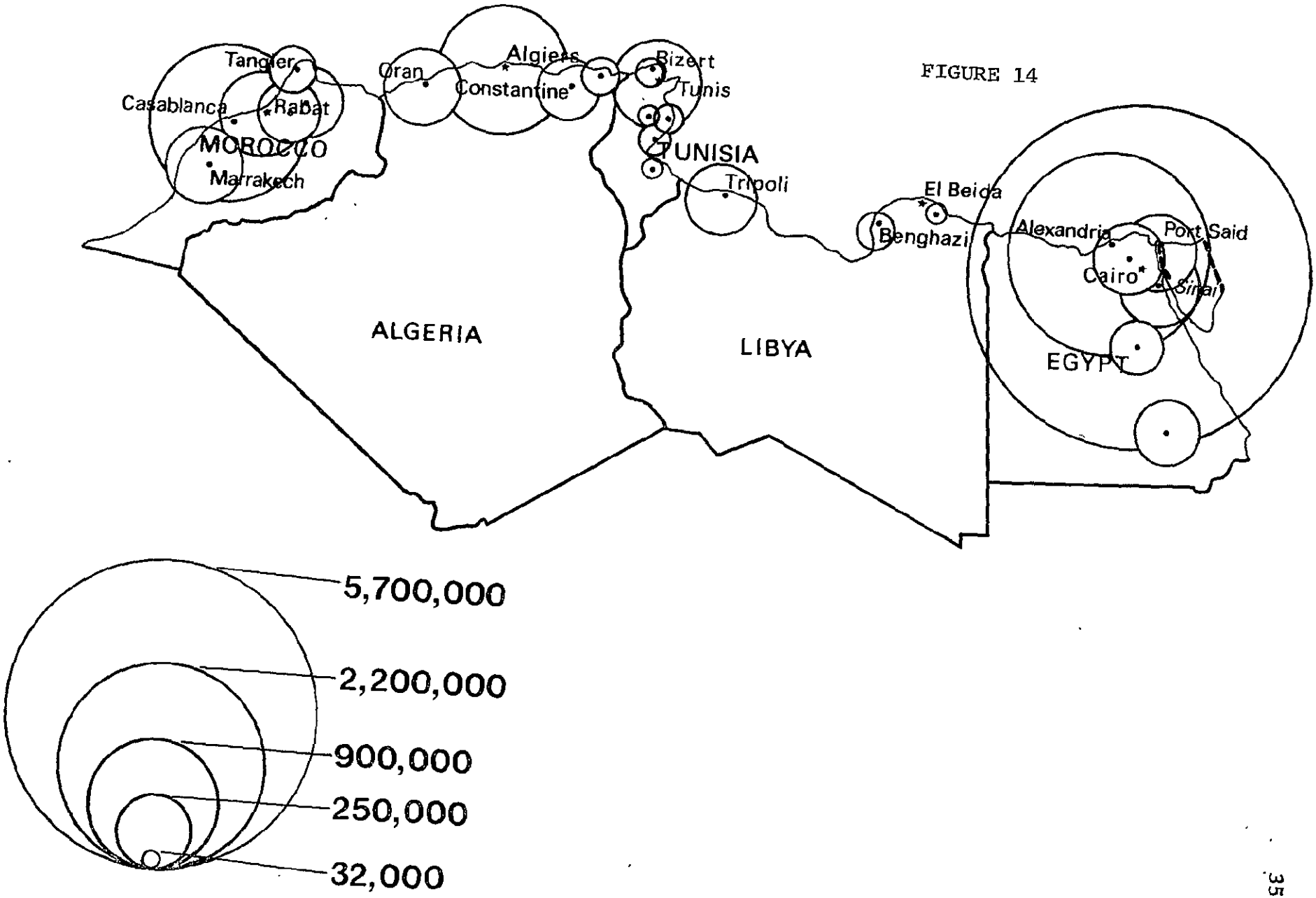
GNP > population

GNP = population

GNP < population

Urban Population
NORTH AFRICA

FIGURE 14



concentration of in-migrants in inadequate housing, either decaying older residential districts or peripheral shanty neighborhoods. Lacking most basic public services, from adequate sanitation to good-quality water, in quantities commensurate with the size of the populations being served, such districts are often not intended to be permanently occupied. When government resources are considerable and a commitment to provision of adequate social services is strong, these difficulties can be overcome by infrastructural improvements. Libya is an example of a country where, at least officially, all substandard housing has been replaced with minimally acceptable public or private accommodations. Elsewhere the scale of the problem is often so vast that it is difficult to move rapidly to acceptable solutions.

Other problems abound. Adequate disposal of garbage and sewage is difficult in many urban districts, resulting in a serious health hazard. Disposal systems that are culturally acceptable, ecologically sound, and economically feasible are not easy to develop. In Cairo part of the problem is solved by recourse to the labor specialization that characterizes much of Middle Eastern society; several small communities undertake solid waste collection in order to support nascent recycling enterprises. Similar, but less formal, efforts are found in many cities. The large cities of North Africa are also the site of a large proportion of each country's industrial capacity. In Tunisia nearly 90 per cent of the country's industry is found in the greater Tunis metropolitan area. While the scale of heavy industrial development is modest by Western standards, the resulting congestion, noise, and air pollution can be considerable.

Most cities are located in coastal environments where local water resources are inadequate to support large populations. This has been a traditional problem for the ancient precursors of contemporary urban areas, a constraint solved by the Romans through the construction of often large-scale aqueduct systems. Similar efforts are underway today, but, unlike the ancients, contemporary technological capacity to tap underground water resources is far greater. The well fields of the coastal cities are vulnerable to overexploitation and the infiltration of saline water into the aquifer layers. As rapid urban growth continues the difficulties of providing adequate water supplies form surface and subterranean sources can be expected to increase.

Adequate fuel supplies are also a problem for lower income groups in all cities and for most socio-economic strata in the non-petroleum rich states. The high cost of fossil fuels places a premium on wood/charcoal as a fuel in many urban environments. For the largest cities the fuel hinterland is very extensive and remote forest districts may be heavily pressured in the struggle to provide sufficient fuel. While the Mediterranean maquis vegetation makes a substantial contribution to meeting this problem through its tendency to sprout vigorously in coppice stands, pressure on natural vegetation for fuel has continued for millenia and is probably the largest single contributor to environmental disruption. Blame for this deforestation is often erroneously placed on the goat. In many situations only the goat can hope to convert the potential forage of degraded maquis into a usable product; at worst the goat contributes the <u>coup de grace</u> to dis-

tricts already devastated by the fuel demands of distant urban centers or by expanding agricultural settlements. Development of fuel alternatives would be a major contribution to lowering the environmental impact of human settlements.

3.5 Environmental Impact & Smaller Urban Centres

Smaller urban centers (10-50,000) generate different types and scales of environmental impact. While the pattern varies from country to country, smaller cities are also experiencing considerable growth. The impact of this growth falls into two main categories: fuel pressures and market functions. For the smaller center fuel requirements are of a totally different order of magnitude than those of major metropolitan areas. While smaller in magnitude, these fuel requirements have greater local impact. Both because they are generally located further from access to fossil fuel supplies and closer to wood resources than are large cities, the pressures generated by smaller regional urban centers are immediately observable in spatial proximity to the source of disruption. The possibilities of reaching local wood supplies at a short distance from the urban center means that the periphery of most places is seriously disturbed by local collectors supplying the local market. This disturbance is reinforced by grazing and browsing pressures of animals concentrated in the zones adjacent to the small city. Whereas in larger urban centers distance to fuel source intervenes, leading to diminishing pressure with distance from an initially heavily exploited zone, in smaller centers the exploitation curve is likely to continue in an exponential mode for longer before leveling off. The combination of fuel collection and animal foraging results in concentric

zones of disturbance that diminish with distance from the urban place.

The second major aspect of the environmental impact of smaller centers is a function of their economic role in an urban hierarchy. As lower order central places, they play an important role in the collection of rural products for shipment to higher order centers and as foci from which goods and services are distributed downward through the urban hierarchy. As such they serve as nodes in the transportation network and attract large numbers of people to periodic and permanent markets. Of particular importance are the animal market functions of smaller urban centers. Large numbers of animals are brought to these markets; overland movements along roads and tracks result in concentrated impacts on roadside vegetation. The temporary sojourn of these herds adjacent to the market center adds to the pressure noted above that is placed on local vegetation resources by local stock. The concentration of people, and of the vehicles that increasingly transport them, along the roads leading to and from the market center, also produces significant impact on the local environment. Where new roads are developed, or old ones upgraded, the increased traffic is certain to promote adverse environmental change. As active market centers such impacts are an invariable, if not inevitable, consequence of their economic role. Because the centers are themselves not large, and the local resources and skills needed to cope with adverse impacts are frequently lacking, such impacts are most often ignored or, if noted, accepted as an inevitable consequence of progress, as is the soil surface disturbance, wind

deflation of exposed surfaces, and general dustiness that characterizes these population concentrations.

4. DESERTIFICATION

4.1 Future Hazards

As a degradational process that flows from the interaction between human systems and the physical environment, desertification is likely to be a major risk affecting development programmes in North Africa. This is not simply due to the region's long history of environmental modification and degradation; it springs from current environmental characteristics and future processes of socio-economic change.

Disaggregation of the components used to produce the FAO/UNESCO map of desertification hazard point to two sets of factors that play an important role in dryland degradation; soil and substrate conditions and population dynamics. The soil factors are summarised in Figure 4.

4.2. Land Vulnerability

The type of degradational results most likely to stem from erosional processes are noted in Figure 15. These fall into 4 characteristic types;

1) AREAS OF SANDY SOIL (either plains or stabilised dunes) where vegetation removal can result in wind erosion, dune formation, and the drift of windborne sand into agricultural areas. The number and extent of agricultural areas affected by this process are relatively few. Many traditional agricultural oases have lived in the presence of this threat for long periods and have developed techniques for coping with and stabilizing mobile dunes.

Vulnerability of Land to Desertification Processes

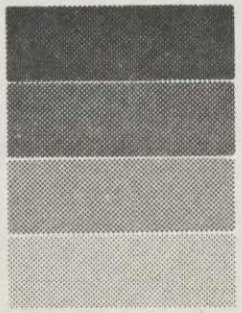
FIGURE 15

sand movement

exposure of pavement and hardpan

sheet and gully erosion

salinization



However, the potential for widespread development of destabilised sand surfaces is considerable and the threat rises in direct proportion to increased grazing and farm utilization of such areas. The interaction of this increased used with the high probability of drought, found in areas with low precipitation totals, combined with the relatively long period of time required by vegetation recovery in moisture-deficient areas, makes such environments high-risk areas that should be approached with caution.

2) AREAS OF SOIL EROSION where rocky bed pavement or hardpan layers are exposed. This exposed impervious substrate is extremely difficult to restore to productivity; once the soil is washed away reconstitution of a suitable medium by natural weathering requires long periods of time because artificial means are costly. Moreover, the development of an impervious surface accelerates run-off and drastically reduces the local soil moisture reserve. The result is to alter adversely the water balance and to reduce the effectiveness of precipitation. Thus increased aridity can be traced to a reduction in effective available moisture constancy in precipitation supplies.

3) SHEET AND GULLY EROSION affect deeper soils. Rather than stripping an area down to near-surface impermeable layers, sheet erosion on disturbed surfaces removes the nutrient-rich upper soil horizons leaving impoverished and more sterile material behind. Gully erosion on steep slopes can create unmanageable fields broken into small parcels with limited communication one to another.

4) SALINIZATION is the final hazard to which cultivated land is

exposed. Unfortunately this problem affects the richest and most productive land and is spread by precisely the irrigation systems designed to overcome the moisture constraints of dry lands. Wherever the water table is close to the surface, the danger of salinization will be present. The widespread tendency to overirrigate in an effort to remove salts from the root zones of crops results in a rise in salt-laden ground water. The institution of drainage is often costly, is hampered by the lack of relief features and is frequently an afterthought in project development. Traditionally, fallowing of irrigated fields has been employed to promote a drop in the water table; this works well if appropriate fallow cycles are maintained. Increased demand means less fallow...a precarious balance is threatened.

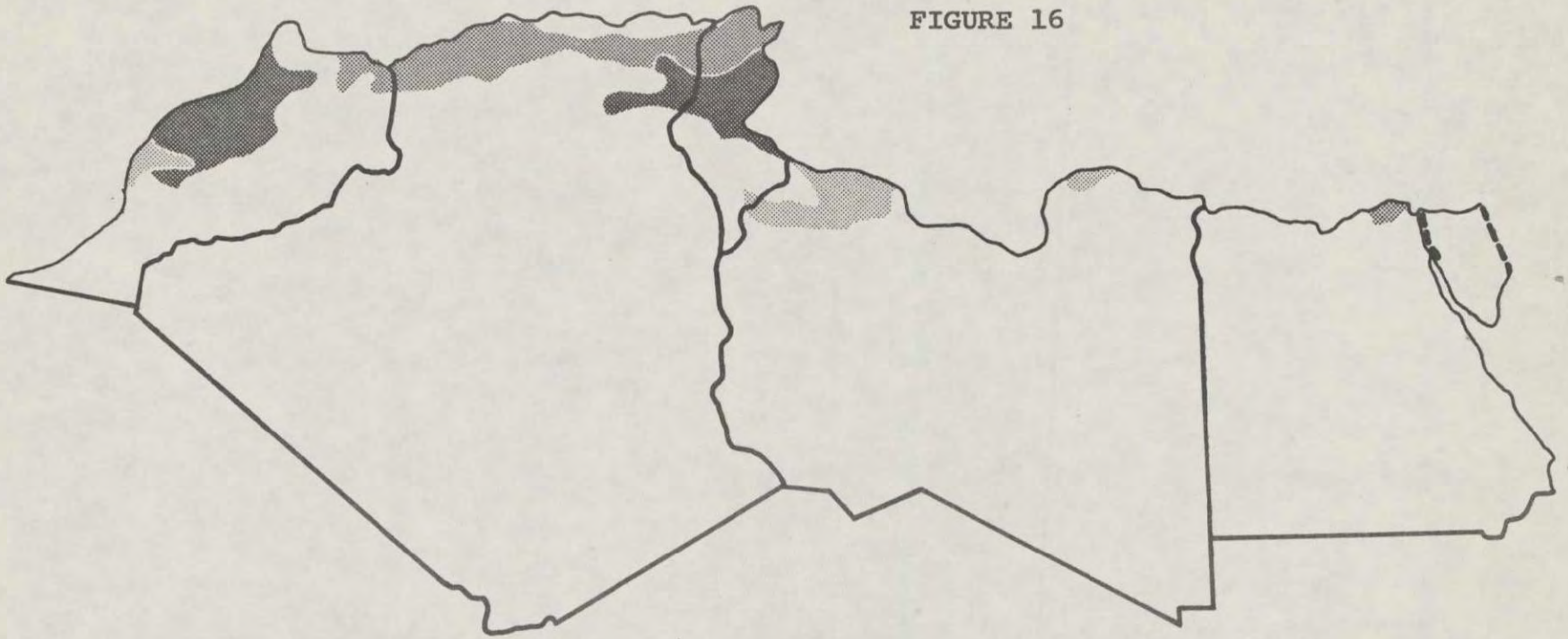
4.3 POPULATION DYNAMICS

Population dynamics also play a major role in promoting environmental disruption. Generally population growth is seen as a major disruptive force. It is probably better to identify zones of population concentration rather than zones of population growth *per se* as potentially hazardous areas. Figure 16 indicates areas with high human and animal populations. Generalization at such a broad scale gives only a first approximation of the problem because local concentrations will occur within these areas, and the zones of decreasing degradation surrounding each major concentration points result in the mosaic, or rash-like, aspect of dryland deterioration.

Moreover, if declining productivity is accepted as one of the indicative signs of adverse environmental effects, then conditions

High Human and Animal Pressure

FIGURE 16



human

animal

human and animal

of population decrease are just as likely to result in disturbance as are conditions of growth. The terrace systems of the Jabal Nafousa of Libya and Tunisia have experienced productivity decreases and maintenance difficulties because the labor required for their success has been attracted to employment in urban and industrial activities. Oasis communities have experienced similar difficulties, compounded by the uneconomic scale of existing operations. The rapid growth of the population concentrations that result from this rural-urban migration flow (Figure 14) constitute additional points of potential deleterious environmental impact.

It is no accident, then, that an assessment of the potential for environmental disruption should indicate that most of the populated portions of North Africa are exposed to high or very high risk levels. While some of these areas coincide with areas of existing severe degradation, other do not. Whether presently degraded or not, all areas exposed to disruption are likely to experience considerable further degradation unless project boundaries are widened (in terms of effects) to include surrounding areas, and the interaction with natural environmental fluctuation (particularly drought) is incorporated into planning. Rigorous rangeland management coupled with destocking in ranching schemes makes little sense if traditional herders are concentrated on unregulated districts and the burden of rangeland deterioration is shifted to these areas as well. Expansion of fodder reserves to carry larger herds through drought periods is counter productive if the result is to increase the stocking ratio during ensuing positive pulse periods and prevent rangeland regeneration thereby. Extension of

dryland farming into marginal districts will not assist long-term development if the result is to bare soil surfaces during an inevitable drought period with resultant (permanent) losses of soil productivity to wind erosion.

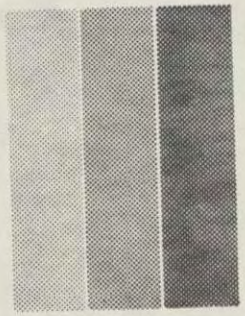
5. CONCLUSION

This short paper has attempted to indicate the possibilities of understanding complex human-environment relationships through elementary correlation mapping. Of necessity, some variables, e.g. economic geology and potential technological hazard, have been omitted. It is, however, useful to review the benefit of such techniques.

SCALE	(1)	Although this is a global overview, such techniques can be usefully employed at smaller scales, e.g. village level, to understand process relationships.
PROCESS	(2)	Process relationships transcent artificially superimposed boundaries be they national or project boundaries.
HISTORY	(3)	Environmental factors, like human factors, have specific histories that are important to understanding current states.
VARIABILITY	(4)	To talk of current states is not to assume a static relationship. It is of paramount importance to understand that variability within a given environment is frequently a key to the threshold levels that indicate the vulnerability of that environment.

Degree of Desertification Hazards

FIGURE 17



PLANNING

(5) Only with an adequate understanding of scale, process, history and variability will integrated planning be possible that will allow increasing production while not envouraging environmental degradation.

PROJECT NUMBER:

PROCESS: ACTION: DATES: INITIALS:

CATALOGUE 1656 NS

ABSTRACT ~~ARDA~~

FICHE RANDD

COMMENTS:

DS/DIU