INVESTIGATIONS NEEDED TO STIMULATE THE DEVELOPMENT OF JORDAN'S MINERAL RESOURCES

By

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The project report series presents information resulting from various kinds of scientific, technical, or administrative studies. Reports may be preliminary in scope, provide interim results in advance of publication, or may be final documents.

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Abstract

The level of living that any society can attain is a direct function of the use it makes of all kinds of raw materials (soil, water, metals, nonmetals, etc.), all kinds of energy (both animate and inanimate), and all kinds of human ingenuity; and is an inverse function of the size of the population that must share the collective product. The relation between raw materials, energy and ingenuity is such that use of a large amount of one may offset the need for large amounts of others. The most vital raw materials are water, soil, and construction materials, for these are needed in large quantities and are hard to import. Metals, chemicals, and inanimate energy are necessary for industrialization. The more of these minerals a nation possesses, the better, but no nation can hope to be self-sufficient in all of them and therefore must trade for some essential materials.

Jordan's natural resources have been little explored. The granitic-metamorphic terrane in the southeastern part of the Kingdom could contain deposits of tungsten, rare earths, feldspar, mica, fluorite etc. and the sedimentary terrane over much of the rest of the country is favorable for the occurrence of oil. Even if none of these minerals are found, however, Jordan's other mineral resources, if fully explored and developed in the light of modern technology, will support a far higher level of living than her people now enjoy. Very likely she can increase her rainfall by about

1/ Report prepared in 1959.

10 percent by cloud seeding, and she has undeveloped supplies of both surface and ground water that are sufficient to nearly double her usable water supply. Even if she does not have oil or have it in large quantities, she can buy it cheaply from neighboring countries, and in addition has undeveloped sources of hydroelectric power, large reserves of bituminous limestone, large reserves of nuclear power as uranium in phosphate rock, and can use solar and wind power for special purposes. Her large supplies of construction, fertilizer, and other chemical raw materials will not only satisfy her own needs, but will yield both raw materials and some manufactured products for export. And she has valuable resources of touristic interest in the form of incomparable scenery, antiquities, and holy places, which, if properly advertised, could well become her largest single source of foreign currency. Revenue obtained from this source and from the export of agricultural products, nonmetallic minerals, and mineral products should support foreign purchase of oil, machinery, and other products not mined or produced internally.

Full development of Jordan's economic potential will take years to achieve and involves many complex activities. One of the most essential is one that can be pressed in the early years, namely the gathering of facts and basic data concerning the character, extent, and distribution of her resources, and the uses that can be made of them. Without such fundamental data or the understanding of their meaning or the ways to use and apply them, costly developmental projects and similar efforts to raise the level of living are likely to have limited success at best.

Basic data on mineral resources are best gathered and published by permanent government agencies, for private organizations and individuals cannot afford to take the risks involved in gathering data that may not have an immediate economic return; and even if private parties do collect such data they are not likely to make them generally available.

Of the activities needed in the field of mineral resources, some are already underway as the established function of government agencies. No bureau however, seems to have responsibility for making geologic maps and for gathering data on such things as stream flow, composition and properties of minerals and rocks, or for investigating the uses to which Jordan's minerals might be put. To satisfy these needs, a Geological Survey and a Bureau of Mineral Industries should be formed and placed in operation as quickly as possible.

The task of collecting and interpreting basic data or mineral resources must be done largely by Jordanians, for only in this way will Jordan acquire the technical competence needed to use the information. Few Jordanians have enough training or experience to work independently in these fields now, however, so help from outside technicians would be necessary over an initial training period of several years. But the number of outside technicians should never exceed the number of Jordanian technicians, and for this reason, neither organization could have a staff of more than a few people during the early years of operation.

Introduction

As a part of the International Cooperation Administration's technical assistance to the Hashemite Kingdom of Jordan (HKJ), the United States Operations Mission in Jordan (USOM/J) proposed in May 1958 to aid the development of Jordan's phosphate industry by exploring and mapping some of the more promising of the known deposits, and searching for additional deposits in the southern part of the Kingdom. Before embarking on this program, the International Cooperation Administration in Washington (ICA/W) asked the U. S. Geological Survey to review data already available on the phosphate deposits of Jordan, to examine the deposits in the field, and to make recommendations as to the work needed to develop the phosphate and other minerals. I was asked to make this examination and did so during the months of October and November 1958.

Although the initial emphasis was on phosphate, it became apparent early in the assignment that attention should be given also to other minerals as well. With the approval and encouragement of Mr. Ralph H. Workinger, Deputy Director, USOM/J, and Mr. Frank S. Wilson, Chief of its Industry and Commerce Division, the study was broadened to an analysis of the work needed to help stimulate development of other minerals as well as phosphate. The time available in the field was not long enough to undertake any original investigations, but it was sufficient to become familiar with each of the major kinds of geologic terranes, and to examine and discuss in the field the problems related to the development of the important mineral resources with those people most acquainted with them. Thus, I travelled by car more than 3,000 miles within the Kingdom; was able to examine all the known phosphate deposits, some of the bituminous limestones, and the Wadi Dana manganese deposit; had opportunity to review the geologic background of groundwater problems at Azraq, Irbid, the Jordan Valley, and many other areas on both the West Bank and the East Bank, including the western part of the eastern desert; and was able to see the important structures and some of the facies relations that bear on the search for petroleum in the northern and western parts of the Kingdom (fig. 1).

A draft of this report, summarizing the main conclusions and recommendations, was prepared and distributed to officials of the government of Jordan and the United States Operations Mission at the close of my stay in Jordan. This is expanded here to include a review of some of the principles of economic development, particularly as applied to Jordan; a description of the minerals that find use in an industrial society; and a fuller review of Jordan's mineral resources and the possibilities they offer for development. The approach taken to these matters perhaps deserves some advance explanation.

The principles of economic development are described in many publications, and no attempt is made to reiterate them in full here[1/]. Most accounts of the subject, however, do not discuss in such detail the part minerals play in an economy, the importance of developing

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1/One of the best analyses of the problem is that of George Hakim and others, 1951.

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mineral resources for domestic use rather than for export, or the work needed to bring this about. These subjects are among the chief ones treated in this report, and some of the principles of economic development are outlined to show how and why it is important for a country to increase its consumption of mineral resources. It would be a mistake, however, to create the impression that resource development is the only measure a nation need take to raise its level of living. The other necessary measures are not discussed much in this report, but some of them are mentioned to place the main subject in proper perspective.

The approach taken to the evaluation of Jordan's potential resources is not the one practiced by most geologists and engineers representing industrial firms, for they are mainly interested, and rightly so, in minerals that can be exported at a profit, and that can be mined and processed by the methods used to treat high-grade ores. Admittedly Jordan's exportable resources are few--in fact, the Mission organized by the International Bank for Reconstruction and Development probably expressed a widely held view when it said (1957, p. 69) that "even with foreign aid, Jordan's resources cannot be developed to the point where they will provide a living even for all the present population and their children, much less for the future population as it will grow over the years." Nevertheless, if Jordan is to achieve her expressed aims of raising her level of living and reducing her financial dependence on external sources (IBRD, 1957, p. 65), she must vastly increase her consumption of raw materials and inanimate energy. This requires, in turn, that she develop her own resources to the maximum degree that modern technology permits; the criterion of interest in the development of many minerals, then, is not whether the substance can be produced for profitable export by old fashioned methods, but whether it can be produced for Jordan's use, by any known method, as cheaply as it can be obtained from foreign sources. Jordan's resource potential, therefore, is viewed here in the light of the maximum development permitted by modern technology.

This supposes, of course, that Jordan will develop advanced technical skills and acquire knowledge that she does not have now, which in turn means that it will be many years before she reaches the goals to which she aspires. Such goals cannot be attained in any other way, however, and these conditions must be accepted as prerequisites. Accepting them as such, however, and viewing Jordan's resource potential in the light of the maximum permitted by modern technology (and, with the currently rising rates of consumption everywhere, it will not be many years before the development of resources in most other areas will have to be approached in this fashion also), I believe Jordan's resources will support a moderately high level of living for a population of the present size. The reasons for this belief are discussed in the section on Jordan's mineral resource potential.

Acknowledgements

Many people gave generously of their time and knowledge in acquainting me with the geology and mineral resources of Jordan and the problems related to their development, and aided in my work in other ways. I am indebted for enlightening discussions and helpful advice to His Excellency, Sam'an Daoud, Minister of National Economy of the Hashemite Kingdom of Jordan, Dr. Hazem Nuseibeh, Under-Secretary of the Ministry of National Economy, Dr. Najm-Eddin Dajani of the HKJ Development Board, and Mr. Farid Azar, Chief, Technical Surveys Section of the Department of Lands and Surveys. Special thanks are due to Mr. Isam Khairy, geologist and Chief of the HKJ Section of Mines; Mr. Maurice Khoury, General Manager, Mr. Djordje Kolcov, mining engineer and Technical Director, and Mr. Ali Rashad Ezzeer, geologist, of the Jordan Phosphate Mines Company; Mr. Ralph Freeman and Mr. Munib Masri, petroleum geologists of the Phillips Petroleum Company; Mr. David Wozab, ground-water geologist of the FAO; Mr. Kamel Kawar, ground-water geologist of the HKJ Development Board; Mr. Leslie Riggins, ground-water geologist of the Baker-Harza Company; and Mr. J. B. Howard, sanitary engineer, and Dr. J. J. F. Rogier, Chief, Health and Sanitation Division of USOM/J, all of whom guided me on visits to one or another part of Jordan to inspect mineral deposits or problems related to them.

This study was undertaken at the instigation and under the general direction of Mr. Ralph H. Workinger, Deputy Director of the United States Operations Mission to Jordan, and Mr. Frank S. Wilson, Chief of its Industry and Commerce Division, both of whom, along with many other members of the staff of USOM/J and the United States Embassy in Amman, facilitated

my efforts by providing working facilities and helpful advice and suggestions. Mr. George Nowak, Financial Advisor of USOM/J working on the Jordan Phosphate Mines Company's application for a loan from the Development Loan Fund, was expecially helpful in supplying much information concerning the costs and problems of mining and marketing phosphate in Jordan.

The final compilation of this report has benefited greatly from the constructive advice of many of my colleagues on the Geological Survey, particularly T. M. Cheney, T. E. Eakin, J. H. Feth, D. M. Lemmon, A. M. Piper, T. W. Robinson, G. L. Schoechle, H. E. Thomas, and M. E. Wing.

The relation of natural resources to level of living

If we think of level of living as the amount of goods and services we consume, this level is plainly low if the average individual has to exert much time and great physical effort to satisfy his minimum needs for food, clothing, warmth, and shelter; and the level is high if he can obtain luxuries as well as necessities at the expenditure of little time and effort. This means that the more raw materials (e.g. food, water, fibres, fuel, and materials for making tools and dwellings) easily available, the higher the level of living. It takes work, however, to gather and use these materials effectively, and over the millenia man has found many ways of getting this work done for him, and thus reducing the effort required to satisfy his needs and wants. Animate energy--slaves and domesticated animals--was captured first for this purpose, but the greatest gains have come from discovery of means to capture inanimate energy--i.e. power from wind, water, and especially fossil fuel. The most efficient way found to use inanimate energy to save labor is to use it to run a machine that will perform a service in a more exact and often faster way than a person can do it.

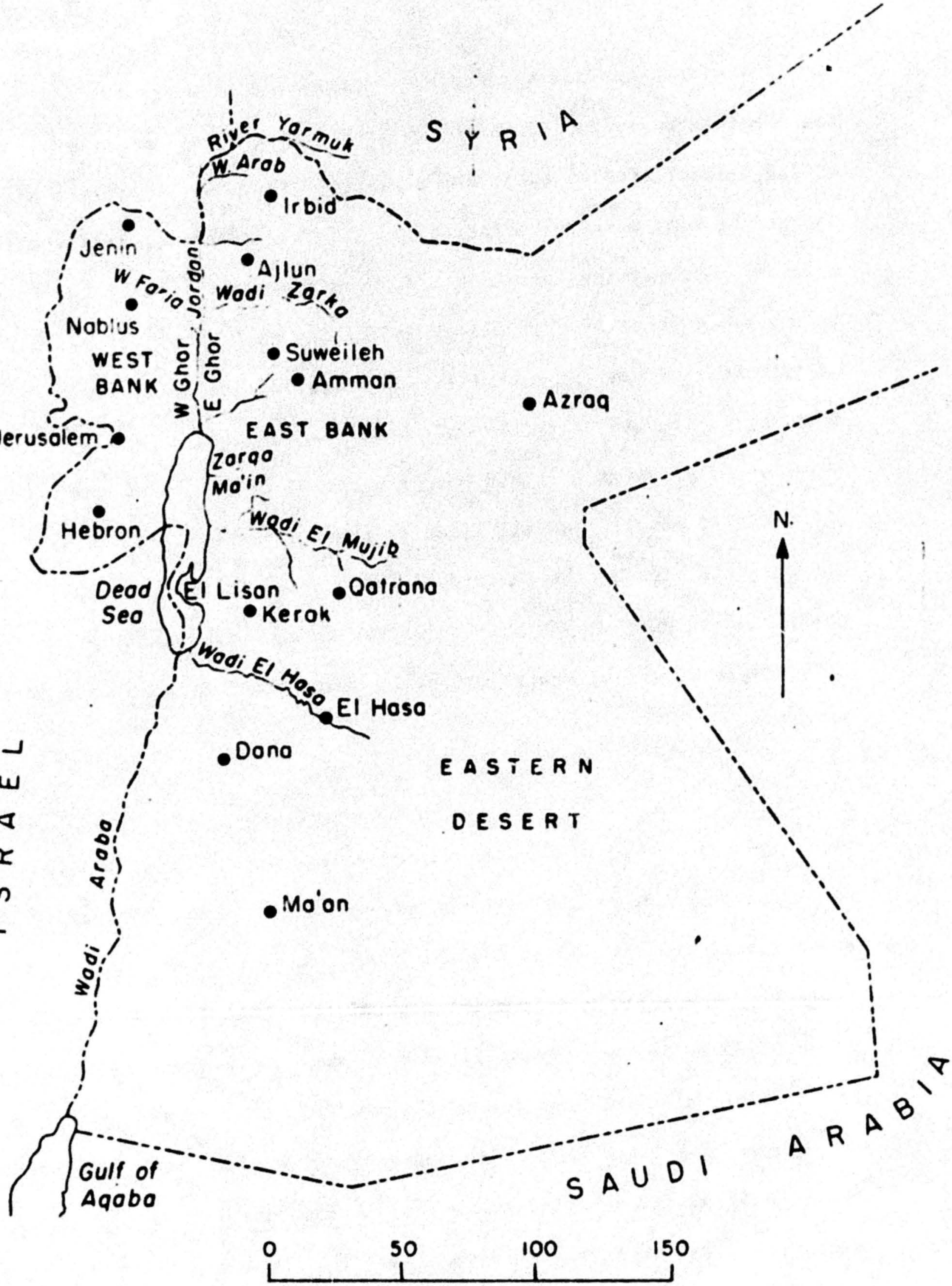

FIGURE I.— Index map of Jordan.

The widespread use of inanimate energy and machines is, of course, the tangible basis for the high level of living--i.e. the consumption of large quantities of goods and services without much physical effort--enjoyed by many western societies today. The essence of this wealth, however, is something less tangible, namely human ingenuity, defined in the broad sense of the collective ability of a group to obtain, distribute, and use raw materials and energy efficiently. Summing all this up, we can say that a group's total consumption of goods and services is a function of the use it makes of all kinds of raw materials, all kinds of energy, and all kinds of ingenuity (McKelvey, 1959). The amount available for the individual, of course, decreases roughly with the number of people that must share the total. Expressed in the form of a simple equation, the relationship among these factors is approximately:

$$L = \frac{R \times E \times I}{P},$$

where L is the level of living of the average person, R is the total useful consumption of all kinds of raw materials by the society, E the total useful consumption of energy, I the total useful consumption of ingenuity, and P the total number of people who must share the society's product. This is an oversimplified statement, but it serves to show the general relation among the most essential factors, and it brings out another important point: the elements of wealth (i.e. R, E, and I) bear a multiplicative relation to one another, for if any of them is zero, the level of living is zero also. This means that the use of a large amount of one of these elements will offset the use or availability or only small quantities of the others. For example, we usually think of a wealthy nation as one that possesses and uses large amounts of metals and energy; Switzerland, however, has scant resources of metals and only moderate resources of energy, yet achieves an extremely high level of living through manufacturing, banking, and trade; and Ireland, which also has scant resources of metals and fuels, achieves a relatively high level of living by making full use of her soil in agriculture, and by keeping her population to a rather low level, mainly through the practice of late marriage.

Although the elements of wealth are those broadly described in the above equation, it is worth examining briefly the most effective ways of bringing them together to produce a high level of living for the average person. To increase its total wealth, a society must find and use more raw materials and energy, as we have said. The average person, however, cannot do the multitude of things necessary to provide a comfortable living for himself, and he has no way of forcing all the people in the society to the effort required to increase greatly the availability of goods and services if the others are satisfied with what they already have. Even an absolute dictator is severely limited in what he can get other people to accomplish. For one thing he cannot force reluctant workers to their maximum effort (particularly in mental endeavors), and, to the extent that he controls their labors and assigns jobs to them, he uses only his own knowledge and ideas and loses the benefit of the knowledge and ideas that might come from others if they had a chance to use their own initiative. For these reasons, maximum benefit to the society as a whole and to its individual members comes from a socioeconomic and political system that not only permits but stimulates personal gain of all kinds--social and intellectual, as well as economic; and that allows and encourages freedom of thought and expression--not merely in the political sense but in all matters, for if people are not free to question (and abandon if necessary) dogma of all types, progress or even change of any kind is impossible. Such a system produces a free society that grows economically and intellectually by reason of its own internal ferment. Even though it is self-stimulating and to a large extent self-regulating, one can single out two extremely important phenomena that serve to keep it growing: one is distribution of the wealth; and the other is creation of wants. The distribution of wealth, whether it is brought about by collecting taxes for public works, raising wages, or any other means that do not severely curtail the individual's desire to accumulate it in the first place, helps raise the level of living of the bulk of the people, and, even more important to the growth of the ecomony, it produces purchasing power. This creates demand, not just for the few expensive items that only the wealthy can afford, but for the myriad of things that the small consumer can buy if he has a little surplus; this in turn stimulates manufacturing, sales, creates new jobs--and so the economy grows. The creation of new wants pries out of the individual some of his economic surplus (or makes him work harder to accumulate a little surplus), creates demand for more goods or service, and hence also stimulates manufacturing, makes more jobs, and so forth. Both these phenomena contribute in a major way to making the society as a whole recover from nature and from its people the raw materials, energy, ideas, and skills that are the elements of wealth and a high level of living.

Another requisite to the growth of an economy is the accumulation of wealth or, better, capital (one might distinguish between these two concepts on the basis that wealth merely implies an accumulation of goods, property, or money, whereas capital implies that this accumulation is available for the constructive purpose of investment). This is partly because the individual must be permitted to accumulate wealth or his incentive to work will be much reduced. More importantly, however, the accumulation of capital is necessary to finance endeavors that will ultimately benefit a large portion of the population, but are too large for small investors to undertake independently, at least without some organizing influence. But, for the reasons already indicated, the accumulation of all wealth in the hands of a few reduces purchasing power, so there must be a fine balance between the accumulation of wealth and its distribution.

In speaking of capital, it may be well to place in perspective another essential element of an economy whose real significance is widely misunderstood--namely money. Money is merely a medium of exchange--a symbol of wealth that can be exchanged for goods and services. In spite of the fact that gold, which is used mainly as money, can be dug up and immediately changed into money, money itself has no inherent value. As already indicated, real wealth consists of property, goods, services, and ideas. Such a medium of exchange is extremely important, of course, for it eliminates the need for a trade based wholly on the cumbersome physical exchange of tangibles. The important thing to recognize, however, is that while at any given time there is some definite amount of money in the world or in a given society and some rather indefinite amount of wealth that it represents, new wealth can be created--not just by discovering more gold or silver[1/], but by recovering from the earth and its people more raw materials, energy, and ideas. When this happens, more money is created to symbolize it.

In summary, wealth consists essentially of natural and human resources, recovered and used to man's advantage. The mere existence of these things is nothing except a potential; to be of benefit to the level of living or to be translated to wealth they must be found and used. This is accomplished best in a free society in which personal effort is stimulated by the hope of personal gain, and in which people are free to question dogma and modify old ways of doing things where such will increase the efficiency of methods of discovering and utilizing raw materials and inanimate energy. The growth of an economy is aided in an important way by the growth of purchasing power resulting from the distribution of wealth, by the creation of new wants, and by the

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1/Silver has important real value because of its properties as a metal, but not many important uses have been found for gold except for ornaments and jewelry. If, therefore, some tremendous bonanza of gold were discovered, or if the alchemists' dream of making gold cheaply were to suddenly come true so that gold could be as abundant as, say, iron or even lead, gold would cease to have any value as money, and the "bonanza" would be of little or no benefit to the discoverer.

accumulation or concentration of sufficient capital to finance large and complex enterprises. New wealth is created not by discovering gold or coining money but by finding and utilizing more raw materials, energy, and ideas.

A self-stimulating, growing society is not only aggressive in finding and utilizing raw materials and energy to satisfy its wants, but it is, through the initiative and imagination of its members, continually finding new uses for raw materials, new ways to recover less accessible ones, and so on. For this reason, resources must not be regarded as fixed or unchanging in total amount. For example, wealth was achieved by the earliest agrarian societies only when they had access to soils that were continually renewed by flooding of large rivers, and to easily manageable sources of water. Except for solar energy, which they took advantage of but could not control, they depended mainly on animate sources for energy; in fact, the wealth of many individuals and groups was achieved mainly through the use of slaves. As metal craft developed, the ancients were restricted to the use of extremely high grade and easily workable deposits of metalliferous minerals. With modern technology, however, we can use poor soils and rehabilitate worn out ones; and we can use sources of water, energy, and other raw materials that were completely unknown or unavailable to the ancients. Modern transportation systems, of course, often make it far cheaper and hence more desirable to import a given raw material than to try to extract it from a very low grade source, even though the latter might be feasible technologically. It is true, nevertheless, that modern technology can create usable resources where none existed before.

Usable natural resources

Common popular concepts of natural resources tend to overemphasize the importance of valuable minerals like gold, gems, and oil, and to overlook the fundamental importance of more prosaic resources such as soil, water, and construction materials. It may be instructive, therefore, to examine briefly the raw materials that are actually utilized by an industrial society and to consider the use and importance of different types. Because of the availability of data, it is convenient to use the United States as an example of such a society; this is a fairly good choice for other reasons also, for the economy of the United States has an extremely broad and diversified base, and thus provides a good cross section of the raw materials used in the modern world. It should be understood, however, that the pattern of use of raw materials in the United States is not the only one, or even the best, that will support a high-level of living.

The relative value of various raw materials consumed by the United States is shown in Table 1. These data show clearly that the value of products derived from the soil--food, fibres, lumber, and other agricultural and forest products--far exceeds that of all other materials, even in an industrial society. Next in value are the mineral fuels. Metals and nonmetals are nearly equal in value.

Table 1.--Per capita consumption of raw materials in the United States in 1900 and 1950[1]

	1900		1950	
	Value[2]	Percent of total	Value[2]	Percent of total
Agricultural materials		70.4		63.0
Foods	$59.3		$68.0	
Non foods	13.0		14.6	
Fishery and wildlife products	1.6	1.6	1.9	1.5
Forest products		15.7		6.2
Saw logs	6.4		3.7	
Pulpwood	0.2		1.6	
Other forest products	9.6		2.8	
(Subtotal)	(90.1)	(87.7)	(92.6)	(70.7)
Minerals		12.3		29.3
Iron and ferro alloys	1.3		2.7	
Other metals except gold	1.2		3.9	
Mineral fuels	8.6		25.8	
Construction materials	1.1		3.7	
Other nonmetallics	0.5		2.2	
Total, except gold	102.8	100.0	130.9	100.0

1/Presidents Materials Policy Commission, 1952, vol. 2, p. 184.

2/In constant 1935-1939 dollars. In this and subsequent tables, raw materials are considered to be essentially untreated products obtained from the earth, and the value stated is generally based on the price at which they were sold by the producer. The actual amount of treatment they have received at this stage varies from product to product. A few are sold as extracted, but most are cleaned, purified, or graded in some way, and some, such as lime and cement, have been altered chemically or physically.

The value of several other natural resources--chiefly solar radiation, certain atmospheric gases, water, and scenery--are not shown in this compilation. The value of most of these is impossible to estimate, but we can gain some idea, at least, of the value of water from the data and assumptions shown in table 2. The annual rainfall of the United States averages nearly 30 inches a year. Not all of this is used, of course, and, on the other hand, some of it is used several times (this is brought out in table 2 by the fact that the amount of water "used" in the manufacture of hydroelectric power exceeds the total runoff). Only a part of what is used, moreover, is sold directly--the value of rainfall used in agriculture is represented in the price and rent of land, cost of food, etc. but is not ordinarily valued separately. The average cost of water used for several purposes has been estimated recently by Gilliland (1955), however, and by applying these costs to the quantities shown in table 2, and making other conservative assumptions we find that the water used for crops, forests, and livestock and withdrawn for personal, industrial, and irrigation purposes has a value of about 6 billion. This neglects the recreational value of water and other uses such as waste disposal, but it is enough to show that the actual monetary value of water consumed is greater than that of any other mineral except petroleum, and is greater than the value of all metallic and nonmetallic minerals produced in the country (compare table 2 with tables 3 and 4).

Table 2.--Approximate volume and value of water used in the United States in 1955[1/]

		Approximate volume (millions of cubic meters[2/] per year)	Approximate value[3/] (billions of dollars)
Total precipitation[4/] (average 30 inches per year)		6,000,000	
Total runoff (av. 8.6 inches per year)	1,700,000		
Total evapo-transpiration (av. 21.4 inches)	4,300,000		
Mined water[5/]		7,500	
Total received and mined		6,000,000	
Evapotranspiration from nonirrigated crops[6/]		1,200,000	1.00
Evapotranspiration from forests[7/]		1,700,000	0.48
Evapotranspiration from grazing land and pasture[8/]		960,000	0.78
Irrigation[9/]		150,000	0.40
Generation of fuel electric power		100,000	0.66
Other self-supplied industrial use		52,000	0.34
Generation of water power		2,100,000	0.42
Public supplies		23,000	1.90
Rural use		3,400	0.22
Total			6.20

1/All estimates, including those from original sources and totals, are rounded to two significant figures.

2/1 million cubic meters (MCM) = 810.7 acre-feet.

3/The costs of waters commonly sold are those reported by Gilliland (1955, p. 2413), as follows: average household, $97.77 per acre-foot; average industrial, $8.13 per acre-foot; average irrigation, $3.25 per acre-foot. Water used for other purposes is ordinarily not sold directly, but its value is taken into account in the price of the land or the value of the product. The costs assumed here are: evapotranspiration from crops and pasture, $1.00 per acre foot; evapotranspiration from forests $0.35 per acre foot; water used for hydroelectric power, $0.25 per acre foot; water for rural use, $8.00 per acre foot. All of these are rough estimates, arrived at in the following ways: the cost of water for rural use is assumed to be the maximum cost of agricultural water reported by Gilliland. The other estimates reflect the value of the product. For example, the value of crops produced on irrigated land in 1954 was about $6.2 billion; at $3.25 per acre foot, the cost of the water used was therefore about 8 percent of the total value of the product. It was assumed that water represented a similar proportionate cost of the value of nonirrigated crops and pasture land products. Water was taken to be 15 percent of the value of forest products, and about 25 percent of the value of hydroelectric power.

4/Langbein and others, 1949, p. 5

5/Ackerman and Löf, 1959, p. 51

6/Crop land assumed to be 450 million acres (Anderson, 1958, p. 58). Evapotranspiration assumed to be 2.2 feet per acre per year, as is reported by the Kansas Water Resources Fact Finding and Research Committee (1955, p. 42) to be the case on the crop land in Kansas; this is taken to be representative of the whole country because the rainfall there (29.26 inches) is nearly the national average.

7/Assumed to be 2.2 feet over 620 million acres (Anderson, 1958, p. 58) per year.

8/Assumed to average 1.2 feet over 640 million acres (Anderson, 1958, p. 58) per year. Evapotranspiration from remaining land (190 million acres, used for urban areas, highways, or composed of wasteland) is assumed to be 420,000 MCM (1.78 feet or 21.4 inches per year) but to have no value.

9/Irrigated land is about 30 million acres. Estimates of volume used for irrigation and other withdrawal uses are from MacKichan (1957).

The water costs on which the estimates in table 2 are based give some indication as to the value water has for different purposes, for these costs reflect the price that the user can afford to pay and still make a "profit" in an economy influenced mainly by supply and demand. For example, most farmers could not pay as much for water as does the householder and still make a profit on their produce; and a lumber company could not afford to irrigate a forest if it had to pay as much for water as the farmer does for irrigation water. Viewed in this way, the "value" of water for different purposes increases in the following order: hydroelectric power[1/], forests, pasture land, rain-fed crops, irrigated crops, industrial uses, and domestic uses. This is merely another way of saying that, as an economy develops, forest land is converted to cultivated land, and cultivated land to industrial and urban use.

1/The value of a unit of water used for this and some other purposes is perhaps misrepresented for the comparison here, for the water is not consumed but can be reused, perhaps several times.

Focusing more closely now in the mineral raw materials consumed in the United States, the data on tables 3 and 4 bring out several important points. Table 3 shows the apparent consumption of the major groups of minerals compared to production, and table 4 lists separately the value of raw materials or groups of raw materials that make up at least 0.01 percent of the total value of the production. The fact that there are about 40 such materials shows the diversity of minerals that find important use in an industrial society. The full list of usable minerals is between 150 and 200 (depending on how they are classified), and it includes a large number of things that have only come into use in recent years. Tables 3 and 4 also show that even a country noted for its diversity of mineral resources does not have within its own confines all the mineral raw materials it needs, but is dependent on trade with other countries for many essential commodities, particularly metals.

Table 3.--Production and apparent consumption of minerals in the United States in 1955 (in millions of dollars)[1/]

	Production	Imports	Exports	Apparent consumption
Fuels	10,744	674	540	10,988
Nonmetallics	2,959	459	178	3,240
Metallics	2,114	1,896	367	3,643
				17,873

1/U. S. Bureau of Mines Minerals Yearbook. Imports and exports include manufactured and semimanufactured products. Data on the value of uranium ore produced in 1955 are not available, but an estimate of $70 million (the value of the 1956 production) is included in the figure for metallic minerals. Imports and exports of uranium have not been estimated.

Table 4.--United States apparent consumption of minerals whose value was 0.1 percent or more of the total in 1955 (millions of dollars)

Mineral fuels	
Coal	1,810
Natural gas and natural gas liquids	1,582
Petroleum (crude)	7,494
Nonmetallic minerals except fuels	
Asbestos	65[1/]
Boron	19
Bromine	38
Cement	892
Clays	132
Diamonds	217[1/]
Fluorspar and cryolite	24[1/]
Gems	24[1/]
Gypsum	40
Lime	126
Magnesium salts	23
Nitrogen compounds	30
Phosphate rock	58
Potassium salts	80
Salt	121
Sand and gravel	527
Stone and slate[2/]	597
Sulfur and pyrite	134
Metallic minerals	
Aluminum	139[1/]
Chromium	49[1/]
Cobalt	40[1/]
Columbium and tantalum	24
Copper	1,118[1/]
Gold	155[1/]
Iron	758
Lead	204[1/]
Manganese	107[1/]
Molybdenum	51
Nickel	167[1/]
Platinum	46[1/]

Table 4.--United States apparent consumption of minerals whose value was 0.1 percent or more of the total in 1955 (millions of dollars)--Continued

Silver	100 1/
Tin	175 1/
Titanium	22 1/
Tungsten	118 1/
Uranium	70
Zinc	202 1/

1/More than 25 percent of the commodity has been imported.

2/The value of stone stated in Table 2 of the Minerals Yearbook for 1955 apparently includes some duplication (see footnote 14, p. 57 of that volume); the difference between the total stated in table 2 of the Yearbook for nonmetallic production, and the total of the values listed for individual commodities therefore has been subtracted from the value reported for stone in the Minerals Yearbook.

It is important to observe in tables 1 and 4 that the value of construction materials--common materials (such as cement, lime, gypsum, stone, sand, and gravel) that many people don't even think of as mineral resources--are more valuable than iron and the ferro-alloy metals, and far more valuable than the precious metals. This brings us to consider the part that minerals play in an industrial society. Soil, water, and construction materials, of course, are the most essential raw materials, for they are the source of the basic necessities of food, clothing, and shelter. Water, construction materials, and other nonmetallics also play essential and increasingly important roles in industrial activities; this is is well shown by the quantity and value of water now used for non-agricultural purposes (table 2), and by the growth in consumption of construction materials and other nonmetallics from 1900 to 1950 (table 1). The increasing use of construction materials has come about as a consequence of the development of the transportation system as well as the construction of more and larger factories and homes. Most of the other nonmetals are used as chemicals and they have multitudinous uses in the processing of ores, food, and fibres; the manufacture of paints, explosives, rubber; and so on through the full range of almost every group of products. One group of chemicals deserves special notice--namely those used as fertilizers, soil amendments, and insecticides. The discovery of the value of animal fertilizers is relatively recent. Their development has made it possible to rehabilitate worn out soils, and their use--together with insecticides, mechanized equipment, and improved strains of plants--has led to attainments in agricultural production that few would have thought possible even a decade or two ago.

Important as these things are even in an industrial society, there is no doubt that the key resources in industrialization are metals and fuels, used for machines powered by inanimate energy. The significance of the use of inanimate energy may be illustrated by comparing the cost of the physical work it will do to that which can be done by human efforts. For example, a gallon of gasoline burned in a conventional gasoline engine produces about 8 horsepower hours, which is as much energy as can be produced by 25 laborers working an eight hour shift on a food intake of 3,500 calories per day. Omitting capital and other costs, the fuel cost alone, at a gasoline price of $0.25 (90 fils) per gallon is equivalent to buying labor at about 1 cent (3.6 fils) per man day (Slichter, 1959, p. 368). Defining a high level of living as the condition in which man's needs and wants for shelter, warmth, food, clothing, transportation and so on are fulfilled with little expenditure of energy on his part, it is easy to see that the high level of living of industrial societies is founded more on the use of large quantities of inanimate energy than anything save technological ingenuity itself[1/].

1/The grand works of architecture of most ancient civilizations were accomplished by the lavish use of slave power, and surely the abundant use of slaves or servants will do wonders to fill the needs and wants of the master. In the industrial society this help is provided by inanimate energy and machines. A touch of the switch in the ordinary home makes available about 2 kw per hour and brings to almost anyone's command about 14,000 kg cal per eight-hour day--the equivalent of the physical energy product of about 70 well-nourished servants--at a cost of 65 cents (234 fils) or less per day, exclusive of capital and related costs.

Although the focus here is on the use of natural resources, it would be misleading to leave the subject of the United States economy without pointing out the essential role that ingenuity and education have played in its development. During the period from 1900 to 1950 the per capita income in the United States increased from 325 to 864 constant dollars--2.68 times. Increase in the consumption of raw materials, especially fuels, contributed to this, as is shown in table 1, but the overall per capita increase in raw materials consumption was only 1.26 times. The difference reflects the contribution of what was broadly referred to in a previous section as ingenuity. This is impossible to quantitize, but the trend can be demonstrated by many statistics. For example, between 1910 and 1950 the proportion of professional persons in the total labor force increased from about 4.4 to 8.8 percent, and the unskilled workers decreased from about 36 to 19 percent of the total labor force.

In summary, a wide variety of resources finds use in an industrial economy. The most essential ones for a nation to have within its own confines are usable soils, water, and construction materials, for not only are their uses fundamental, but, as low cost items used in large volume, they are expensive to import. Metals, fuels, and chemicals are essential to an industrial nation, but no nation is or can hope to be self-sufficient with respect to all of these materials. The fewer a nation has to import, the better, of course, but even if she has to import many of them she can do so with ultimate profit. This is because raw materials are sold at prices that reflect supply, demand,

and the effort and materials required to obtain them, rather than the function they will perform. Viewed in terms of the work produced by a machine powered by inanimate energy, both metals and fuels are now sold at bargain prices, and their intelligent use yields a margin of profit that more than pays for the cost of the raw materials involved.

Jordan's current economic status

With this background of understanding of the factors that influence the growth and development of an economy, it is worth while now to examine Jordan's current economic and technologic status. Shown in table 5 are some statistics on a group of countries selected to cover the range of economic development over the world today. Ideally it would be desirable to list all the things referred to in the level of living equation previously discussed. This is not possible, of course, simply because many of the essential ingredients cannot be measured quantitatively. Instead, several statistics have been selected that are indicative of fundamental relations and trends. The level of living of each country is indicated by the per capita income, a value obtained by dividing the total national income by the size of the population; this is not as reliable a figure as we would like (apart from the difficulty of measuring the national income, we have no way of knowing how fairly the per capita average represents the level of living of the bulk of the population), but it is the best available measure. The degree to which the population is urbanized and engaged in specialized activities, including manufacturing, is suggested by data on the proportion of the labor force engaged in agriculture; this may also be considered a measure of the extent to which the population as a whole is engaged directly in obtaining basic necessities, as opposed to activities that may produce a further economic surplus, and hence is also indicative of the level of living. The population density with respect to agricultural and forest land is a crude means of appraising the availability of soil and the extent to which the country's population is straining its capacity to supply food and other essential agricultural products. Data on the per capita production and consumption of iron, steel, and energy provide clues to the extent to which a country is using the kinds of raw materials and forms of energy that increase the efficiency of human operations and permit the accumulation of an economic surplus. The use of ingenuity is difficult to judge, of course, but the indices shown in table 5 give some indication of the extent to which the population has a chance to acquire new information and is prepared to apply it.

The data in table 5 provide general confirmation of some of the principles already discussed. They emphasize again that the complexion of the economies of all countries, even those with comparable levels of living, is not the same, and show that the same result can be achieved in different ways. They show, however, that in a general way the per capita income tends to increase with decreasing employment in agriculture and decreasing population density; with increasing consumption of metals, energy, and newsprint (which is a crude measure of the extent to which knowledge is distributed); and with increasing literacy, educational advantages, and so forth.

It is important to note that the correlation between per capita income and production of iron and energy is not as good as that between income and consumption of these things. This emphasizes the fact that the fundamental value of raw materials is in their use, not their sale. Countries deficient in essential resources must obtain them through trade with those that have a surplus, of course. But mere export of raw materials does not bring about