Annals of the Academy of Romanian Scientists
Series on Agriculture Forestry and Veterinary Medicine Sciences
ISSN 2344-2085 Volume 1, Number 1/2012

AGROSILVOPASTORAL SYSTEM AND FOOD SECURITY IN THE CONTEXT OF GLOBAL WARMING

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Abstract. In the paper is presented a possible prediction of medium temperature increasing with 3^0C up to 2070 year, when over 68% of Romanian territory will be affected by desertification and aridity, with major consequence of bioclimatic and soil changes. These changes will influence the grassland and animal productivity from mountainous zones. The indigenous agricultural system named grove (trees + grassland) or extensive orchard (fruit trees + grassland or agricultural crops) should be more studied by agronomy and forestry specialist for extending on large surfaces like an efficient solution for limiting negative effects of global warming on food security. With the wooded screens of forestation and irrigations, the silvopastoral system is a complementary solution to prevent the desertification and aridity effects on crop and animal productivity.

Key words: climatic prediction, agrosilvopastoral system, grassland productivity

Introduction

The latest projections of climate evolution on earth, general warming due to human activities (deforestation, industrialization, transport, etc.), with increasing carbon dioxide emissions, melting ice caps and mountain glaciers, sea levels rise, flooding, aridity and desertification, increasing thunderstorms processes (hurricanes, typhoons, tornadoes, cyclones, etc.) will have a major impact on all humanity with the worst unforeseeable consequences [1, 2].

Forecasts of global warming will affect the country's pastoral area. Increasing the air average temperature of 3^0C, which is forecast in the years 2070, will lead to aridity and more accentuated desertification of plains and hills with major negative implications on crop production and livestock produced on natural grasslands.

One of the most effective measures to improve the negative impact of desertification and aridity factors with forestry plantations and irrigation is agrosilvopastoral system promoting, in which all components: grass, animal, wood, habitat, biodiversity are in ecological and economically optimal balance.

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The agrosilvopastoral system is specifically in Mediterranean countries with arid climate, known as the "dehesa" and "montado" in Spain and Portugal [6, 9] and in the northwestern U.S. state of Oregon, called "agroforestry" [10].

In our country, in some areas, have been practiced more combinations of agriculture with woody vegetation such as: pasture - trees, meadows - fruit trees, arable crops - fruit trees or wild trees. The combination of pasture - isolated trees is known to us as the "grove" due to the excluded trees from clearing forest or by planting new ones to provide shade for animals.

The planting wood vegetation in existing grassland like wooden Iberian model "Dehesa", adapted to our conditions, known as "grove" or "glade", can substantially diminishes the negative effects of aridity and desertification that will occur in the future [7].

Woody plant species have the advantage they prospect a larger volume of the ground, stopping landslides, reduce erosion of soil, reduce the amplitude of diurnal air and soil temperatures, protects the grass plants and animals of sunburn and dehydration, wind, heavy rain, retain snow that melts slower, extra produce timber and firewood, fruits and fodder, provide a habitat for many species of birds, which in turn consume insects and many other advantages from which improvement of biodiversity and landscape beautification.

Pastoral lands in our country, especially communal pastures are almost no shade for grazing animal, that cause the cow milk production may decrease by 20-40% during periods of strong sunburn. Planting of trees for shade, resistant to animal hoof and the accumulation of excess manure in animal rest areas, would fully solve this problem. Besides the assortment of woody species adapted to these special stationary area conditions is necessary to apply individual protection measures in the early years of growing the young trees until they resist to pressure from grazing animals. After this critical period the plantation may last decades, even centuries, such as some species of oak in our country.

These technologies must be applied as soon as possible so that the future plantation of trees and fruit trees on the grassland shall be well established and developed to exercise their protective influence on the sward and animals, before emphasizing the perspective of the aridity and desertification phenomena.

To achieve these objectives, complex interdisciplinary research is needed on some older agrosilvopastoral systems existing on form of woody vegetation (groves, selvedges, orchards, etc.), in combination with herbaceous vegetation of permanent pastures used by animal grazing or meadow regime.

The results of this research will be the basis of future solutions for “groves” action on regions and bioclimatic altitudinal belts of all grasslands from our country as a

main solution to stop the desertification and aridity effects which will expand more in the near future.

Implementation and expansion of this combined agriculture and forestry system, in addition to the diminishing and balancing role of the extreme weather factors will certainly bring economic and social benefits by increasing the grassland and animals productivity, plus additional the utilization of woody vegetation that is difficult to purchase in the plains and hills. Agrosilvopastoral system contributes to soil erosion and landslide protection on the slopes, increasing the potential for carbon fixation per unit area and not least the beauty and attractiveness of existing landscapes.

2. Climate change forecasts

2.1. Climate change and its consequences in Romania

From the data base WMO (World Meteorological Organization) in Geneva, the average temperature has risen between 1901 to 2000 with 0.6^0C that is very much what. For Romania, as INMH -Bucharest, this increase is 0.3^0C higher in southern and eastern regions (0.8^0C) and lower in intra-region (0.1^0C). Warming is more pronounced after 1961 and especially after 2000 (2003, 2005) when the frequency of tropical days (maximum daily > 30^0C) increased alarmingly long and winter days (maximum daily <0^0C) decreased substantially. As a result, several areas of our country are at high risk of drought and desertification,particulary where the annual average temperature is above 10 ^{0}C, the amount of annual rainfall is below 350-550 mm; rainfall from April to October are under 200 - 350 mm and soil water reserves, at 0 -100 cm, on March 31 is less than 950 -1500 mc/ha.

According to the United Nations Convention to Combat Desertification (UNCDD) the aridity index (annual amount of precipitation / potential evapo-transpiration - ETP) for the arid zones and deserts is 0.05 and 0.65 for dry sub-humid areas, the limit above which a territory is considered to be close to normal. According to this ETP agreement for steppe and silvo steppe is 400-900 mm and 300 mm water in mountain zone.

In the fourth report (2007 year) of the International Committee on Climate Change (IPCC) for the period 2020-2030 compared to 2000 in an optimistic variant is expected to increase average global temperature by 0.5^0C and a pessimistic variant by 1.5^0C. During the period 2030-2100 the increase in the two variants is between 2.0^0C and 5.0^0C, what is very much. If we would take the year 2070 an increase of only 3^0C above current levels, then 68% of Romanian territory situated below 500 m altitude will be subject of aridity and desertification process, respectively more than double the current mountain area (Table 1).

Table 1) Percentage altitudinal distribution of the relief of Romanian territory **(**after GEOGRAFIA ROMÂNIEI vol.I, 1983**)**

Altitude (m)	***% of Romanian territory (237,5 thousand km^2)***	***From which:***		
		Mountain	***Hill***	***Plain***
over 2000	1	3		
1500 - 2000	3	7		
1000 - 1500	6	19		
700 - 1000	12	36	3	
500 - 700	10	16	12	
300 - 500	18	12	38	1
200 - 500	12	7	24	5
100 - 200	18		18	35
0 - 100	20		5	59
over 500 m	**32**	**81**	**15**	
under 500 m*)	**68**	**19**	**85**	**100**

*) the affected territory of aridity and desertification process in situation when the medium temperature increase is 3^0C forecast until to 2070 year

By increasing the average air temperature of 3^0C in Romania is expected that Dobrogea, south of Moldova, western Transylvania, Banat, south Oltenia and much of southern Romanian Plain, that over 30% of the country area will be affected by a process of desertification and the remaining surface approx 38% by a sharp aridity process, which will include further all our plains, up to 85% of the hills and almost 20% of mountains area with the lower altitudes.

2.2. Forecast changes in bioclimatic

Predicted climate change will have a major impact on the current redistribution of vegetation on zones and altitudinal levels which in turn will influence habitats and economic performances. According to forecasts for the years 2070 an increase of 3^0C of average air temperature in the mountain area, after current altitude gradients (-0.5^0C / 100 m alt.) [4], an increase of the current distribution of primary vegetation with 600 m is estimated.

For our country mountains these bioclimatic changes on 2070 year is presented in Table 2.

From these data it results that in the high mountains will disappear the alpine and sub-alpine levels (Pinus mugo), being replaced by spruce and beech forest level. Also the steppe zone will replace the upper levels of oak forests and silvosteppe will replace the lower levels of beech forests. These major changes in the altitude distribution of woody vegetation in the mountain area will allow a natural decreasing with 40-70% of actual forest area and the dramatic consequences of water balances and rainfall will be expected.

Table 2 Change of bioclimatic and vegetation levels to an increase in average air temperature of 3^0C (forecast year 2070)

Current level (zone)	***Altitude*** *(m)*	***Temperature annual mean (^{0}C)***		***Annual rainfall (mm)***		***Levels (zones) changed after tens years***
		Actual	Year 2070	Actual	Year 2070	
Alpine	2200-2400	-1	2	1500	1250	Spruce
Pinus mug	2000-2200	0	3	1450	1150	Spruce
Pinus mugo	1800-2000	1	4	1350	1050	Spruce + Beech
Spruce	1600-1800	2	5	1250	950	Beech
Spruce	1400-1600	3	6	1150	850	Beech
Spruce + Beech	1200-1400	4	7	1050	800	Oak
Beech	1000-1200	5	8	950	700	Oak
Beech	800-1000	6	9	850	600	Silvosteppe
Beech	600-800	7	10	800	500	Steppe
(Oak) (Silvosteppe) (Steppe)	**GRADIENT for each 100 m alt.**	**-0,5 ^{0}C**	**-0,5 ^{0}C**	**+45 mm**	**+45 mm**	(Subhumid – dry) (Semiarid) (Arid - deserts)

2.3. Prognosis of changes in mountain soil

Climate change will also affect the physic - chemical properties of soil (Table 3). Thus, the thickness of soil over the next 60-70 years will be about the same, taking in account that 1 cm soil is formed in amount 100 years in the temperate zone. Instead of some agrochemical properties are subject to change on a nondescript term until approaching a specific balance imposed by temperature and precipitation projected for the 2070 year.

Soil reaction (pH) and degree of base saturation (V%) will change in corresponding with the altitudinal rise of the level of more active bioclimatic indicators for vegetation [8].

The slower changes of the soil will make the productivity of natural vegetation and crops to be lower, although more favourable conditions of heat will be at higher altitudes in the future.

Table 3) Changing soil conditions to increase the average air temperature with 3^0C (forecast 2070 year)

Actual level (zone)	*Altitude (m)*	*Soil thickness (cm)*		*Soil layer, A*			
		Actual	*Distant future*	*pH in water*		*V %*	
				Actual	*Nearest future*	*Actual*	*Nearest future*
Alpine	2200- 2400	20	**Slow growth** (about 1 cm per 100 years)	3,6	4,5	6	24
Pinus mugo	2000-2200	35		3,9	4,8	12	30
Jneapăn	1800-2000	50		4,2	5,1	18	36
Spruce	1600-1800	65		4,5	5,4	24	42
Spruce	1400-1600	80		4,8	5,7	30	48
Spruce+ Beech	1200-1400	95		5,1	6,0	36	54
Beech	1000-1200	110		5,4	6,3	42	60
Beech	800-1000	125		5,7	6,6	48	66
Oak	600-800	140		6,0	6,9	54	72
(Oak) (Silvosteppe) (Steppe)	**GRADIENT for each 100 m alt.**	**-7,5mm**		**-0,15**	**-0,15**	**-3%**	**-3%**

3. Components traditional agrosilvopastoral

For centuries in our country has been practiced more combined culture system between woody vegetation (trees and fruit trees) and the grasses of pasture or arable crops. Next there are mentioned the most important of them, particularly with major role in the development of subsistence agriculture.

3.1. Communal pastures with trees

Given the characteristics of the forest microclimate more balanced than the one extreme of the open field, from a long time ago in our country have done work of thinning the existing forests in order to install swards for animal feeding, the action called "groves".

In areas where the wood vegetation was cleared were planted solitary trees, tree clusters or/and tree alignments for animals sunburn protection simultaneously with wood making necessary for household.

The action of "setting" of seedlings in grassland can be named grove, as the establishment of forest belts in arable land is called wooded screen [3].

Thus, as a results of tree planting process on grassland there are the known “groves” or “glades”, where live in good harmony woody vegetation, swards and

animals. Up to collectivization of agriculture the majority communal pastures were planted with different species of trees for shade to animals.

Species of wild trees and fruit trees used primarily for shade, were chosen according to the stationary conditions in willows and poplars in meadow, acacias, oak, ash, wild hair, walnut, etc. in the plains and hills, beech, fir, spruce and other species in the mountain zone. Testify and now the secular oaks groves from Cristian, Harman, Daisoara, Fişer–BV, Reghin-MS, Ţigăneşti-BC, Remetea-BH, Poşmuş-BN, Dioşti-DJ and others. Among these is distinguished the secular oak from Poşmuş - Şieu that in 2006 turned 600 years old, being perhaps the oldest tree in Romania [5].

Unfortunately, many of these secular trees were burned, cleared, vandalized, without putting anything in place, animals on pasture feel the full effects of heatstroke and sunburns during the summer period, with the decrease of milk and meat production.

3.2. Fruit trees-meadow and pasture system

In some areas of hills and depressions there are grassed orchard with fruit trees used as hay making or grazing animals. Most widespread species is plum, followed by apple, pear, walnut, etc., cultivated extensively with unbalanced production from year to year. So it was created a jointhousehold orchard-meadow that has proven both to produce fruit with minimal intervention and used as pasture or meadow in animal feeding. Also the animals benefits of more shade and supplementary feed because of fruits attacked by pests and diseases that have fallen from trees.

In orchards located on abrupt slopes from hill area the fruit trees also have an anti-erosion role and stabilize land against landslides. A special case is the alignment of mulberry trees along the roads where geese on pasture supplement their food with mulberry fruits on July-August months when the grass is low rate.

Many of these systems of grassed orchard are in abandon, only in a few places the are thus the orchards maintained in households from the counties of Subcarpathian area Vrancea, Buzau, Prahova, Arges, Dambovitaand Valcea.

3.3. Terrace with arable, slope with meadow and the row of trees system

One of the most interesting complex systems for improving the sloping agricultural land consists in terracing for arable crops in the grass embankment used as meadow and a row of trees on the top edge of the slope, especially specific in south-western of Transylvania. For hundreds of years this system has provided grain crops, hay for livestock farming fruits for direct consumption and

preserving in terms of protection against surface and depth erosion of the soil on greater slopes. Unfortunately, this system is now largely abandoned, being invaded by woody vegetation and unvalued grasses.

Returning to the old system of effective utilization of arable land-meadow–fruit trees with modern means of mechanization, organic fertilization from livestock farm and other measures in addition to practice of organic farming and tourism, would have great future in these disadvantaged areas with major handicaps.

3.4. Protection of traditional systems

In our country it is found that there were and still are in some form, agrosilvopastoral different systems that need to be better known and reviewed in the future.

Their studies were marginalized, agronomists considering that is the job of foresters, foresters themselves dealing with complete forest, less than isolated trees on pasture, etc.

While Mediterranean countries heavily affected by heat and excessive dry periods, foresters and agronomists have already taken concrete action with awareness and generalization of traditional systems as Spanish Dehesa. In our country, these systems have not been taken into account before to extend them to prevent negative effects of global climate warming.

Therefore, it is considered necessary an inventory of all our agrosilvopastoral systems, by mixed teams, agronomists and foresters, followed by study of their functionality as a solution of protecting the sward, arable crops, grazing animals, trees, fruit trees, etc., economic source of fodder, livestock products, cereals, fruit, wood, landscape beauty, and more. After establishing the main functions of agrosilvopastoral systems can go further modernization of maintenance and utilization of these complex resource that can better adapt to future climate change.

Thus the system agrosilvopastoral with afforestation of degraded lands, establishment of forest belts, expansion of irrigation and other means can complete specific measures to combat desertification and aridity that will affect both the pastoral land and livestock.

A complex agrosilvopastoral system can cross more easily a warming climate period than the current system with pasture without trees, simple arable crops and another.

Conclusions

In Romania because of the increasing the average air temperature only with 3^0C, until 2070, according to forecasts, over 30% of the country will be affected by desertification and about 38% of intense aridity, which will encompass all our plains, up to 85% area of hills and almost 20% of the pre mountain and low mountain area;

The forecast of global warming with 3^0C, in our country will create major disturbances in the altitudinal distribution of vegetation belts of the Carpathians, to increase the upper limit of spruce with 600 m, reaching 2400 m altitude, with the gradual disappearance of subalpine (Pinus mugo) and alpine belts. Maximum productivity of forests and natural grasslands currently located at the 1000 – 1200 m by global warming will rise to 1600 – 1800 m altitude;

The possibilities of increasing the production of mountain grassland that will benefit by higher heat and humidity than at present, are seriously diminished by the physical - chemical soil properties that will change much slower than the climate, difficult access conditions, etc. Causes for which will be necessary to develop other related activities such as agro tourism;

The local agrosilvopastoral system is called the grove, on grassland being species of trees, especially oaks and orchards with far-between different fruit species where is growing grass that is used by grazing or mowing. More detailed studies on these mixed production systems, their extending to areas already affected by aridity and their protection where there still are, are necessary to perform as soon as possible by teams of specialists in agriculture and forestry;

In the future, are necessary to carry out the complex studies and long-term research, located in different areas affected by desertification and aridity, where the main factors to be monitored are climatic, edaphic and vegetation productivity of wood and pasture vegetation, livestock and crops from agrosilvopastoral systems, in order to determine more accurately their evolution over time, data that will be basis of the future development programs of agrosilvopastoral system, as an viable alternative for food security in the context of global climate warming.

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