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LAND RESOURCES OF THE REPUBLIC OF MOLDOVA: CONDITIONS AND CHALLENGES OF RATIONAL USE

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Abstract. The article discusses geographical position of the Republic of Moldova and specifics of its natural landscape. It characterizes the country's natural resources, dynamics of their transformation in 1940-2011 as well the crop yield results within the past 60 years. Finally, the work presents the main factors for diminishing crop yield efficiency of Moldovan lands designated for agricultural activities.

Key Words. Land, terrain, soil, soil erosion, crop yield.

Introduction

Republic of Moldova is located in the South-West of the Eastern European Plain, predominantly in the inter-stream area of rivers Prut and Dniester. The country has a unique location at the intersection of the Eastern European, Carpathian and Mediterranean geographic regions.

The territory of Moldova extends in the meridian direction with a total area of 33.8 thousand square kilometers. The country's territory extends 350 kilometers from South to North and 150 kilometers from West to East, bordering with Romania in the West and with Ukraine in the North, East and South.

Moldova's natural resources are characterized by a substantial diversity of landscape. Its land surface combines predominantly hills and plainswhile a major part is also covered by valleys, cloughs and gullies. The country's landscape represents a combination of low-height plains and stilted buttes which occupy mostly the central part of the Republic's territory. Moldova's average height above the sea level equals 147 meters, while buttes above 300 meters high comprise less than 3% of the total area of the country.

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One of the main natural riches of the Republic of Moldova is fertile soil with a very diverse structure identified by large inhomogeneity of natural conditions which influence the process of soil formation.

Land reserves of the Republic of Moldova

The land reserves of the Republic of Moldova as of January 1, 2011comprise 3,384.6 thousand hectares and include seven categories of land (Statistical Almanac of the Republic of Moldova 2011):

- agriculturally-designated land occupying 2,008.7 thousand hectares or 59.4% of the total territory of the country;
- populated land occupying 312.1 thousand hectares (9.2% of total territory);
- land reserve fund occupying 466.7 thousand hectares (13.8%);
- industry-, transportation-, communication- and special purpose-designated land - 58.9 thousand hectares (1.7%);
- forest reserves and land intended for nature protection purposes – 450.9 thousand hectares (13.3%);
- watersurface reserve fund – 87.3 thousand hectares (2.6%).

Table 1. Dynamics of the National Land Reserve, Republic of Moldova (1995-2011, thousand hectares)

Indicator	1995	2000	2005	2011
Total Land	3,385.3	3,384.2	3,384.6	3,384.6
Land Designated for Agriculture	2,032.6	2,016.6	1,951.8	2,008.7
Populated Land	441.7	299.6	308.6	312.1
Reserve Fund Land	462.5	620.6	553.8	466.7
Industry-, Transportation-, Communication and Special Purpose-Designated Land	58.4	58.4	58.8	58.9
Forest Fund and Nature Protection Land	344.1	354.6	428.5	450.9
Water Surface Fund Land	46.0	34.4	83.4	87.3

Source: Statistical Almanac of the Republic of Moldova (2011)

Such a high relative weight of agriculturally-designated land within the total land structure, on the one hand, speaks of a high degree of plow of the country's land reserve fund (plowed land and perennial plantations represent 84.5% of the total farmland and 62.4% of the total land reserve structure), yet, on the other hand, implies a lack of forest land in the country.Republic of Moldova holds one of the leading positions in the world by the degree of land plow, but ranks one of the lowest in Europe by the area of available forest land. As of 2011, the total area of Moldova's forest land is equal to 463.1 thousand hectares or 13.7% of the country's territory given a respective European average of 29% and a world average of 31% (Paramacli, 2006). Changes of the national land fund within the

last 17 years (1995-2011) are summarized in Table 1 (Statistical Almanac of the Republic of Moldova 2011).

Analysis of the dynamics of the farmland area in Moldova in 1940-2011 demonstrates a substantial decrease of land use as a main factor of production in agriculture. For instance, the total area of utilized farmland within the given period decreased by 365.7 thousand hectares or 12.8% from 1940 to 2011 (from 2,864.0 to 2,498.3 thousand hectares accordingly).

Table 2 demonstrates that the total area of cultivated land (plow and perennial plantations) by the end of collectivization in 1950 equaled 2,112 thousand hectares while the area of pastures and hay lands exceeded 691 thousand hectares (i.e. one hectare of pastures and hey lands correspondingto three hectares of total cultivated land). 30 years later the area of plow land and perennial plantations increased by 199.5 thousand hectares, whereas the area of pastures and hay lands decreased by 403.4 thousand hectares respectively. As a brief conclusion, additional plow of pastures provided an increase in Moldova's total area of cultivated land.

Table 2.Area of LandDesignated to Agriculture, Republic of Moldova (1940-2011, thousand hectares)

Year	Land Designated to Agriculture, Total	including				
		Plow Land	Perennial Plantations			Pastures, Hay Land, Stratum
			Total	Including		
				Gardens	Vineyards	
1940	2,864.0	2,057.1	199.0	81.0	118.0	608.0
1950	2,803.0	1,986.0	126.0	43.0	83.0	691.0
1960	2,717.0	1,904.0	383.0	158.0	220.0	430.0
1970	2,694.0	1,898.0	430.0	167.0	251.0	366.0
1980	2,598.4	1,841.7	469.8	178.0	256.0	287.6
1990	2,565.9	1,736.3	474.8	234.0	201.0	354.8
2000	2,543.6	1,820.7	334.9	137.0	149.0	388.0
2005	2,521.6	1,840.2	297.8	131.9	155.5	370.8
2011	2,498.3	1,812.7	298.8	133.3	149.6	386.8

Source: Statistical Almanac of the Republic of Moldova (2011)

A substantial part of the area of low-fertile pasture land, most often located on slants at a 4°-6° angle, were increasingly utilized for growing grains, baits, grapes and other agricultural products. With a purpose to fulfill the Soviet-standard production plans and sell agricultural products to the state in 1950-1975, local farmers adhered to a number of inorganicmeans of agricultural

development before implementing intensive crop raising technologies. Inclusion of low-fertility slant areas into agricultural production in these years only amplified the already existing problem of water erosion of soil within the country. As a result of involvement of the new lands to achieve higher crop collection the total structure of land designated to agriculturewent through a substantial change (Table 2).

By 1980 each hectare of pastures and hay lands corresponded already to eight hectares of total cultivated land which corresponded to a level 2.7 times higher than the one of 1950. Considering that the total area of Moldova's farmland during the last quarter of the 20th century remained relatively stable (nearly 2,560 thousand hectares), it is not difficult to notice that since 1990 – a starting point of liberalization of agricultural economics – an inverse process was initiated: the total area of farmland began to decrease whereas the area of pastures and hay land, on the contrary, increased.

As a result, by 2011 the area of plow land and perennial plantations across the country decreased to 2,115.5 thousand hectares while the area of pastures and hay land increased to 386.8 thousand hectares. Now each hectare of pastures and hay land corresponds already to 5.5 hectares of total farmland.

The farmland structure

Analysis of the farmland structure shows that within the last 25 years the area of pastures in the Republic did not go through substantial changes and averaged approximately 1,840 thousand hectares per pasture. At the same time, the total area of perennial plantations within an identical period diminished by almost 1.6 times from 469.8 thousand hectares in 1980 to 298.8 thousand hectares in 2011. Latest practice managed to correct the mistakes of the first half of the 20th century: with garden and vineyard grubbing the pasture reserve has been continuously increasing (Paramacli, 2006).

The system of farming agriculture formed by the end of the 20th century in the Republic of Moldova has had a negative impact on the environment and a break of all chains of the ecologic system. Some of the most significant anthropogenic factors favoring the development of negative processes include a low level and inorganic forms of crop farming, incorrect fertilization of slant soil, industrial pollution and others. These factors have amplified the effect of water and wind erosion, excessive drainage and moisturizing, pollution of soil and water pools with nitrates, pesticides, heavy metals, loss of humus and violation of natural biological cycles.

Erosion in general causes a large damage to national agriculture: the most fertile layer of soil is being depleted, general soil chemical composition and physical properties deteriorate, itsbiological activity is being reduced. The more eroded the soil is, the less humus it contains. Often non-outwashed soil contains 4%-5% of humus, semi-outwashed soil contains 1.5%-2% of humus, and outwashed soil – approximately 0.5%-1.5% respectively ("Soil of Moldova," Vol.3. 1986).

Land as a natural resource is the main factor of production in agriculture and a space basis for deployment and development of other industry sectors. Economic transfer to market relations has identified the weak sides and mistakes of productive land use in agriculture.

Importance of agriculture in Moldova originates from the country's natural environment and fertile soil. Rich black soil comprises over 80% of the area of Moldova's total farmlands. However, in order to evaluate objectively the effectiveness of appropriate land use, it is logical to give a brief characteristic to the current condition of the land resources of the country.

First. More than one half of the total farmland (57%) is located on slant areas of which nearly two thirds are inclined at an angle of 2°to 6°. Accordingly, as is well-known, slant and steep hillsides are subject to water erosion.That is why Moldova's lands are covered by gullies with a total area of over 30 thousand hectares (Hydrometeoizdat 1982).

Soil erosion is the most urgent, the most acute and even threatening problem not only for the country's agriculture, but also for the entire national economy as well as the state of the landscape and human environment. Based on the calculations of republican scientists, every fifth hectare of land requires irrigation, whereas every third hectare – anti-erosional or landslide control.

Is it commensurate with the capacity and the state of the current agrarian economy of the Republic? Certainly it is not.

Second. The territory of the Republic is located in an area of risky farming, where lack of precipitation (long-term absence of rains) leads to substantial harvest shortage and even plant perishing. An average annual amount of precipitation is at the level of 420-550mm, whereas during a vegetation period it is 320-440mm, which is substantially below the norm for appropriate plant development. Historical precipitation minima (up to 400mm) are observed in the South of the Republic causing a high variation in agricultural crop yield.

Third. According to analytical data, approximately 100 years ago humus comprised over 5% of the Moldovan soil contents. Obviously, during subsequent years soil fertility gradually diminished. Currently the level of humus in soil has reached the level of 3.1% on average across all arable land, preserving only approximately 60% of initial soil fertility by the end of the 20th century. Thus, natural soil fertility is evidenced to decrease over time, which certainly has a negative impact on land productivity.

Fourth. Based on scientifically-backed recommendations, not more than one third of the Republic's territory should be subjected to agricultural cultivation whereas another one third is advised to remain in initial natural condition. Such land allocation could maximize the chances of preserving ecologic equilibrium in nature.

The majority of economically developed countries with intensive agricultural production also adhere to this principle. In Moldova, as was mentioned above, agriculturally designated land occupies nearly three quarters of the territory of the country. The plow practice of Moldovan lands is rational neither from the ecologic, nor from the economic point of view. In addition, the water and thermal regimes of arable land are violated, the effects of draught, water and wind erosion are magnified, soil productivity and economic stability of crop farming have declined.

Nevertheless, the potential of Moldovan black soil remains high, although is not utilized to the full extent and is currently an important reserve of increasing the levels of agricultural production.Applying the method of economic comparison, we can confidently say that in the currently formed environmental and economic conditions the country'slands can provide an output of corn per unit of land 2.5 times higher than the currentlyachieved level, winter wheat – 2.1 times higher, sunflower – 2 times higher, grapes – 1.8 times and sugar beet – 1.7 times higher than the currently achieved level respectively (Table 3).

Potential an Historical Yields of Major Farmland Crops

As can be noticed from Table 3, Moldovan farmers achieved a crop yield close to potential levels of winter wheat by 84%, of corn – by 76.1%, sunflower – by 84.5%, sugar beet – by 93.1%, grapes – by 123.3% respectively.

Thus, the biggest lag lies within the grain crops. Excessive crop yield above the potential level for grapes – as shown by domestic and world practice – is undesirable since it leads to a deterioration of quality of produced output which is unacceptable for this type of crops.

Table 3. Scientifically Estimated (Potential) and Historical Yields of Major Farmland Crops

Farmland Crop Type	Crop Yield, center/hectare			
	Potential	Historical Average within 2006-2010	(Years)	Maximum Achieved (Year)
Winter Wheat	48.0	22.9	36.9 (1987-1991)	40.3 (1993)
Corn	66.0	26.8	43.0 (1987-1991)	50.2 (1989)
Sunflower	25.8	13.0	19.6 (1986-1990)	21.8 (1989)
Sugar Beet	451.0	259.6	296.0 (1987-1991)	420.0 (1989)
Grapes	76.7	41.9	70.0 (1978-1982)	94.5 (1982)

Source: Statistical Almanac of the Republic of Moldova (2011)

In 2011 the area of cultivated land in the Republic of Moldova totaled 1,460.3 thousand hectares, of which grain crops occupied 919.6 thousand hectares and sunflower – 252.4 thousand hectares respectively. In other words, the area of grain crops and sunflower exceeded 1,170 thousand hectares or 80.3% of cultivated land. That is why – given this magnitude – it is crucial to identify the effectiveness of use of land occupied by these crop types.

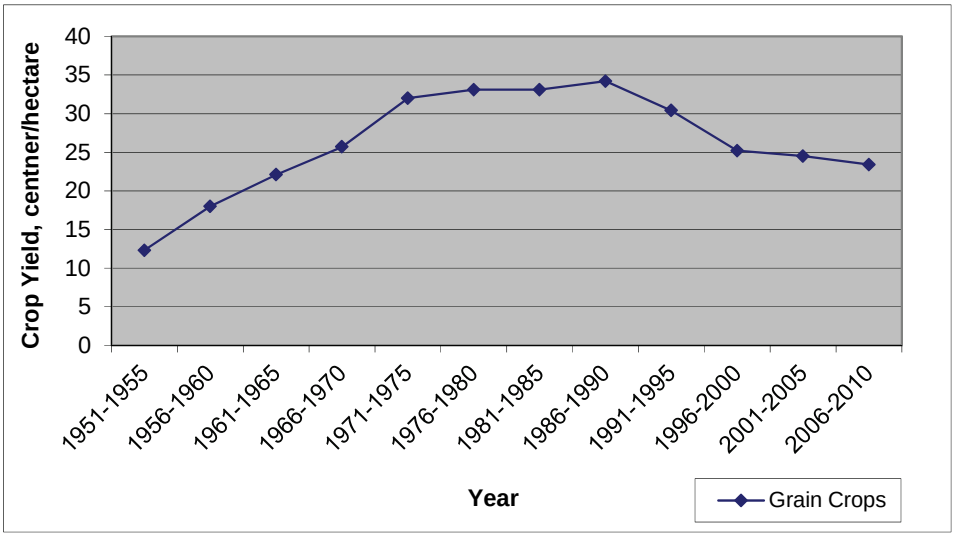
Let us consider the yield dynamics of grain crops and sunflower within the past 59 years (1951-2010) in Table 4 and Figure 1. We can observe that the average yield of grain crops and corn fell down by a factor of 1.5, of winter wheat – by a factor of 1.6, and sunflower – by a factor of 1.5 respectively.

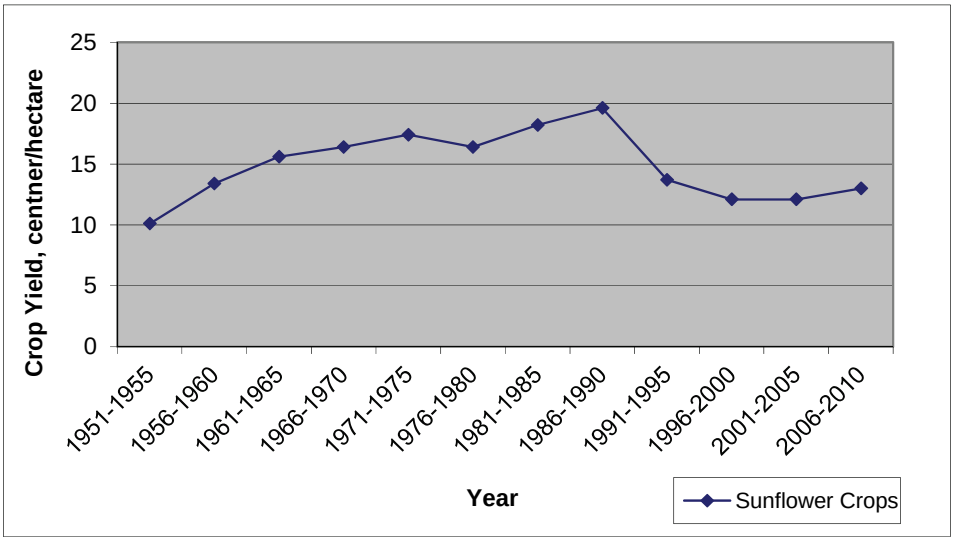
Table 4. Average Annual Productivity of Land Resources, Republic of Moldova(1951-2010 centner/hectare)

Year	**Grain Crops**	**Including**		**Sunflower**
		Winter Wheat	**Corn**	
1951-1955	12.3	11.8	14.0	10.1
1956-1960	18.0	16.4	20.6	13.4
1961-1965	22.1	15.5	30.7	15.6
1966-1970	25.7	20.6	33.8	16.4
1971-1975	32.0	33.1	35.7	17.4
1976-1980	33.1	35.3	35.4	16.4
1981-1985	33.1	34.5	36.5	18.2
1986-1990	34.2	36.5	39.6	19.6
1991-1995	30.4	32.5	33.1	13.7
1996-2000	25.2	24.5	30.3	12.1
2001-2005	24.5	24.0	27.9	12.1
2006-2010	23.4	22.9	26.8	13.0

Source: Statistical Almanac of the Republic of Moldova (2011)

Figure 1.Grain and Sunflower Crops: Dynamics of the Average Annual Yield in the Republic of Moldova, 1951-2010.





Source: Statistical Almanac of the Republic of Moldova (2011)

Let us consider several main reasons for a steep decrease in the productivity of land. First, the level of chemical interference in the production of grain, technical, vegetable and other crops has substantially diminished. If in 1980-

1990 a loss of major elements of nutrition for plants was compensated by 60% via an intake of mineral and organic elements, nowadays a similar loss is compensated by only 10%.Within the last 20 years total injections of organic fertilizers into the soil across the Republic fell from 9.7 million ton to 0.07 million ton or by a factor of 140, whereas injection of mineral fertilizers – by a factor of 27 from 217.2 thousand to 11.3 thousand ton. The use of water for irrigation has decreased down to 100 cubic meters per hectare which is four times lower than a norm of one watering. Due to financing limitations, Moldovan farmers inject three-four times less mineral fertilizers than in Canada, 7-25 times less than in the US, China and the European Union (Paramacli, 2006).

Full independence of land users has led to a substantial change in the structure of cultivated land. The trend is toward a steep decrease of relative weight of plantings of peas and perennial grasses that contribute to the growth of soil fertility and toward an increase in the cultivation area of sunflower and winter rape which are highly profitable, yet the most soil-exhausting, types of crops. In other words, Moldova has come to a planting structure which is not in line with recommendations of science and common practice. If during the pre-reform period (until 1993) perennial plantings and peas occupied nearly 16% in the structure of total cultivated land, while today they cover only 4%.

It is important to notice that nowadays science has developed high-yielding sorts and hybrids across nearly all grain crops, sunflower, sugar beet, and vegetable types. However, as a rule, such sorts require higher doses of fertilizers, a wider application of chemical means of plant protection and strict technological discipline, i.e. things which are nearly nonexistent in the country's reality. A return to older primitive technologies given modern high-yielding sorts of crops and hybrids is nothing but an illusion – instead of higher crop yields farmers obtain opposite results.

If analysis of crop yield stability involves a period of 25-30 years or longer, a polynomial rather than a linear trend line could be used since the former is smoother and is more precise in reflecting a general trend. Figures 2 and 3 present a 45-year trend of change for average annual crop yields of winter wheat and corn within 1966-2010.

Dynamics of the crop yield of winter wheat as the main food crop shows that the selected 45-year period can be divided into two parts: the first one can be characterized by a upward-sloping trend of the crop yield supported by the trend equation $y= -0.031x^2 +1.265x + 21.502$ and covering the period 1966-1993 or 28

years, and the second one – covering the period of 1994-2010 or 17 years – with a downward crop yield trend.

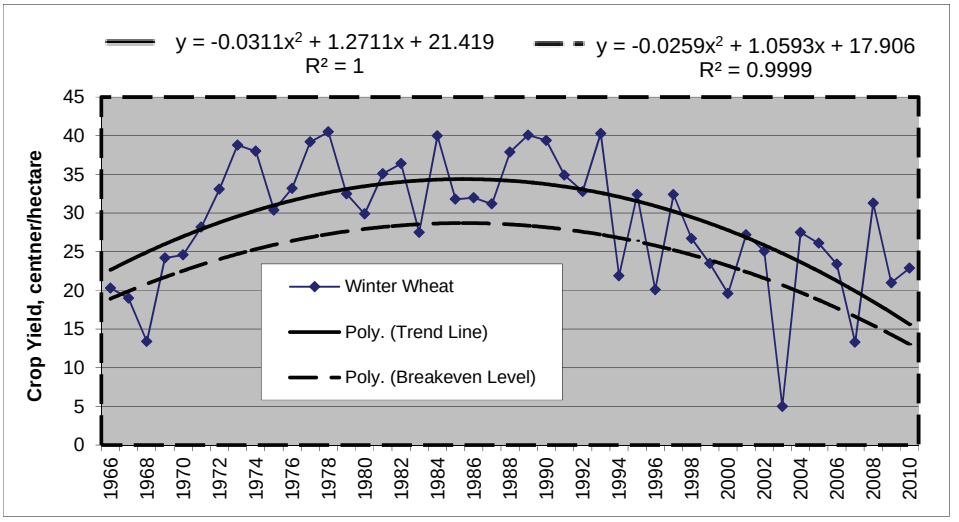


Figure 2. Crop Yield Dynamics of Winter Wheat, Republic of Moldova (1966-2010)

During the first half of the analyzed period the crop yield of winter wheat fell for three years below the breakeven level, whereas in the second half – already for six years, given that the breakeven level represents a 17.5% decrease in the trend data when the sales of grain become unprofitable or loss-making. As we can see, for nine years out of 45, i.e. every fifth year, the crop yield of winter wheat was below the breakeven level. The latest 17 years can be characterized by a particularly low stability when every third year on average the economic rationale of raising wheat was not justified.

A similar trend can also be observed in the production of corn (Figure 3).

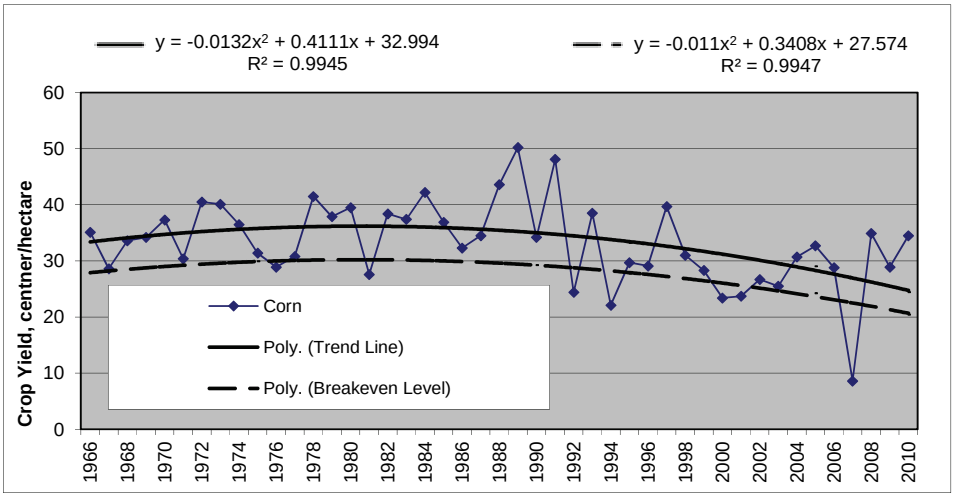


Figure 3. Crop Yield Dynamics of Corn, Republic of Moldova (1966-2010)

This relationship confirms not only a threatening character of potential draughts, but also the drawbacks of the currently formed technologies of cultivating the leading agricultural crop types based, on the one hand, on diminishing fertility of soil and, on the other hand, on total decline of technology quality conducted at simultaneous neglect of the innovation component of agriculture's economic development.

In conclusion it is important to note that the effectiveness of agriculture and plant cultivation is firstly determined by the level of use of natural potential of land – the main factor of production in the agricultural sector. However, land fertility – despite all the above-mentioned drawbacks – remains to be high and needs to be further preserved.

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