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The Economics of Water Supply and Control:

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By ALEKSANDER TUSZKO

Water Economy Committee of the Polish Academy of Sciences, Warsaw, Poland

WATER ECONOMY IN POLAND

THE conception of water economy has recently been acquiring a twofold aspect—first as embracing the economic, administrative, technical and biological considerations involved in the state husbandry of water, secondly as a separate branch of learning lying at the juncture of natural, geophysical, technological and economic sciences and tying them together.

The primary purpose of water economy is deliberately and purposefully to subordinate water circulation in nature to human needs, relating requirements to resources by impounding the greatest possible quantity of precipitation and allowing it to return to the sea in the manner which provides the greatest social benefit. Rational husbandry of water resources to cover present and future needs should be based on a long-range plan for the development of the national economy, for water plays a major role in the maintenance of life and associated production processes.

The complicated modes of co-existence of societies in our day and age confront water economy with tasks which are much harder to accomplish than those of even the recent past. Technological and economic advancement in recent decades has been characterized by the speedy growth of heavy and light industries including those industries that are heavy users of water.

The growth of populations and higher consumption *per caput* have resulted in an increased demand for food. This necessitates intensification of agricultural production and the development of livestock farming. There is also an increase in electricity consumption and this consumption *per caput* is often regarded as an index of the economic development of a country. We have been witness to an intensive search for new sources of power; atomic power is now coming on the scene. Modern means of transport such as railways, road haulage and most recently air transport have been developing.

As a result water is becoming relatively more important as a raw material, as a biological agent, than it is in uses where substitutes can be found. Therefore, in the plan for the utilization of water resources priority is given to satisfying the needs of the centres of habitation,

agriculture and industry in all those spheres where it has no substitute today and where there is unlikely to be a substitute in the future.

Nevertheless, water power gives great benefits in comparison with thermal and even nuclear power by virtue of its constant and indestructible reserves which are regenerated by the cycle of water circulation in nature; and at the same time it saves such valuable raw materials as coal and oil. Water power should therefore be fully utilized in every country where the supply of these resources is smaller than the needs. Also, water-ways should be adapted to the requirements of modern navigation wherever this is economically justified in the complex planning of water routes.

The trends of organizational forms of water economy are beginning to exceed the bounds of individual countries. It is necessary to maintain the principle of complexity in interconnected balances of water needs and resources in vast areas, linking the uses of water for power, navigation and other purposes, and having consideration for the far-reaching influence of the water economy on the natural system of water distribution. As a result of all these factors, rivers which have been eagerly chosen as state frontiers dividing countries and nations are becoming arteries uniting people because of their community of interests.

Poland has an area of 311,730 sq. km. and a population of 28·6 millions (1957 figures). It lies in the Sarmatian lowlands within the great European lowlands where the influences of various climates meet and clash, in the main oceanic from the west and continental from the east. The climate is therefore marked by unstable weather, fluctuations of temperature and variations in atmospheric pressure. Almost the entire country lies within the river basins of the Wisla (Vistula) and Odra rivers. The Vistula river basin covers 174,300 sq. km. (55·9 per cent. of the total area of the country) and the river basin of the Odra 106,200 sq. km. (34·1 per cent.), other Baltic river basins occupying 30,000 sq. km. (9·9 per cent.). The remaining 0·1 per cent. drains into the Black Sea. The water supply comes mainly from rainfall. Only a small proportion of water flows through rivers from the neighbouring countries of Czechoslovakia, the Ukraine and Byelorussia. From this point of view Poland differs from countries such as Hungary, Germany and Rumania in which the rivers bring large quantities of water from areas beyond their frontiers.

The quantity of precipitation in an average year amounts to 186,000 million cu. m. corresponding to an average rainfall of 597 mm. for all

Poland. The distribution of precipitation is uneven so that the mountains have from 800 to 1,500 mm. and the lowlands 450–550 mm.

Only 5,000 million cu. m. flow into Poland from other countries in rivers. The difference between the inflow of 191 cu. km. and the discharge of 58 cu. km. is used up in the main to promote the life of plants, humans and animals. Part of the water evaporates unproductively. Agriculture and forestry use about 155 cu. km. and are therefore the main users of the rainfall.

Water resources vary from one area to another. The average coefficient of flow in the mountain areas, for instance, is as high as 14 litres per sec. per sq. km. In the lowlands this drops to 3–4 litres per sec. per sq. km. The range of flows in the various months is quite large. In the case of mountain streams, for instance, the flows vary by several hundred per cent.

The irregular discharge of water in different years and months and the irregular distribution of water resources in the country make it difficult to utilize the apparently large volumes of water which hitherto have been flowing unused to the seas. Enormous quantities of water are discharged at times of spate and floods, but the average flows, particularly in the lowlands, are in many cases already insufficient to meet the demand. In years of drought the flows in the rivers in critical months amount to 20–30 per cent. of the average flows. Therefore with unregulated water husbandry only part of the resources in the rivers and streams can be used directly.

Calculations show that about 36·6 cu. km. of water sinks into the surface soil, and about 76·5 cu. km. sinks deeper. The one part of this water constitutes an underground reservoir which feeds the rivers and streams during periods of less precipitation and smaller inflows; the other part, which seeps deeper into the soil and cannot flow back into the rivers and streams, constitutes a store from which some of the water can be regained by pumping. Roughly speaking, approximately 25 cu. km. of surface water feeds the rivers and streams and about 33 cu. km. finds its way into the rivers from the underground reservoirs with some time lag. Of the above 25 cu. km. about 20 cu. km. is discharged at time of spate, and it is precisely this water that not only brings no economic benefit, but also causes damage in the river valleys and destroys the beds of rivers and streams.

Present and prospective water needs

A. Settlements and industry. In 1950 Poland's total population was

25 millions and by 1957 it had risen to 28·5 millions. In the post-war period Poland has had one of the highest natural rates of population increase in Europe, averaging 1·75 per cent. per annum in the years 1950–4 and going as high as 1·9 per cent. in 1955. It has been calculated that in 1975 the population will be 38 millions. In 1957 of the total of 28·5 millions, 13 millions lived in the towns and cities and the remaining 15 millions in the countryside. The urban population in 1975 is expected to number 21 millions—i.e. 53 per cent. of the total—and the rural population 17 millions.

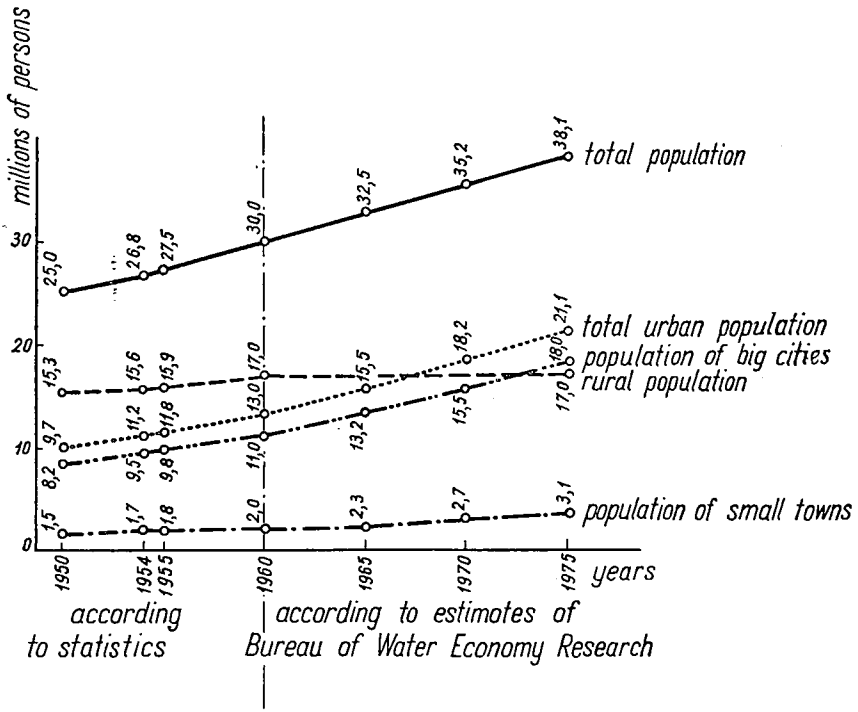


FIG. 1

As these figures show, the necessary development of the towns and cities confronts the national economy with a big and responsible job within the next twenty years in order to maintain rational economic development. In view of the growth of the urban population it is necessary that waterworks should considerably increase the volume of water they provide for the inhabitants, the municipalities and the

light industries which usually consume between 20 per cent. and 35 per cent. of the piped water.

The amount of water used *per caput* per day varies with the sanitation amenities and with the extent to which small industries use piped water. This ranges from 30 litres (in houses without water-mains and sewage systems) to 250 or even 400 litres per day per person where houses have sewage systems and all the amenities for the full use of hot and cold water. According to estimates, waterworks will have to provide about 4·5 million cu. m. of water to towns per day in 1975, compared with 0·53 million in 1950 and 0·88 million in 1954.

The minimum requirements for piped water for the countryside have been put at approximately 0·5 million cu. m. per day. This should be supplied by group water-mains.

In total, therefore, apart from industry, the piped-water requirements in 1975 are estimated at approximately 5 million cu. m. per day, or 1,800 million cu. m. per annum. This means an almost sixfold increase in comparison with 1954, which is not surprising considering that in 1950 about 40 per cent. of all urban residents were without piped water.

Industry needs incomparably greater quantities of water. In the mid-nineteenth century the rapid expansion of industry began in Poland as elsewhere. Huge coal and metallurgical centres came into being in Silesia, a textile industry grew up in Łódź and its environs, various manufacturing industries were established in Warsaw, Radom, Kielce and Czestochowa. After the Second World War, however, industrialization proceeded at a much faster rate and the problems of water supply and sewage disposal have become increasingly difficult.

The long-range plan for the development of the water economy worked out by the Water Economy Committee of the Polish Academy of Sciences estimates that consumption of water for industrial purposes in 1975 will most probably exceed 11 million cu. m. daily—i.e. about 4 cu. km. per annum. This means that the demand for water will be trebled in the period from 1950 to 1975, since the daily industrial water consumption in 1952 amounted to 3·5 million cu. m.

In the final account the demand for water in the towns, countryside and industries in 1975 has been estimated at 7·02 cu. km. per annum, compared with 2·25 in 1950; this gives an increase of 4·77 cu. km., of which 3·82 cu. km. will be discharged into open waters as sewage; the remainder, 0·95 cu. km., will evaporate, reducing the flow in the rivers.

The great consumption of water by industry necessitates the introduction of planned husbandry of water and hence the appropriate siting of industry near abundant sources—for instance, on big rivers. Transfers of large quantities of water over considerable distances obviously involve heavy costs in the construction of canals or aqueducts with pumping stations.

Such siting is not always possible since many other factors must be considered in setting up new industrial centres or expanding existing ones. These include a whole number of economic factors as well as the development dynamics of large centres of habitation. As a result such industrial centres as Upper Silesia, Łódź, &c., are in watershed areas which do not have sufficient supplies of water of their own.

In such cases the problem must be faced of transferring water stored in areas with surpluses to areas with shortages. It appears that at present about 70 per cent. of the towns in the country lie in areas which are entirely without surface streams and rivers or else with small ones with basins not exceeding 1,000 sq. km. in area. In 1975 there will be 158 large towns so placed (65 per cent. of the total) and they will have half the total urban population.

There are difficulties already in providing sufficient water for the population and for industry. Upper Silesia, Łódź, Walbrzych and so on, suffer from shortages. Fig. 2 shows the supplies in the main towns and industrial establishments in 1950, and the difficulties encountered at that time in satisfying the demand. The areas of the arrows indicate according to a chosen scale the water required. Shading and dots down to solid black have been employed to indicate increasing difficulties in providing water; white indicates the possibility of completely satisfying the demand. Fig. 3 illustrates the difficulties expected with water supplies in 1975. There will be new deficit areas and the situation will have become worse in present areas of shortage. Along the Vistula and Odra watersheds there will be a disastrous situation unless there are huge transfers of water.

The increase of demands by industry and settlements in 1975 compared with 1950 amounts approximately to 5,000 million cu. m. per annum, of which about 4,000 millions will be discharged into the rivers as sewage. The remaining 1,000 million cu. m. will evaporate as an irretrievable loss, reducing the flow of water in the streams and rivers.

Supplies of water to towns and countryside bring with them the problem of disposal of municipal and industrial effluent water. Surface

waters—rivers and lakes—have some capacity for self-purification. This capacity is limited, however. If the waters are overloaded with an excessive proportion of effluent in relation to the flow of water or to its surface area then, in extreme cases, biological life in the waters

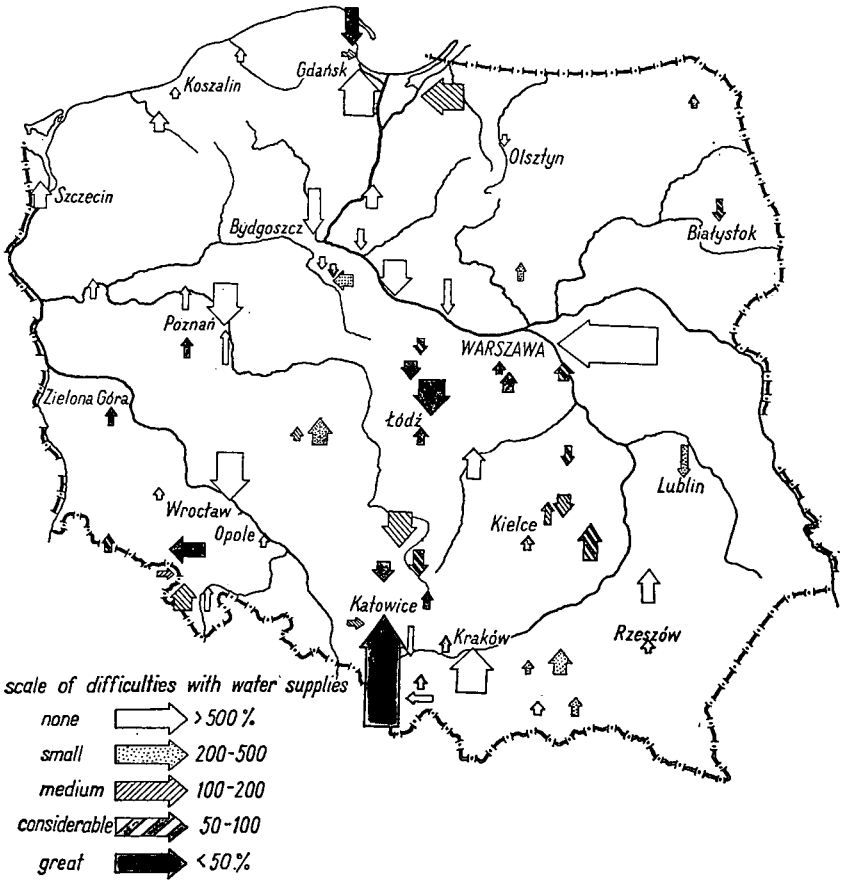


FIG. 2

may disappear and the capacity for self-purification be lost. In such cases the rivers are turned into huge sewers, and lakes into sewage reservoirs. The water in them becomes unfit for use not only for the direct needs of man but often for industry and agriculture as well. In many countries, including Poland, the problem of pollution of surface waters is becoming increasingly urgent.

The Bureau of Water Economy Studies at the Polish Academy of

Sciences has done research on the pollution of Polish rivers during the low-water period in summertime, when the rate of flow is low. The bureau determined the ratio of the flow of water to the quantity of sewage added per 24 hours at various points. From calculations made

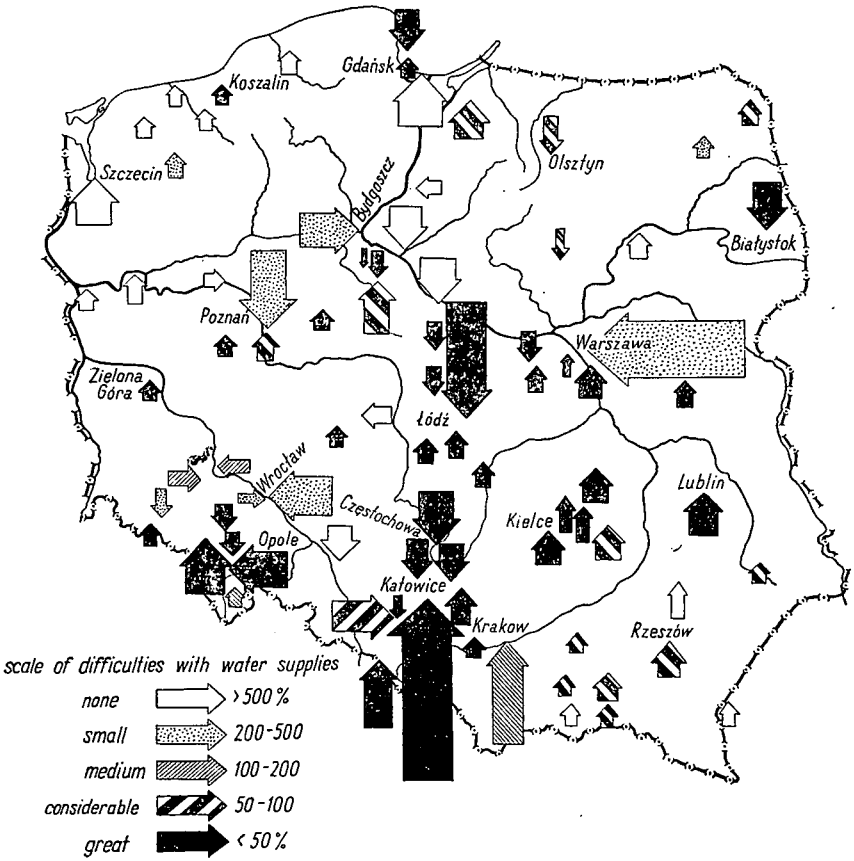


FIG. 3

for 1950 it appears that 64 per cent. of all sewage was directed to the streams and rivers which do not have large flows at low-water time and in most cases the sewage was discharged into the rivers unpurified. Sewage handling is still unorganized and insufficiently controlled. This has led to a disastrous situation today on such rivers as the Przemsza, Kłodnica, Upper Odra and a number of others. Of sixty-six towns in the Vistula River basin which have sewage systems, forty-four have no plant at all for purifying sewage.

In the Odra River basin most of such purification plants as exist are not in operation. The situation in industry is even worse in this respect, as many enterprises discharge highly injurious sewage into the rivers without any purification whatever.

Fig. 4 illustrates pollution of rivers in 1950. The circles in white

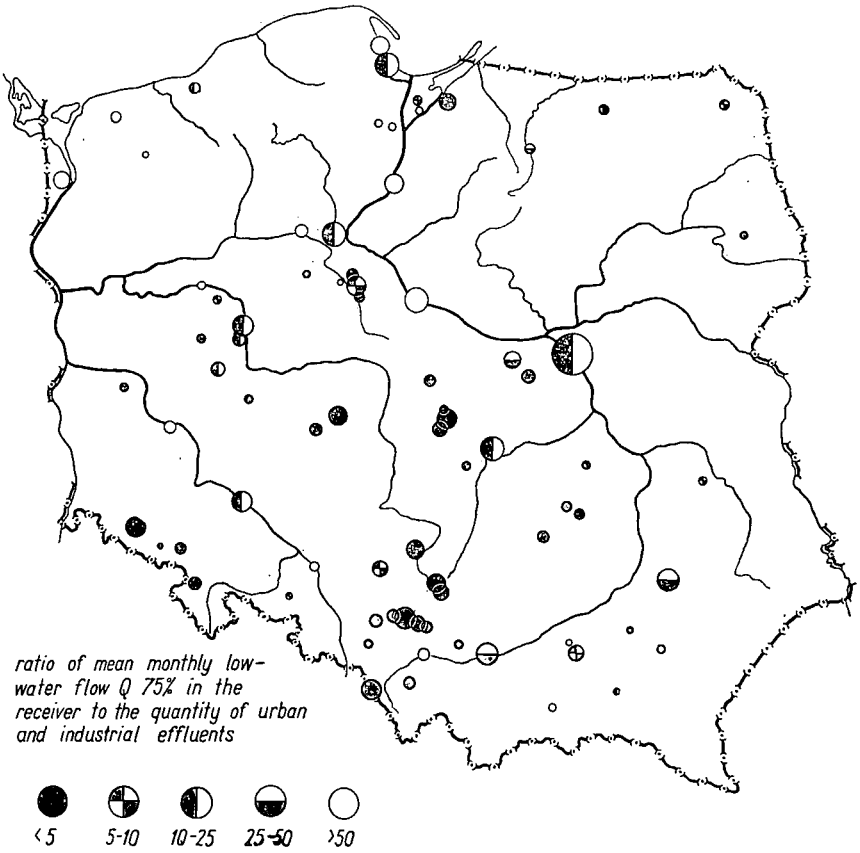


FIG. 4

stand for good rivers, and the darkening of the circles represents progressive worsening of the situation, black standing for a disastrous situation. There are clearly centres of pollution in Silesia, in the Łódź area, &c. If sewage continues to flow unpurified into rivers, then in twenty years' time, in view of the expansion of towns and industries, we shall have a situation as pictured in Fig. 5. There would then be a very dangerous situation since all forms of life would disappear even

in the large rivers. Without exaggeration it can be said that while man once fled from rivers in fear of floods, rivers polluted with sewage would prove to be even more dangerous, as it would be more difficult to purify the rivers than to control the floods. The water economy has the great job of building sewage purification plants which twenty

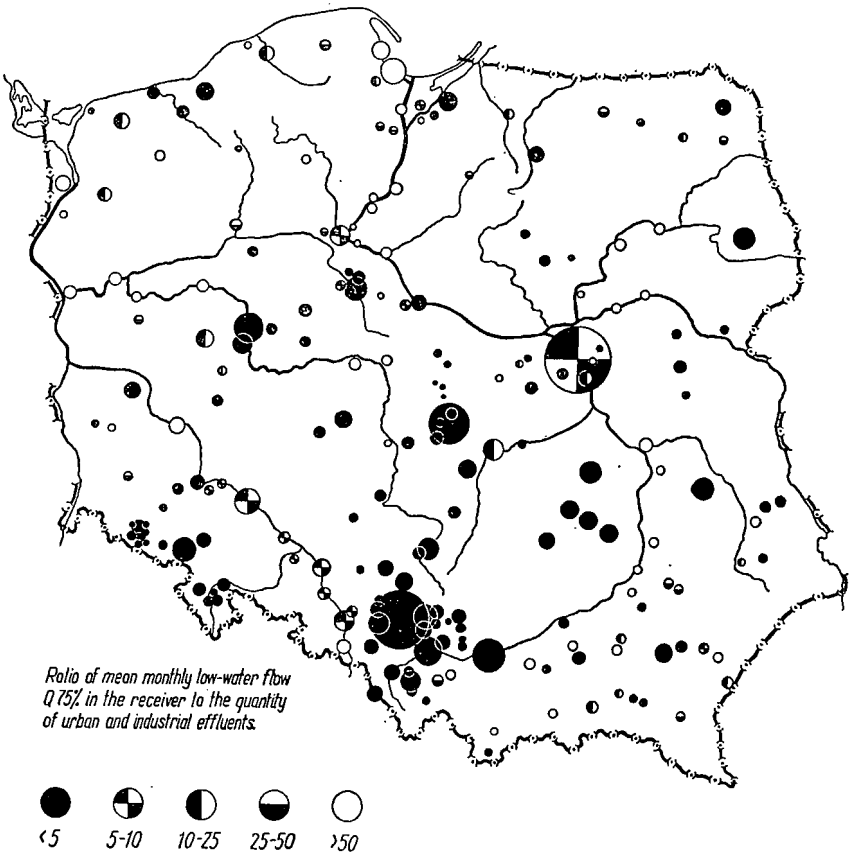


FIG. 5

years from now should have a capacity on a national scale of 100 cu. m. per second, or about 9 million cu. m. of sewage daily.

Agricultural and industrial utilization of sewage should go hand in hand with purification. Agriculture can be benefited by directing part of the sewage, especially town sewage, to the fields and meadows as fertilizer, whilst industry can retrieve valuable materials which are at present lost in effluents.

B. Agriculture and forestry. The population of the world today numbers about two and a half thousand millions and twenty-five years from now it will have grown to three and a half or four thousand millions. In order to ensure better food and clothing for this enormous number of people agricultural output must increase by from 3 to 4 per cent. per annum—faster than the expected rate of growth of population. It is not strange, therefore, that each national state strives for self-sufficiency in satisfying the fundamental needs of its citizens.

Therefore, in accordance with the principle of self-sufficiency in staple food supplies and with a specific diet, the size of the total population is limited by the volume of these commodities required. This in turn determines the necessary dimensions of the agricultural and stockfarming output. The expected growth of agricultural output to provide for the increase in population entails the necessity of intensifying agriculture which in turn results in an increase in the water requirements of plants and animals. Therefore, before expecting the water economy to undertake tasks imposed by the future requirements of agriculture and forestry, the future water needs of these sectors must first be established. On the other hand, the effects of this increased use of water on the flow in the streams and rivers must be determined, for a good part of the water used by plants transpires into the air.

Analysis of the present consumption of food in Poland shows that although it does not differ much from that in neighbouring countries so far as calories are concerned, the diet cannot be regarded as satisfactory, for it contains too many bulky foods such as potatoes and bread and too little meat, fat, sugar, fruit and vegetables.

The prospect is that by 1975, for which the basis of a water economy plan are being worked out, food supplies will have to be increased not only because of the population growth but also because of a highly desirable change in the pattern of nutrition.

Increases in output necessary to satisfy the demand for agricultural produce, according to the estimates of the Bureau of Water Economy Studies at the Polish Academy of Sciences, are presented in Table 1.

The planned expansion of stock-farming and the associated increase in fodder produced from meadows is dependent in the first place on the provision of adequate volumes of water for irrigation. It appears that about 4 million hectares of meadows should be worked more intensively. Calculations of the Bureau of Water Economy Studies show that 8,000 million cu. m. of water will have to be used for

Daily food consumption per person

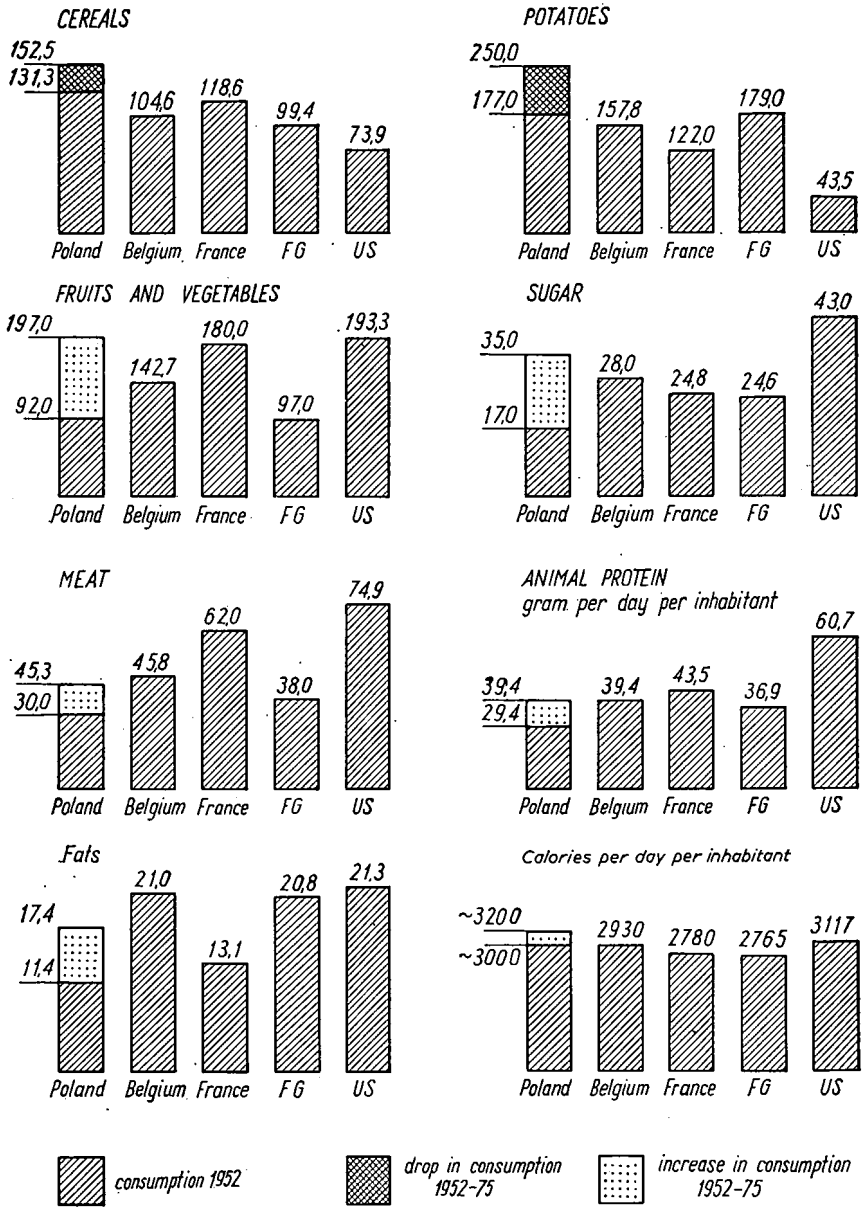


FIG. 6

irrigation in a year of medium dryness and even more in a drought year. A considerable proportion of the water earmarked for irrigation will evaporate and this will reduce the flow in the rivers, mainly in the vegetative period during which the flow of many of the rivers is insufficient even today. Taking into account the increased evaporation due to intensification of agriculture on arable land and the increase of areas under forest, it appears that the total irretrievable losses reach approximately 10,000 million cu. m.

TABLE 1. *Growth of output necessary to satisfy demand (1952–75)*

Produce	*Unit*	*1952*	*1975*	*Increase*	*Increase per cent.*
Wheat	mlns. tons	1·80	4·35	2·55	142
Rye	,, ,,	6·00	8·40	2·40	40
Potatoes	,, ,,	29·40	42·90	13·50	46
Sugar-beet	,, ,,	6·60	12·60	6·00	91
Hay	,, ,,	9·60	23·70	14·10	145
Cattle	mlns. of head	7·20	12·90	5·70	79
Hogs	,, ,,	9·75	14·20	4·45	46
Meat	mlns. tons	0·90	1·95	1·05	117
Lard	,, ,,	0·17	0·32	0·15	88
Milk	,, ,,	8·80	20·30	11·50	132

Calculations show that the smallest proportion of the loss in discharge (17 per cent.) is accounted for by the forests. Tilled fields account for 33 per cent., while the largest loss is from meadows—50 per cent. These figures, of course, relate to the proportions set in the Plan.

In order to determine their influence on the low-water flows during the four summer months, these irretrievable losses have been computed, the result being 5·5 cu. km. for an average year and 7·1 cu. km. for an average dry year.

Water consumers

A. Water-power industry. In the post-war period the development of the power industry the world over has been proceeding at an accelerated pace. The average capacity added each year in the years 1945–55 is given below:

	per cent.		*per cent.*
U.S.S.R.	17	France	13
Italy	15	Belgium	13
Austria	14	Sweden	6
Poland	13·5	Switzerland	4·6

These figures show that countries which have lagged behind such

countries as Switzerland, Sweden or Belgium in the production of electricity are displaying an unmistakable tendency to catch up. Since the last war Poland has made great strides, generating 21,500 million kW-hrs. in 1957 compared with 5,800 million kW-hrs. in 1946. In comparison with the electricity consumption *per caput* in other countries, this is not a large amount. In Sweden, for instance, the figure in 1953 was 3,121 kW-hrs. per inhabitant; in Switzerland, 2,800; in the German Democratic Republic, 1,340; in Belgium, 1,130; in Czechoslovakia, 580; in the U.S.S.R., 660; and in Poland, 546 kW-hrs. per inhabitant (760 kW-hrs. in 1957). Poland, however, is a country with relatively small water-power resources and their utilization is insignificant. Fig. 7 shows the water-power resources of Europe and the extent to which they were exploited in 1953.

It can be seen there that the water-power resources of such a small country as Norway are as great as 104,000 million kW-hrs., 20 per cent. of the resources being used. Poland is a long way down the list, behind Rumania and Germany, with 13,000 million kW-hrs., of which only 4 per cent. is being used at present.

Rivers in Poland do not have large falls like those in the Alps, in Scandinavia and in the Caucasus. Dams have been built such as that at Roźnów on the River Dunajec which impounds water to a depth of 30 m. The power is utilized by a hydro-electric station with an installed capacity of 50 MW (50,000 kW). The hydro-power station at Dychów also uses a head of 30 m. obtained by means of a small rise in head level resulting from a weir across the River Bobra and the exploitation of the drop of a long section of the river (about 30 km.) by cutting a canal across a loop formed by the river. The open canal which brings water to the turbine house has a minimum gradient and a length of 10 kilometres. The water-power resources are distributed as shown in Fig. 8. It is planned to build reservoirs and cascades on Polish rivers in the next twenty years to make it possible to use water power to generate 7,000 million kW-hrs. per annum.

B. Water transport. The state of water-ways in Poland has not been satisfactory to date.

As a result of constant fluctuations in the waters of the uncontrolled rivers there are big changes in the depth of navigable channels. Generally speaking, they do not meet the requirements of rational modern navigation. Man-made water-ways (canals) or canalized sectors of rivers together with the uncontrolled rivers have been neglected for years and do not form a system of water-ways adapted

Electricity production and water-power resources, 1953

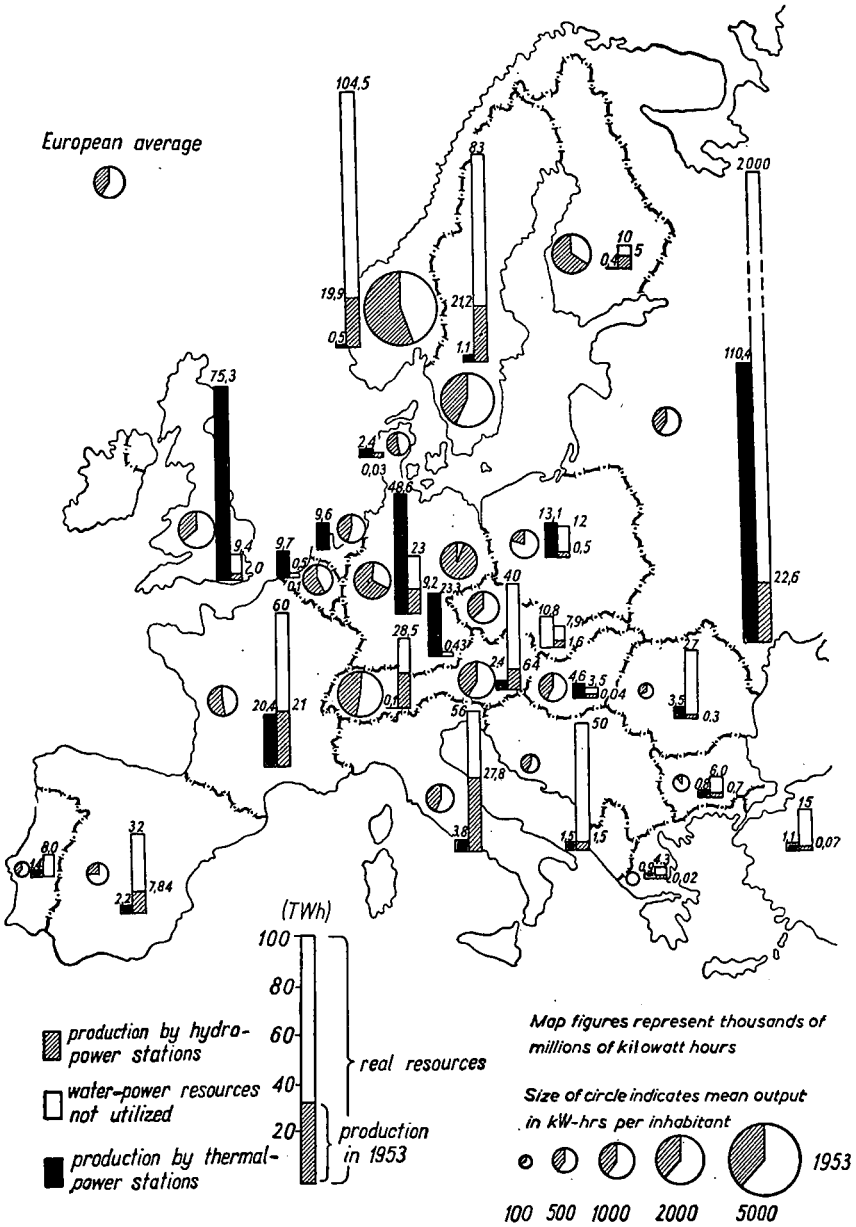
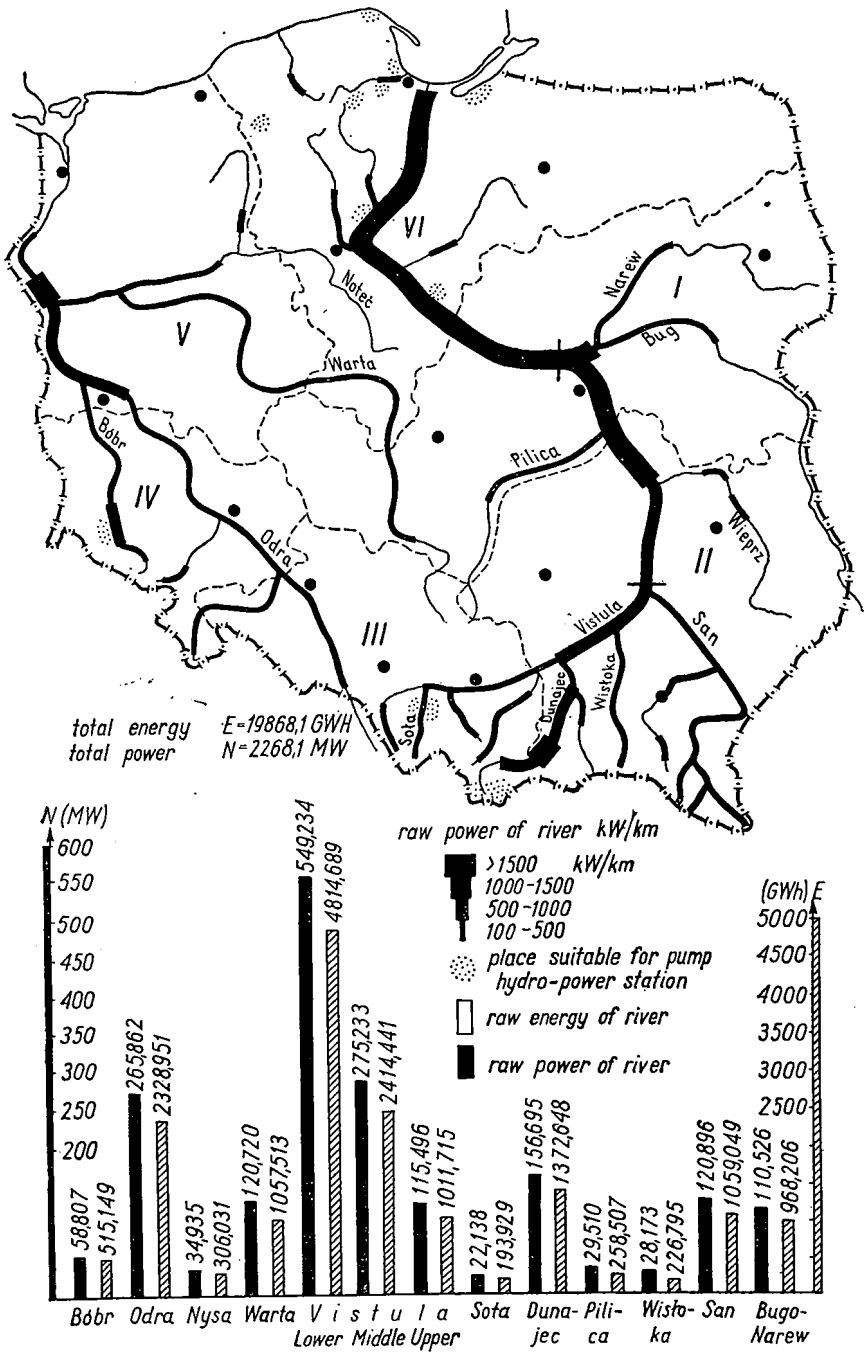


FIG. 7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4814,689
275,233
2414,441
115,496
1011,715
22,138
193,929
156,695
1372,648
29,510
258,507
28,173
226,795
120,896
1059,049
110,526
968,206
Bóbr
Odra
Nysa
Warta
Vistula
Lower
Middle
Upper
Sota
Duna-jec
Pili-ca
Wisło-ka
San
Bugo-Narew

FIG. 8

to the transport needs of the country as do the splendidly developed systems of France and Germany. The volume of goods carried by inland water-ways and the magnitude of the work done by Polish water-ways is insignificant in comparison with railway goods traffic.

Table 2 on p. 498 gives comparative data concerning the ratio of length of water-ways to length of railway lines and the ratio of goods carried in tons and work in ton-kilometres for the water navigation and railways of Poland and several other European countries.

From the table it appears that the distribution of our water-ways and railway lines in relation to the area of the country is similar to that of France. However, the volume of goods carried and work done by the water-ways is altogether different in the two countries. In France goods traffic on the water-ways reaches 52·5 million tons and 8,300 million ton-kilometres, whereas in Poland the comparable figures are barely 4·85 million tons and 570 million ton-kilometres. Water transport in France carries 31 per cent. as much goods as the railways; in Poland, on the other hand, the proportion is a mere 2·2 per cent. The figures speak only too eloquently of the neglect of the rivers which in their present state cannot be considered even in part as water-ways capable of transporting large volumes of goods.

The question arises, however, whether in view of the growth of other large-scale means of transport such as railways and motor haulage, the construction and improvement of the water-ways system in Poland is not out of date. It appears that in many countries which have dense networks of railways and motor roads water transport has been continuing to grow, as pictured in Fig. 9 (France).

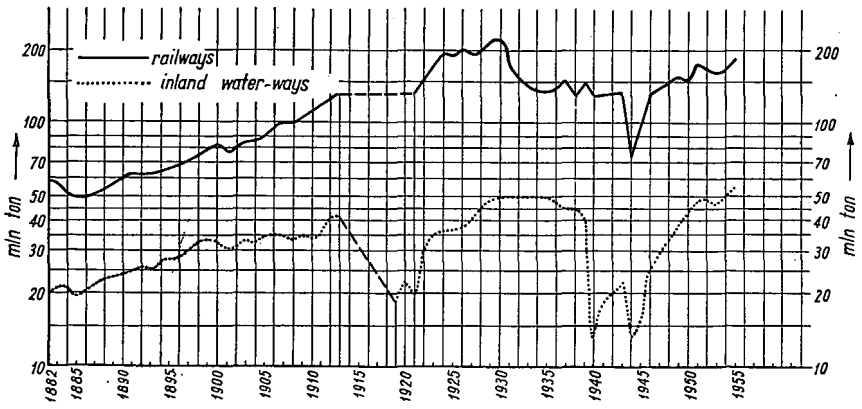

FIG. 9

TABLE 2. *Goods carried by inland water-ways and railways in 1954 and comparison of ratios of length of water-ways and railways and ratio of goods carried by navigation and rail*

Countries	*Area in thousands of sq. km.*	*Length of inland water-ways / Length of railways* — *Total in hundreds of km.*	*Length of inland water-ways / Length of railways* — *in km. per sq. km.*	*Length of water-ways as percentage of length of railways*	*Length of water-ways as percentage of length of railways + water-ways*	*Unit*	*Traffic* — *Navigation*	*Traffic* — *Railways*	*Navigation traffic as percentage of railway traffic*	*Navigation traffic as percentage of railway + navigation traffic*
Belgium . .	31	1,569 / 4,980	5·1 / 16·0	31·9	24	million tons / thousand million ton-km.	51·1 / 4·1	62·5 / 5·6	82 / 73	45 / 42·3
France . .	551	7,807 / 39,800	1·42 / 7·5	19·0	16·4	million tons / thousand million ton-km.	52·5 / 8·3	169·3 / 41·5	31 / 20	23·7 / 15·8
Federal Germany	245	4,900 / 31,500	2 / 12·4	15·4	13·4	million tons / thousand million ton-km.	109·4 / 25	229·0 / 51·6	48 / 48	32·2 / 32·6
Poland . .	312	4,500 / 23,090	1·44 / 7·5	19·2	16·3	million tons / thousand million ton-km.	4·848 / 0·574	221·9 / 48·2	2·2 / 1·2	2·1 / 1·6

It appears from the work of the Polish Bureau of Water Economy Studies that in working out overall integrated solutions for the water economy of the country, it is entirely possible to create a system of water-ways, in particular:

1. a 1,000-ton water-way along the Vistula from the outlet of the Przemsza to the Nowa Huta with canalization of the Przemsza to Mysłowice;
2. a 600-ton water-way along the Vistula from Nowa Huta to Sandomierz;
3. a 1,000-ton water-way along the Vistula from Warsaw to Gdansk, including the Zeran-Zagrze Canal;
4. a 1,000-ton Central Canal linking the Upper Silesian Industrial Basin with the Vistula at localities between Włoclawek and Płock via Czestochowa and Łódź;
5. a 600-ton water-way along the River Odra from Racibórz to Szczecin;
6. a 600-ton water-way from the Vistula to the Odra (via Bydgoszcz);
7. a 600-ton transit water-way (as part of the east–west water-way system) running along the River Bug from Brześć to the outlet of the Vistula;
8. a 600-ton branch from Racibórz along the Odra to Morawska Ostrava, with a prospect of an outlet into the Danube River basin.

The development of Poland's water-ways into a navigable system will make possible convenient transport at low cost in domestic and foreign traffic. Poland will cease to be a bottle-neck between the highly developed system of water-ways of the west and the rapidly growing water-ways of the east.

The connexion of the water-ways provided by the rivers Bug and Vistula, the Central Canal and the River Odra, with an outlet into the Danube River basin, will open up tremendous commercial vistas for the north–south route, giving in Polish territory the equivalent of the western Rhine–Main–Danube Canal. Poland has all the natural prerequisites for becoming a country linking together water-ways of the west, east and south to serve the common interests.

Floods

From 1310 to 1955, a period of almost 650 years, eighty-two serious floods were recorded in the Odra River basin, most of them major disasters. Flooding by the Vistula and its tributaries, especially the

mountain tributaries, has been more common and much more violent, thus causing even more damage than the Odra.

Flood statistics of the Vistula River basin are less detailed than those for the Odra basin, but detailed material can be found concerning the Zulawy district on the Lower Vistula which at one time was the area in greatest danger of flooding. In the past 625 years there have been 132 floods (on the average once every five years) when the swollen waters of the Vistula burst the levees and flooded the areas they protected. Construction of levees along the Lower Vistula to protect the Zulawy area began in the eighteenth century. The areas most exposed to floods today are those in the Małopolska region where the Carpathian tributaries of the Vistula add a great deal of water. The greatest disaster of this kind in Poland during this century was in 1934. The raging waters flooded about 100,000 hectares of land where the Danube joins the Vistula and the levees were washed away in a number of places. The resulting damage was estimated at 75 million zlotys in the currency of that time.

Water economy in Poland has a major task in improving the protection against floods, mainly active protection, that is by the construction of reservoirs with a total impounding capacity of 4,000 million cu. m. and by afforesting the slopes and mountains, as well as by passive protection consisting of river control work, especially on mountain streams, and additions to levees.

Perspective balance and trends of development of the water economy in Poland

In both south and north of Poland are areas where water needs can be satisfied by local resources and where surplus water can be impounded for transfer to areas with short supplies. Particularly favourable hydrological and topographical conditions for storing water are to be found in the southern part of the country in the Carpathian foothills and to some extent in the Sudeten Mountains (Fig. 10).

The distribution of water resources indicates that the Carpathian foothill area should play a special role in improving the water economy in large regions of the country. This area has a large annual rainfall (21 cu. km.) and suitable run-off which amounts to 9 cu. km. Though it accounts for only one-eighth of the area of the Vistula basin it provides almost one-third of the outflow of the entire basin. The rhythm of the annual swelling of the rivers in this area makes possible more rational use of the storage capacity of reservoirs built in the Carpa-

thians than is possible in the case of valley reservoirs, since the waters in this area rise in the summer as well as in the spring.

The mountain areas should become the principal water stores, with huge volumes of pure healthy water.

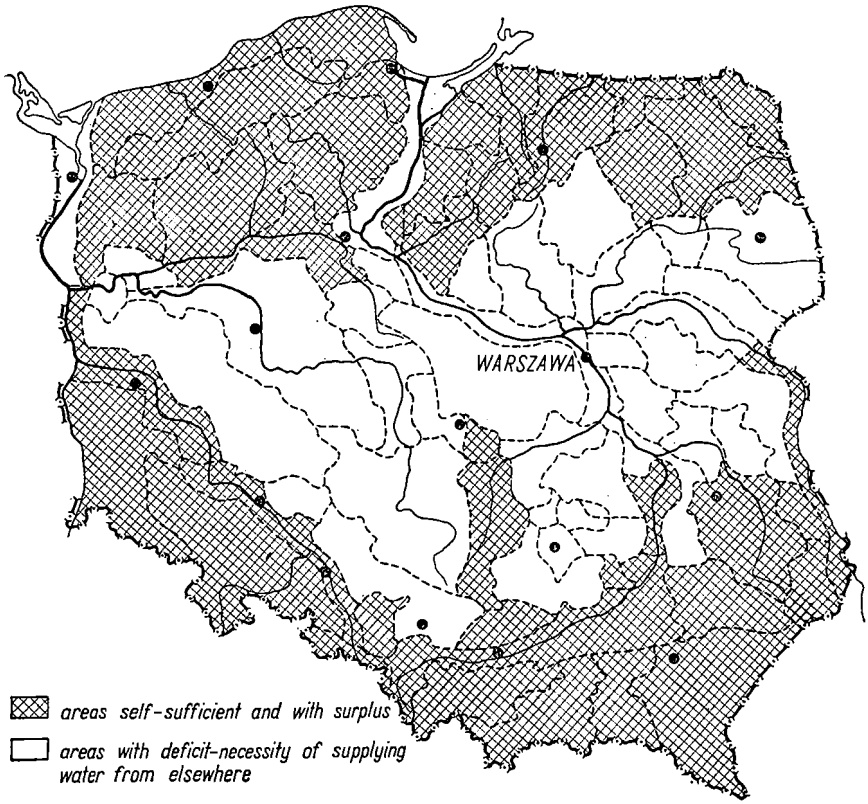

FIG. 10
Distribution of water resources

Water is in short supply in large areas in the Wielkopolska-Kujawy and Mazowsze-Podlesie plains, in the Vistula and Odra watersheds and the Silesian Highlands.

If the water economy is to meet the needs of the various sectors of the national economy it is necessary to make a number of fundamental investments. A picture is taking shape of the Poland of the future: a whole system of reservoirs is being built in the Carpathian foothills; reservoirs are going up on the Rivers Soła, Skawa, Raba, Dunajec, Poprad, Wisłoka, Wisłok and San with a total storage capacity of approximately 3,500 million cu. m. The water from these

reservoirs is intended in the first place for covering the shortage during low-water periods on the Vistula and will ensure a reserve for industry, partly in Silesia and partly in the industrial region which is growing up along the Upper Vistula. The impounding of water during high-water periods will make for better flood protection in the valley of the Vistula and its tributaries. The water will also be harnessed to generate electricity (700 million kW-hrs. per annum). The area of forests will increase and they will help to slow down run-off of surface water and protect the soil against erosion.

In order to accelerate the rate of growth of settlements and industry in the valley of the Upper Vistula from the Przemsza to the San, an Upper Vistula cascade will be built and the Przemsza canalized. This will ensure supplies of water for industry and the transport of coal from Silesia for this area. Hydro-power stations will be built at the falls produced by the cascades to generate electricity. On the middle reaches of the Vistula, which at present is the most untamed stretch of the river, a reservoir will be built. It will work together with the Carpathian reservoirs to even out the flow on the Vistula for the needs of the centres of habitation, industry and agriculture. The canalization of the middle reaches of the Vistula will not take place, however, until a late date.

The cascades of the Lower Vistula will be used for power in the main, but will also be designed to facilitate supplies of water for industry and agriculture. The power stations of these cascades will utilize water power to produce about 4,500 million kW-hrs. of electricity per year. All of the cascades of the Vistula will have locks for letting through vessels of a deadweight of up to 1,000 tons. A modern water-way for the transport of goods will thus come into being (Fig. 11).

The Bug will be canalized from Brześć to its outlet. The resulting water-way will comprise the eastern section of the east–west route. It will make one huge transport system out of European water-ways going from west to east.

The waters of the Bug impounded in reservoirs will serve agriculture and even out the flow of the river. They will also produce electricity. In the north-eastern region in the Mazurian Lakes District the waters impounded by raising the level of the lakes will be transferred for irrigation purposes in the Narew River basin.

A 300-km. long Central Canal will be built running westwards from the Vistula between Płock and Włoclawek, through the Łódź and

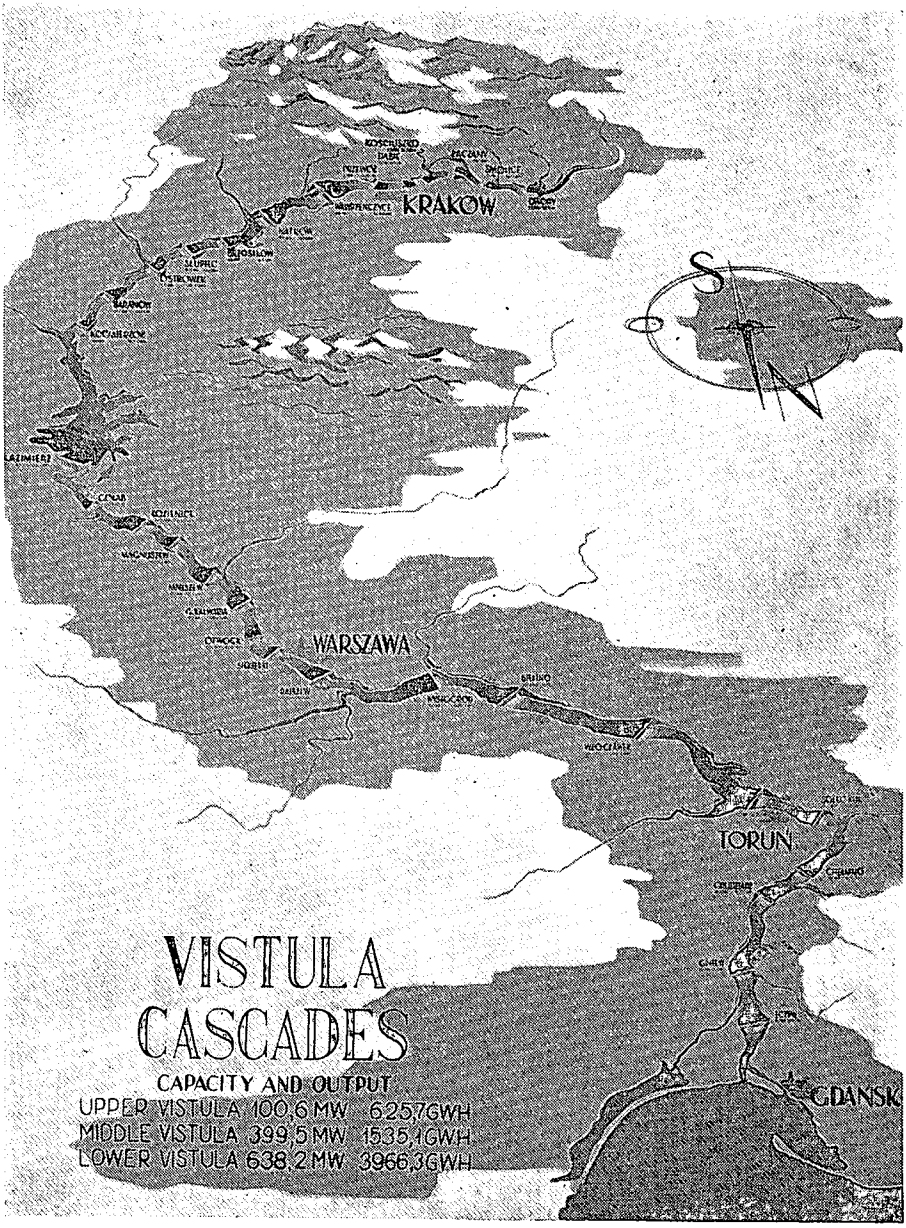
KRAKOW
WARSZAWA
TORUN
GDANSK
VISTULA
CASCADES
CAPACITY AND OUTPUT
UPPER VISTULA 100,6 MW 625,7 GWH
MIDDLE VISTULA 399,5 MW 1535,1 GWH
LOWER VISTULA 638,2 MW 3966,3 GWH

FIG. 11

Czestochowa regions, reaching Silesia to join the canalized Przemsza in the Mysłowice region. The canal will be the backbone of Poland's water economy. The water pumped from the Vistula into this canal at the rate of 100 cu. m. per sec. will make it possible to fill many economic needs; farms will get 800 million cu. m. of water for irrigating crops. This water will be distributed by means of streams in the areas with short supplies.

The canal built to join the lower reaches of the Vistula with the main part of the Upper Silesian Industrial Basin can be easily adapted for navigation without high costs. The Central Canal will then take over transport of coal to many centres of industry and habitation along its banks as well as in the Vistula River Valley from Włocławek to Gdansk, together with coal exported through Gdansk. This canal will connect the east–west and north–south water-ways.

The key role in the Odra River basin will be played by a reservoir to hold about 700 million cu. m. which is to be built in the vicinity of Racibórz. The water from this reservoir will ensure supplies to the River Odra during dry periods, thus enabling modern navigation to continue even below the canalized reaches of the river. There will be guaranteed supplies of water for farmers for irrigating adjoining areas. Reservoirs will also be built on the tributaries of the Odra in the Sudeten Mountains. The utilization of the impounded waters by hydro-power stations will produce 160 million kW-hrs. of electricity per annum (Fig. 12).

Following the realization of the Water Economy Plan the total storage capacity of reservoirs will rise to 9,000 million cu. m. The water from these reservoirs will fully cover the needs of the population, industry and agriculture. The irrigation of meadows will enable an increase in hay crops from 25 to 57 quintals per hectare from an area of approximately 4 million hectares. The irrigation of tilled land coupled with proper farming based on the newest developments of science and agricultural engineering will help to increase crops to a sufficient degree to cover the demand for food.

The water-power resources of the rivers will be utilized to a high degree by hydro-power stations which, with a total peak capacity of approximately 1,900 MW, will produce about 7,000 million kW-hrs. per annum. There will be reserves of water for industry, towns and settlements; the rivers and canals will bring the water to the large industrial centres. The agricultural utilization of sewage and special

FIG. 12

sewage purification plants will protect the rivers and canals from contamination.

New water-ways with a total length of 2,200 km. will come into being to transport about 25 million tons of goods per annum. At the same time, flood protection will be increased.

Contents of Volume I

Volume II

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