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Standard Review

Challenges of land use change and land protection in Vojvodina

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The entire region of Vojvodina (region in northern Serbia) is an agricultural - steppe - forest zone. The area of Vojvodina covers 2,150,000 ha of which arable land is 1,579,643 ha (73,45 %). Total forested area is about 130,000 ha or 6% of the total area. At present, all the ecosystems (agro and forest ecosystems), in this region are highly endangered. This is the consequence of local and global economic activities after 1945, which altered societies relationship with the natural environment (Bouma et al., 1998). The soils in Vojvodina are affected by aridification, acidification, eutrophication and pollution. As a region with highly productive agricultural soil, it is subject to and endangered by, different destructive processes, primarily wind erosion, that is climatic extremes, because of which its maximal productive potential cannot be utilised. Wind erosion, as a very destructive factor, causes the detachment and transport of the most fertile particles of the arable topsoil, permanently changing its fertility properties. In addition droughts might also reduce yield. This is multiplied by potential effects of climate changes. Environmental improvement is only possible by integral understanding of urban, non-urban and green spaces, rural landscapes, protective green areas, diversity in agro-ecological areas and protected areas. That is why afforestation is planned over almost 100,000 ha by the establishment of different types of forest plantations and other plantations, such as greenways, shelterbelts, bee-keeping plantations, buffer plantations, eco-corridors, etc. By the implementation of planned afforestation, it could be possible to increase the yield in agriculture, timber production, protection against wind, to improve the environmental conditions, production of honey, development of hunting, sports, recreation tourism and sustainable land use.

Key words: Sustainable land use, afforestation, agro - ecosystems, forest ecosystem.

INTRODUCTION

The entire region of Vojvodina (northern part of Serbia) is a mosaic of agricultural, steppe and forested zones. Its total area is 2,150,000 ha of which arable land occupies 1,579,643 ha or 73.45%. The region of Vojvodina belongs to the Pannonian Plain and is a grassland ecosystem, such as might be found in North America (Midwestern Plains), Russia (Belyaev, 2007) and China (Peng and Foster, 2007). Much of the former grassland has been cultivated. As grassland, this is a region where plant production is limited by soil moisture. The dominant soil type is a dark-brown chernozem, which develops typically under grasslands with humid climate (Zivkovic et al., 1972). A long-established scheme for classifying temperate grassland soils on the basis of A horizon organic matter content and colour was originally developed in Russia. It was used in the past, or is still applied, also in other parts of Eurasia and North America. In this scheme, dark-coloured chernozems occupy the humid part of the climatic range of grassland ecosystems (Belyaev, 2007; Pinno and Belanger, 2008).

At present, the ecosystems in Vojvodina are highly endangered. This is the consequence of global economic activities after 1945 in Eastern Europe (Bouma et al., 1998). Societies relationship with the natural environment has been radically altered and the environmental change is the result of technological, socio-economic and political developments in each country. The main soil degradation types are chemical deterioration on 12%, water erosion

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Table 1. Methods of soil usage (ha).

Arable land	Orchards	Vineyards	Meadows	Pastures	Fish ponds	Barren land	Forests	Total
1,579,643	16,469	12,196	32,326	119,176	30,140	230,650	130,000	2,150,600
73.45%	0.76%	0.57%	1.51%	5.54%	1.41%	10.76%	6.00%	100.00%

on 52%, physical deterioration on 17% and wind erosion on 19% (Oldeman et al., 1990). As a region with highly productive agricultural soil, it is subject to and endangered by, different destructive processes, primarily wind erosion. Wind erosion, as a very destructive factor, causes detachment and transport of the most fertile particles of the arable topsoil, permanently changing its fertility properties and the droughts also reduce the yield (Sapundzic, 1978; Letic et al., 1984; Vlatkovic, 2001).

The area of forests in Vojvodina is about 130,000 ha or 6% of total area. The low forest area caused the difficulties in realisation of sustainable agricultural production. The sustainability of agricultural production will depend on more tree planting in future, by means of forest belts and agro forestry systems. Environmental improvement in the region of Vojvodina is possible only under the integral understanding of urban and nonurban spaces, green spaces, rural landscapes, protective green spaces, diversity in agro-ecological areas and protected areas. Most authors noted the positive influence of forests on water, soil carbon sequestration and diversity. The intensive afforestation (Burley, 2002) is planned on almost 100,000 ha by establishing types of forest with different functions, such as greenways, shelterbelts, beekeeping plantations, buffer plantations and eco-corridors. By the implementation of the planned afforestation, it will be possible to increase the yield in agriculture, timber production, protection against wind, to improve the environmental conditions, production of honey, development of hunting, sports, recreation, tourism and sustainable land use. In addition, it is also possible to link the protected areas by eco-corridors and in this way to establish an ecological network (greenways). This is of highest relevant because the basic network of protected areas (special centres of autochthonous biological diversity) consists of about 200 single sites. The basic network of protected areas covers 5.5% of the total Province area.

This paper present the review of actual land use structure and soil erosion, forests, protection greenery and nature protection in the Vojvodina Province.

LAND USE STRUCTURE

Sustainable agriculture is a system of whole-farm resource use balanced with whole-farm productivity (Wernon et al. http://www.unl.edu/nac/morepublications/ec1972.pdf). The overall level of productivity achieved is dependent upon the ability to coordinate and manage soil, water, plant and animal resources under given climatic and economic conditions. This is extremely important since, of the total land area of 2,150,600 ha in Vojvodina, about 83.24% is used for agricultural production (Table 1).

Table 2. Classes of land use in Vojvodina.

Classes	Area (ha)	(%)
class I	968,800	45.0
class II	328,400	15.2
class III	382,300	17.7
class IV	35,500	1.9
class V	53,100	2.4
class VI	88,900	4.1
class VII	19,300	0.8
class VIII	7,200	0.5
Other	267,100	12.4

Table 3. Site types in Vojvodina.

Soil	Area (ha)	(%)
Automorphic	1,462,705	68.0
Hydromorphic	572,709	26.6
Halomorphic	106,622	4.9
Gitja, Daj, Sapropel	8,564	0.5

The main land use is arable land (Classes 1 and 2). About 60.2% of the land is represented by these two classes (Table 2). These two soil classes belong to automorphic site type, which occupy 68% of the land area (Table 3).

Chernozem, as the dominant soil type, occupies 938,881 ha (45% of total area) (Table 4). This soil type is highly productive agricultural soil and it is subject to and endangered by, different destructive processes, primarily wind erosion, that is climatic extremes.

Hydromorphic soils cover 572,709 ha of predominantly forest soils (Galic et al., 2006). In the past, deforestation occurred mostly on humogley 348,846 ha. This soil type is now used by agriculture. The land use change was not the best solution for this soil type because the suitability for agricultural production depends on climatic conditions that is precipitation.

Another potential soil type for afforestation is solonetz. The selection of tree species for the afforestation of halomorphic soils in Vojvodina is a special problem, considering the very low productivity as the consequence of a series of unfavourable soil properties (Galic et al., 2008; Ivanisevic et al., 2008). Low productivity determine

Table 4. Soil types in Vojvodina.

Automorphic site type	1462705	Hydromorphic site type	572709
Soil type	ha	Soil type	ha
Lithosol and regosol	17054	Pseudogley	13752
Colluvium	3806	Fluvisol	194422
Rendzina	14481	Humogley	348846
Ranker	10	Eugley	15269
Chernozem	938881	Peat	420
Vertisol	36139		
Semigley	370496	**Halomorphic site type**	**106622**
Eutric cambisol	56164	Solonchak	19865
Dystric cambisol	1412	Solonetz	86757
Luvisol	13752		
Rigosol	10510	**Gitja, Daj, Sapropel**	**8564**

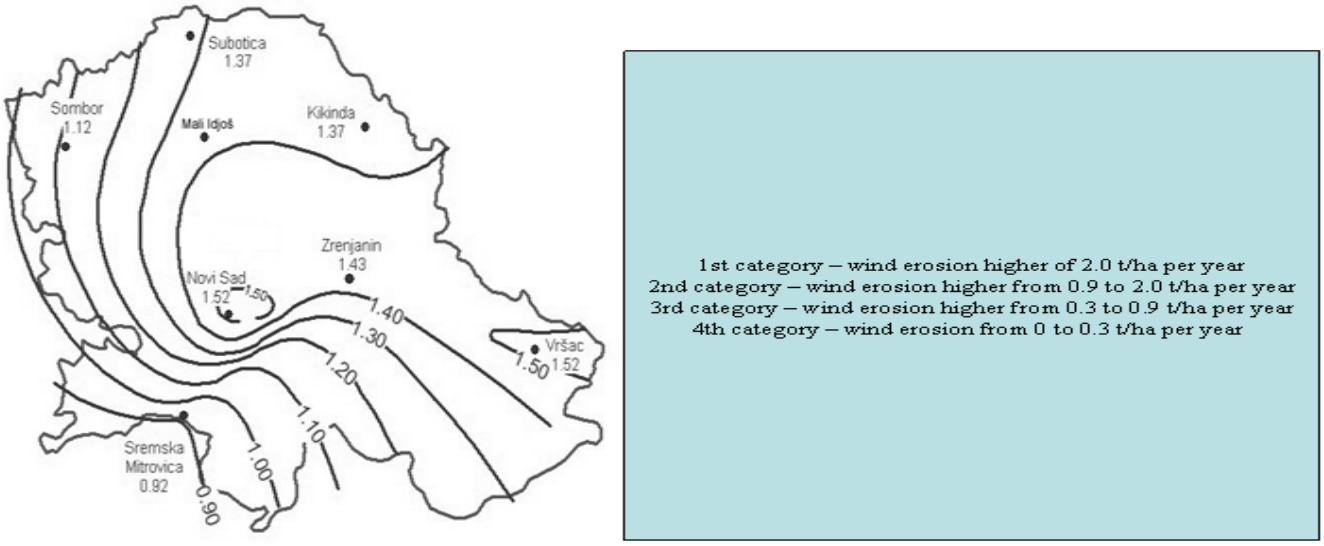

Figure 1. Intensity of wind erosion in autonomous province of Vojvodina (Vlatkovic, 2001).

the potential, level and character of this soil type utilisation in forestry.

SOIL EROSION

Major challenges in the 21th century at the global scale include the severe degradation of agricultural soils (Sartori et al., 2007). Sustainable ecological solutions are required to restore degraded lands and to prevent further land degradation, but soil erosion is an increasing environmental problem. One third of the planet Earth is affected by wind erosion, transport and deposition of material (Chen and Fryrear, 1996). Soil loss caused by wind erosion presents a problem on cultivated lands and pastures in Europe (Goossens et al., 2001), Africa (Bielders et al., 2000), Asia (Zhibao et al., 2000), Australia (Gillieson et al., 1996) and North America (Buschiazzo et al., 1999). The main agent of soil erosion in Vojvodina is wind. The intensity of wind erosion in Vojvodina is shown in Figure 1.

The soil with the highest wind erosion rates in Vojvodina are soils with the highest yields, the chernozem (Sapundzic, 1978; Letic et al., 1984; Vlatkovic, 2001; Galic, 2004; Orlovic et al., 2004). This region is the most unafforested region in Vojvodina too.

LAND-USE CHANGE

In the past, the greatest part of the Pannonian lowland was under swamps (Magyar, 1960). The 19th century was significant for swamp drainage. Vasilic (1981) pointed out that the process of technological revolution and the need of increasing the arable area caused the conversion of forest to agricultural land. By the government decision,

some forests were cleared in order to make arable fields and the traits of pre-existing vegetation were removed. The technological revolution and urbanization in Vojvodina caused great changes in nature, the consequences of which were reflected in the risk and decrease in ecological, ambient and landscape values in all parts of Vojvodina. Typical agricultural production in Vojvodina in the past was organized on small farms of up to 2 ha on the average.

Land use change in Vojvodina after the World War II was caused by characteristic processes, such as collectivisation and industrialization of agricultural production (Bouma et al., 1998) and urbanization. Maximum size of an estate was 7.5 ha. If a private estate was greater, it was deprived or collectivized. Collectivization and industrialization led to the increase in cultivation plots ranging from 50 to 100 ha, as in other eastern European countries.

During the transition process, the privatization of Estates during the collectivization was executed by the will of the political elite. Today, individuals can own more than 10,000 ha. In relation to land privatization, no improvement in agricultural soil protection is expected in the future. The idea of having a greater number of trees on small farms in Vojvodina, although a sustainable solution, cannot be sustained in the private sector.

FORESTS AND AGROFORESTRY SYSTEMS

Trees and shrubs play an important role in today's integrated agricultural system (Praestholm et al., 2006; Pinno and Belanger, 2008). Forests along the rivers offer precious habitats to wild animals, protect river and stream banks and can act as a buffer zone protecting water quality and contributing to ecosystem protection in rivers and streams. Trees and shrubs are planted in shelterbelts for erosion control improving harvest yields and affecting the quality of many cereals susceptible to wind (Wilkinson, 1999). Windbreaks protect homes and farm buildings and reduce energy consumption. They can be used to reduce cattle stress, improve gain in mass and reduce mortality. Well designed shelterbelts can additionally increase income from wood assortments, fruits and biomass, with the increase in wild animal populations and contribute to the beauty of landscapes.

Aforestation in Vojvodina almost always depends on soil characteristics. It is well known that Vojvodina is an agricultural, steppe and forest region in which, prior to intensive agricultural development and urbanization, the area of forests was much greater than today. In the past, great complexes of lowland forests were distributed throughout the flooded regions (Vlatkovic, 2001) and sand dunes was found in the region of southern Banat. First vegetation (Vasilic, 1981) was represented by the forests of oak, elm, European hornbeam, ash, small-leaved linden, with frequent occurrences of poplars and willows. Forest clearing in Banat during the 18th and 19th and even 20th centuries was the consequence of colonization and water drainage. Jovanovic (1962) and Vasilic (1980) claim that greenery outside forests in Vojvodina must have, first of all, the function of land stabilization and increase in crop yield. According to Jovanovic, this function is expressed in the alleviation and removal of the influence of extreme climate: winds - drying and wind erosion; insolation - heat, drought, evaporation; rainfall - moisture, floods and swamp formation. It is also well known that ecological stability, and especially the individual factors of habitat conditions of soil and water balance in Vojvodina, are undermined due to, among other things, pronounced poor condition of forests and non-forest greenery, because these functions are proportional to dendromass production (Vuckovic, 1997).

Forest areas occupy about 130,000 ha or 6% of the total area in Vojvodina and they are reduced to separated localities in river inundations (Danube, Sava, Tisa, Begej, Tamis, Bosut), premountain and hilly parts of Fruska Gora and Vrsacki Breg, as well as two Sands (Deliblatska Pescara and Suboticko-Horgoska Pescara) (Figure 2). In addition to the above forest areas (previously mentioned localities) in Vojvodina, there are forests owned by organisations or individuals, which can be classified as non-forest greenery, because their main purpose does not include forestry. This type of forests accounts for only 10% of the total forest area, or 0.43% of the area of Vojvodina.

Plantations are usually the first step in converting treeless areas to forest cover. In Vojvodina, there were large programs of tree planting, like in China (Richardson, 1990; Peng and Coster, 2007), USA (Stanturf and Madsen, 2002), New Zealand (Wilkinson, 1999) and Russia (Belyaev, 2007). The General Plan of forest belt establishment was adopted in order to improve the condition of non-forest greenery (Simunovic, 1967*).* It was estimated that altogether 70,749 ha of forest shelterbelts should be established by the mentioned plan: in agriculture 51.8% (36,666 ha), water management 35.9% (25,374 ha), traffic 5.6% (3,973 ha), railways 0.3% (236 ha) and municipal services 6.4 % (4,500 ha). According to this program, Banat (eastern part of Vojvodina) was assigned the greatest area of non-forest greenery that is approx. 29,576 ha (41.8%), Backa (northern part of Vojvodina) - 20,052 ha (28.3%) and Srem (southern part of Vojvodina) - 20,131 ha (30.9%) of the total predicted area. Vlatkovic (2001) claims that the location of non-forest greenery in Vojvodina presents a particular problem. The most fertile soils in central Srem and Backa sub-regions, as well as in central and northern Banat sub-region, are forestless, with no climatic factor regulators and with no positive impacts to air in the atmosphere. For this reason, the establishment of forest greenery and the protection of soil, as the most important natural resource (Hadzic and Antonovic, 1993) of human

Figure 2. Forests in Vojvodina (Orlovic et al., 2005).

living and working spaces, present the possibility of nature protection that is ecosystem balance, as the condition for survival of human population and the living world. The solution for solve the problem is establishment agroforestry systems in order to to create integrated and sustainable land-use systems. Pilot projects across the globe clearly show that agro-forestry - tree plantation on small farms can improve environment protection, and enhance security in food production (Editorial Ecological Engineering, 2007).

Relationships among forestry, protection greenery and nature protection

The natural heritage of Vojvodina is extraordinarily diverse with important ecosystem, species and genetic diversity. In the area of Vojvodina there are extraordinary natural and landscape features, specific for South-East Europe, such as the Deliblato Sands (the largest Sand area in Europe), the mountains Fruska Gora and Vrsacki Breg and the rivers Danube, Sava, Tisza, Begej, Tamis and their floodplain zones (Apatinski Rit, Monostorski Rit, Koviljski Rit, Obedska Bara, Carska Bara, etc.), the steppe zones in central and northern Banat, loess areas along the Tisa and Danube rivers (Titelski Breg, Slankamen, Surduk).

The basic network of protected areas, special centres of autochthonous biological diversity are consists of about 200 spatial entities, covering 5.5% of the total Province area. They are: the National Park "Fruska Gora"

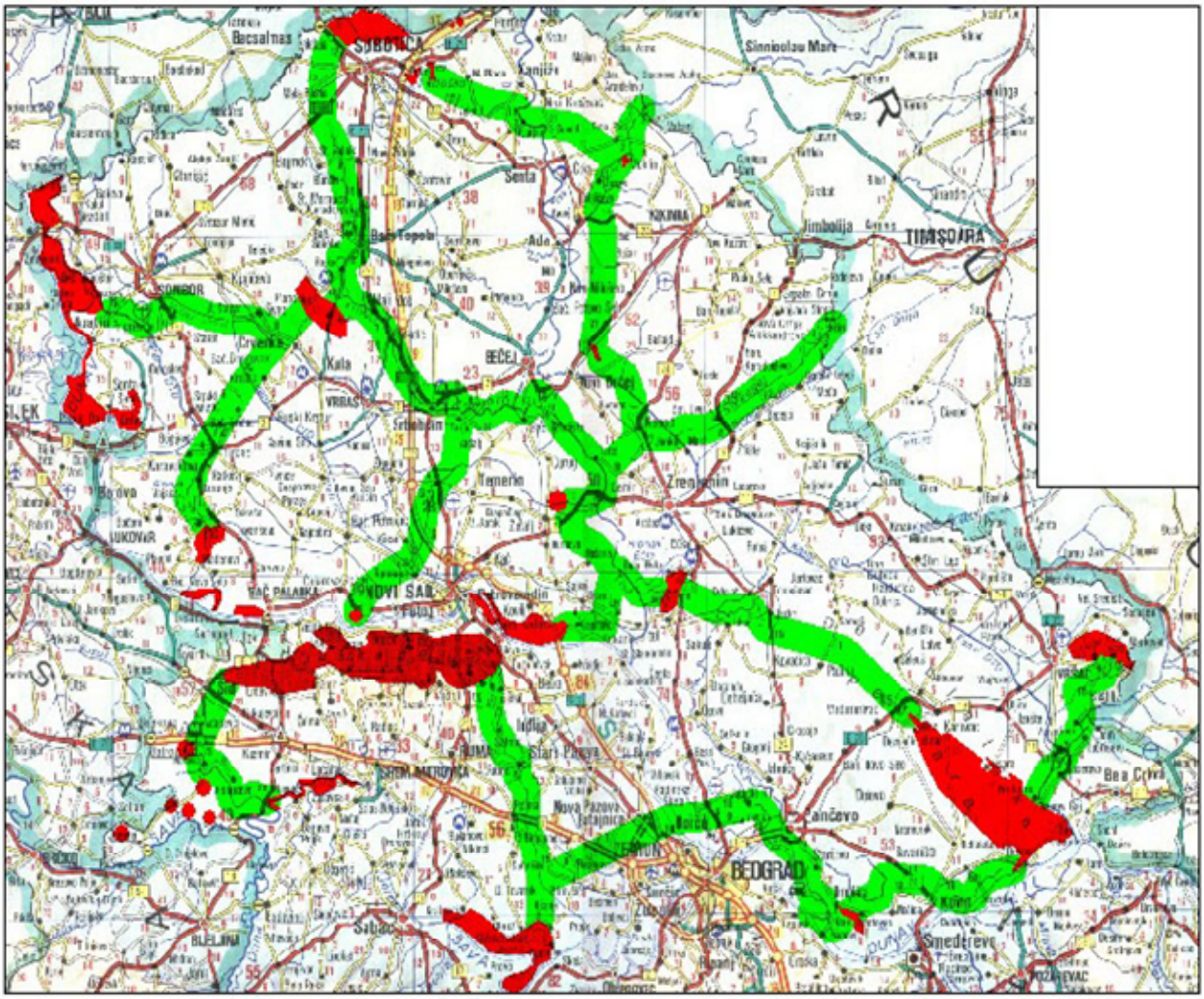

Figure 3. Potential greenways in Vojvodina (Orlovic et al., 2005). Legend: Red colour are protected areas; Green colour are potential greenways.

with 25,393 ha of protected area, Special Nature Reserve "Gornje Podunavlje" with the protected zone on 19,611 ha, Special Nature Reserve "Koviljsko-Petrovaradinski Rit" with the protected zone on 4,840 ha, Special Nature Reserve "Karadjordjevo" on the area of 2955 ha, Special Nature Reserve "Zasavica" with the protected zone on 1,150 ha, Special Nature Reserve "Deliblatska Pescara" on 34,829 ha. Forests are protected on 88,774 ha, which means that 68% of forests in Vojvodina are covered by some level of protection. The above areas are excluded from the regular forest management and all works need special approval.

In the above areas, the following three different ways of forest ecosystem and protective greenery management are possible: 1. Maintaining the state without interventions, so that wood volume of poor quality is produced under optimal habitat conditions – the principle of green organizations; 2. Further management using the previous method, with no interventions regarding the species being renewed, only to maintain forest stands or the stands of the same species; 3. Based on the principle of sustainable development: gradual return of autochthonous forests, application of integral forest protection, establishment of stands using approved reproduction material, protection of valued woody species (and not only annual plants) and balanced hunting stock.

Protected areas outside forests are: Special Nature Reserve "Ludasko Jezero", Special Nature Reserve "Stari Begej-Carska Bara", Special Nature Reserve "Selevenjske Pustare", Special Nature Reserve "Pasnjaci Velike Droplje", Special Nature Reserve "Slano Kopovo" and Natural Monument "Dunavski Park". They occupy altogether 3,470 ha.

Sustainable management of protected areas is possible by the establishment of eco-corridors forming the ecological network (Figure 3). The potential eco corridors are

described by Orlovic et al. (2005).

SUMMARY AND RECOMMENDATIONS

Soil erosion leads to the degradation of fertile lands. The reason is the unorganized land use and a low percent of forested land. It is evident that plantation establishment can arrest erosion and promote restoring systems. Land use change in future requires a program of afforestation of agricultural land.

Plantation establishment by afforestation is an important step towards the establishment of tree cover on degraded land and soil protection. Afforestation in Vojvodina almost always depends on soil characteristics. Potential soil types for afforestation are humogley and halomorphic soils such as solonetz. The selection of tree species for the afforestation of halomorphic soils in Vojvodina is a special problem, considering the very low productivity, as the consequence of a series of unfavourable properties of this site type. The potential level and character of this site type utilisation in forestry is restricted by low productivity.

For the sustainable management of protected areas, it is necessary to establish eco-corridors and in this way to establish the ecological network. In this way, the area covered by trees will be increased, the diversity will also be increased and the processes of soil degradation will be reduced. It is also essential to favour native species adapted to ecological conditions of the region, find the natural mixture of native species for planting and sequence the time of planting. These will be the most important activities in future land use changes in Vojvodina leading to agroforestry systems which combine agriculture and forestry and create integrated and sustainable land-use systems.

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