Problems of Rational Agricultural Land Use in Ukraine

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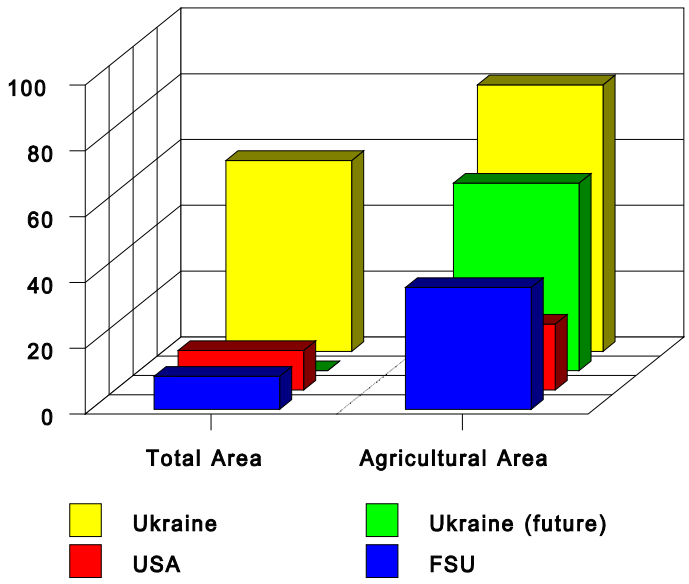
Ukraine has been a center of agricultural production for millennia. Today Ukraine is one of the most extensively farmed areas in the world. Of its total area of 60.4 million ha, 70% is presently devoted to agricultural production, and 81% of that area is arable land. This proportion of land used for cropping substantially exceeds that of other northern countries with major agricultural economies. For instance, 37% of the total agricultural land of the former USSR is arable. Comparable figures for some other countries are 48% for France and Germany, 37% for Hungary, 25% for England, and 20% for the United States (Fig. 1). The abundance of agricultural land and a generally favorable climate contribute to Ukraine's high potential for crop production. Nevertheless, currently there are deficiencies in meeting the country's demand for food and other agricultural raw materials.

This situation is attributable, in part, to agro-political policies under the former command economy. Twentieth century expansion of agricultural land use led to both economically unsustainable production costs and an unprecedented increase in agro-environmental risk. The post–World War II period was especially characterized by rapid escalation of cultivation. In some regions of Ukraine (e.g., Vinnitskaya, Ternopolskaya, Kirovogradskaya, Cherkasskaya) over 90% of the agricultural land is cultivated. Today, 58% of the total area of the country is cultivated. This compares with 10% of the total area of the former USSR and 12% of the total area of the United States (Fig. 1). No other developed country has such a high proportion of land under cultivation.



The intensification of cultivation, the doubling of row-crop area in post-wartime, and the practice of amalgamating crop fields into larger units has contributed to increasingly severe environmental and natural resources problems, especially soil erosion. Annual soil loss in Ukraine amounts to approximately 600 million metric tons, including more than 20 million metric tons of humus. Almost 7 metric tons of soil were lost for each metric ton of actual grain produced during the eleventh five-year-plan period (1980–1985). The total annual economic damage attributable to erosion is 3.45 billion rubles, and the loss of agricultural net profit is 2 billion rubles (1986 exchange rate).

Moreover, biological activity of the soil has decreased, and freshwater resources have declined in supply and quality. According to World Health Organization data, one-fourth of the Ukrainian population contends with water supply contamination. Moreover, freshwater resources per capita in Ukraine are only one-fourth that in the United States. Clearly, the intensity of crop production in Ukraine has increased ecological risk and social concern in the republic.

The history of Ukraine during the period of domination by tzarist Russia includes similar patterns of events. The expansion of cultivated areas, for example, is believed to have contributed to droughts and subsequent crop failures in some regions and, in turn, to declines in cattle production. Steppe conditions rapidly spread northward into the Forest-Steppe Zone of Ukraine. Droughts, which were previously known in the Kiev region only once a century, now occur approximately every 10 years.

Perspectives for Agricultural Land Use

Rational agricultural land use is imperative in Ukraine. Existing agricultural systems are not appropriate to changing production, technological, economic, ecological, and energetic realities. With the additional pressure of transition to a market economy, a new agricultural paradigm is required. In the extreme, it may require the removal of 10 million ha (nearly one-third of the existing cultivated land) from cultivation. This land would be converted primarily into permanent vegetation, including 6 to 7 million ha of grassland and about 2 million ha of reforested area (Table 1). Even if this happened, the remaining proportion of cultivated land (56.8% of the total agricultural land area) would still be the highest in Europe, and three times greater than that in the United States (Fig. 1). Nevertheless, it is believed that a return to more natural landscape and vegetative patterns will contribute substantially to restoration of ecological equilibrium and stability.

In the view of Ukrainian scientists, a key element of this plan is the need to increase permanent pasture and forest area by 2.7 and 1.8 times, respectively. It is important to acknowledge that reforestation is necessary for environmental improvement and also critical to meet national economic demands. Two hundred years ago, one-half of Ukraine's territory was covered by forest. Today, only 14% of the area is forested and mature timber is nearly depleted. It is estimated that only 6% of the original natural stands remains and, if the Carpathian forests

are excluded from that total, only 4% remains. Even during the period of economic stability (1960s–1980s), Ukraine was not able to improve the age structures of its forests. With today's continued harvest of lumber to meet national demands, the problem of age structure is exacerbated by inadequate forest management policies that still permit unsustainable harvests. Moreover, experience has shown that some cultivated lands on previously forested areas are poor choices for crop production. On 800,000 ha of pine forest sands, for example, only 50 to 60 metric tons of rye may be expected to be produced within a period of 50 to 60 years, while over the same time period, 300 m^3 of valuable timber can be produced at less cost. Additionally, reforestation may be expected to promote optimization of the oxygen-carbon ratio in nature.

Table 1. Agricultural Land Use in Ukraine; Area in Millions of Hectares.

	Present, 1986-1990 average	Future, after reallocation
Total land area	60.40	60.4
Agricultural land[1]	39.40	37.9
Arable land	32.30	22.3
Planted with crops	30.90	21.5
Grains, total	15.90	15.0
Wheat	6.30	6.0
Barley	3.50	3.5
Oats	0.60	0.8
Corn	2.10	1.1
Peas	1.40	1.6
Other[2]	2.00	2.00
Industrial crops, total	3.70	2.60
Sugar beet	1.60	1.00
Sunflower	1.60	1.40
Other[3]	0.50	0.20
Vegetables, potatoes, etc.	0.50	0.50
Fodder crops, total:	10.20	3.40
Corn for silage	4.00	2.00
Permanent pasture	7.30	15.80

[1]Excluding personal plots.
[2]Rye, triticale, groats, rice, grain sorghum.
[3]Rapeseed, soybean.

Future grazing lands expansion would greatly increase the contribution of pasture forages to livestock production. At present, pasture forage amounts to only 5% of the total fodder nationally; in the Kiev region there is even less pasture (2.7%). Grazing lands that can provide more than one-half of the protein required for cattle will substantially decrease the need for feed grain. After the adjustments of the land use plan, the feed grain demand is expected to decline by 5 to 6 million metric tons annually. An example of this projection is as follows. One ha of

alfalfa-grass eaten by grazing cattle would yield 8,176 kg of milk (3.4% fat content) and 900 to 1,100 kg of beef during the 5- or 6- month pasture period. Annually, Ukraine requires about 28 million metric tons of milk and 4.5 million metric tons of meat. Thus, 6 million ha of alfalfa-based pasture would provide the Ukrainian population with all the required milk and one-half of the required meat.

The need to transform crop lands into grazing lands is further emphasized by consideration of the energy required for production. In the case of corn silage, 73% of the energy expended in production is for harvesting and transportation. In contrast, energy utilization for pasture management is six times more efficient than for corn grain production. From the standpoint of ecological energetics, soil erosion on pasture lands averages one-sixth that of croplands. Therefore, energy conservation of the land is correspondingly more efficient; energy is stored in the organic matter and nutrients of the soil, not lost through erosion.

The mind-set of Ukrainian agronomic specialists toward rotations that include meadow crops must be overcome in order to convert crop lands to grazing lands. Moreover, it is imperative that long-term pastures and meadows be established close to livestock facilities and that areas of steep slopes, water-protection zones, and lands contaminated by radionuclides be placed under permanent grass cover. In fact, it is difficult to imagine that so much steep land is in cultivation in many regions of Ukraine, e.g.:

Vinnitskaya	513,000 ha
Odesskaya	504,000 ha
Khmelnitskaya	487,000 ha
Kharkovskaya	329,000 ha
Lvovskaya	276,000 ha

It is projected that the conversion of these highly erodible lands into pasture lands would reduce soil conservation expenditures involved in contour cropping by two-thirds to four-fifths.

Finally, the expansion of grazing lands would satisfy the government's social policy requirements by promoting milk and meat production on permanent pastures without additional material and technological expenses and investments by the state. This transformation of land use should be carried out simultaneously with the land reform process (the transfer of land to private ownership and the development of a legal system for land sale) in order to ensure appropriate intensive agricultural uses of the agrolandscape. Intensive cropping must be localized on the 22.3 million ha of flat, fertile land designated for such activity in recent legislation.

Solution of the Grain Shortage Problem

For many years, the economic well-being of Ukraine was determined by grain production. Grain was the only source of agricultural profit. Ukrainian grain occupied a prominent place in

the world market and supported the competitiveness of the remainder of Ukrainian agriculture. In 1913, the Ukrainian grain yield was 25 million metric tons, a quantity greater than that produced by the German Federal Republic in the 1980s. Immediately before World War II, total Ukrainian grain production reached that of the United States (Table 2). The highest average annual yield (47.4 million metric tons or almost 1,000 kg/capita) was achieved during the twelfth five-year-plan period (1986–1990). However, when total grain reached more than 51 million metric tons in 1989, only 62% of the national livestock need for feed grains could be provided internally. Given the current state purchase and storage systems, the grain needs for the livestock industry cannot be met only by increasing production.

Grain production will still constitute the core of Ukrainian agriculture in the future. However, the critical factor in providing sufficient grain for human and livestock consumption will be the geographical focusing of grain production and the efficient use of production, rather than an increase in production. Under a rational land use plan, about 70% of Ukraine's arable area should be planted with grain crops, resulting in a slight reduction in total land use for grains (Tables 1 and 3). A comprehensive analysis shows that a stable annual average bulk yield of dry, cleaned grain could achieve 45 to 47 million metric tons.

Winter wheat is the predominant Ukrainian staple grain crop. The area devoted to this crop should continue at 6 million ha and could be reduced only if replaced by an expanded area in spring wheat. The continuing importance of winter wheat relates to needs for providing stable grain production, ensuring ecological equilibrium in agrolandscapes, and reducing peak work loads during the spring field-work period. Moreover, climatic conditions of Ukraine maximize winter wheat production efficiency (Table 4). Annual bulk yields of this crop are expected to be 20 to 24 million metric tons. Of this amount, Ukraine will be able to sell about 5 million metric tons to foreign markets or exchange it for feed grains.

There is great potential for corn as a crop in Ukraine. At present, Ukraine devotes more area to corn production than any other country in Europe. An analysis suggests that in the future the area planted in corn would be 1.0 to 1.1 million ha for grain and 2 million ha for silage production, and gross yield is expected to be 5 million metric tons (Tables 1 and 3). Future increases in corn production levels may be achieved by applying grain production technology for growing silage corn and harvesting it for grain.

More people now advocate the American model for corn production. However, the direct transfer of such successful models as the corn-soybean system practiced in Iowa (USA) is not feasible because of differences in bioclimatic potential. Iowa straddles the 42nd parallel while Ukraine lies primarily between 45^{o} and 52^{o} North latitude. Annual precipitation in Iowa is approximately 840 mm, and the daily July temperature is nearly 24^{o}C. In contrast, at Cherkassy in central Ukraine, these important climatic indices are 549 mm and 18^{o}C. Thus, much of the arable land in Ukraine is in a drier, cooler climate than the land in the North American Corn Belt. Consider also that 60% of the arable area of the United States has a total annual moisture potential of 700 mm while in Ukraine only 1.7% of the cultivated area has a similar water-supply capacity.

Among the remaining grains, barley is the second largest crop in Ukraine (Table 3) but it is first in importance as forage. At present and in the future, the area devoted to barley (winter and spring) should be 3.5 million ha, which will produce 10.5 million metric tons annually.

Peas need to be grown on 1.6 million ha and yield about 4 to 5 million metric tons annually. No other leguminous food grain crop can surpass the yield of peas in Ukraine.

Oats is a superior grain insofar as its protein quality is concerned, and it is undervalued in this regard. Oats will be planted on an area of 0.8 million ha and yield 2.4 million metric tons annually.

Winter rye and triticale should be grown on 0.6 million ha, resulting in 1.7 million tons of grain annually. Increases in yield capacity of groats are expected to provide future bulk yield increases while the planted area would remain unchanged at 0.6 million ha. The remaining grain crops, rice and grain sorghum, will require 0.8 million ha and would supply 2.2 million metric tons of grain annually.

In some parts of southern Ukraine, without irrigation, it is more appropriate to grow grain sorghum because of increasing fuel costs. This will lead first to the replacement of corn. Overall, the total area under grains and grain-legumes would constitute 15.0 million ha, and the total annual yield will reach 48.8 million metric tons (Table 3).

The industrial crops of Ukraine are sugar beet and sunflower (Table 1). Anticipated future yield improvements will permit the volume of sugar production to remain constant while allowing substantial reduction in the amount of land devoted to sugar beet, from 1.6 million ha to 1.0 million ha. Edible rapeseed and soybeans will become the principal oil crops although sunflower is a traditional Ukrainian crop with a trend toward reduced production area. World experience indicates that sunflower is a good precursor crop for rapeseed, which will become a more important oilseed in the northern and western Forest-Steppe Zone and the Forest Zone. Soybean plantings have been increasing, and by the year 2000, 0.5 million ha are expected to be planted in soybeans. The area devoted to industrial crops would be 2.6 million ha, due to the reduction in cultivated land.

Potatoes and vegetables will continue to be grown on 0.5 million ha, while the area used for production of corn for silage and green fodder should be halved to 2.0 million ha. Pure fallow in rotation prior to winter crops will involve 0.8 million ha.

Table 2. Grain Yield in Ukraine and the United States and Relative Areas Planted in 1990 Compared to 1940.

	Yields (100 kg/ha)				Area planted 1990 as percent of 19	
	1		1			
Cr	Ukraine	USA	Ukraine	USA	Ukraine	USA
Whe	12.1	10.2	40.1	22.8	104.7	115.6
R	11.1	8.1	24.3	17.7[1]	14.0	15.0
Cc	16.3	17.9	38.3	73.6	79.0	75.0
O	12.1	12.9	26.5	19.5[1]	21.5	20.0
Barle	14.2	12.5	32.8	26.2[1]	69.0	63.0

[1]1989 data.

Table 3. Projected Future Grain Production in Ukraine.

Crop	Area cropped, million ha	Average yield, 100 kg/ha	Total production, mil. metric tons
All grains	15.0	32.5	48.8
Winter wheat	6.0	35.0	21.0
Rye and triticale	0.6	28.0	1.7
Barley[1]	3.5	30.0	10.5
Corn	1.1	45.0	5.0
Oats	0.8	30.0	2.4
Groats[2]	0.6	20.0	1.2
Peas	1.6	30.0	4.8
Other	0.8	28.0	2.2
Food grain	7.6	32.9	25.0
Feed grain	7.4	32.2	23.8

[1]Winter and spring barley.
[2]Assorted grains for human consumption.

Table 4. Power Efficiency of Grain Production in the United States and Ukraine.

	Tonnes of grain production per tonne of petroleum used		Coefficient of energy efficiency	
Crop	USA	Ukraine	USA	Ukraine
Wheat	8.7	13.0	2.38	3.5
Corn	15.8	8.3	4.59	2.4
Barley	9.6	11.6	2.60	3.2
Oats	16.0	15.0	4.00	3.7

Re-establishment of Soil Fertility

One result of decreasing the area under cultivation is reduction of soil energy losses. Better focusing of crop land use will permit concentration of the application of organic and inorganic fertilizers into about 22.3 million ha, 30% less area than at present and will involve 10 to 15 metric tons per ha depending on soil and climatic conditions. This will allow greater emphasis on utilizing agricultural by-products as fertilizers and growing a variety of crops as green manure. To increase fertility on areas converted to grazing land, legume and grass-and-legume combinations will be enhanced with inorganic fertilizers. Increased production and use of agricultural lime is also crucial to the process.

Additionally, integrated pest management approaches should be utilized. It is not, however, regarded as expedient to intensify agricultural drainage and irrigation activity. It would be better to use existing irrigation and drainage systems to grow more productive crops than to expand such operations.

Application of Technology

The reduction of arable land will make technology the key in maintaining agricultural production. Although yields of major Ukrainian crops continue to lag behind those of western countries, experimental studies indicate that technology is now available in Ukraine to close the gap (Table 5). Applications of Ukrainian-developed technologies are growing yearly. The theoretical goal of intensive use of agricultural technology is to narrow the difference between potential and actual crop yields, especially to produce products most useful to society.

The practical basis of such technology is increasing plant growth processes based on morphophysiological knowledge and manipulation. Acceptance of biological limits of potential and actual crop production capacity is the basis for the dynamics of intensive technologies, for timely and correct agronomic decision making, and for efficient utilization of soil fertility and

related resources. In developing crop improvement technologies, therefore, priority will be given to development of high-yielding cultivars that are resistant to disease and insects and that respond positively to efficient use of equipment and fertilizer.

Climate and weather cannot be controlledConly predicted. Thus, the adoption of farming practices suitable to local climates combined with technological adjustments to local agro-ecological factors are needed to provide stability of yield and bulk production of farm crops. In every eco-climatic zone there is, as a rule, a predominant ecological limiting factor that crop technology must address. In Ukraine, moisture is the uncontrollable yield-limiting factor in the Steppe and Forest-Steppe zones, the regions of the majority of agricultural production. Thus, technological improvements will largely focus on methods for accommodating that environmental factor.

Ukraine=s most valuable resource in carrying out the policy of agrarian reform will be the intellect and knowledge of its citizens, combined with their desire and ability to improve their individual and societal condition. With improved agricultural production and the development of different forms of property ownership, production processes will become more complicated, and competition among the forms of ownership will ensue. The use of science will be a part of the general process of competition. Those who can use science most effectively will win the economic struggle for survival and contribute most to improving the country=s food system.

Table 5. Comparison of Crop Production (100 Kg/ha) by Three Technology Systems.

	Technology		
Crop	Ukrainian[1]	Western	Ukrainian Experimental
Wheat	40B44	75B82	75B98[2]
Barley	30B35	55B55	70B80[2]
Corn	40B42	90B103	88B110[2]
Sugar beet	280B320	420B500	550B650[3]

[1]Data from Ukrainian Ministry of Farm Produce.
[2]Experimental data, 1987B1993 averages, from the Ukrainian Research Institute of Agriculture.
[3]Hybrids, data from the Ukrainian Sugar Beet Institute.

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