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Agroforestry in practice



AGFORWEB

AGFORWEB - Agroforestry practices in West Balkan for sustainable development:
weaknesses and strengths

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Agroforestry

Agroforestry is a combination of forestry and agriculture and implies combining permanent plantations of woody crops with arable crops or domestic animals on the same production area. By introducing woody species to agricultural areas, we directly affect the temperature, humidity, insolation and wind flow inside the plantations (microclimate), which results in a greater resistance of plants to stressful conditions such as climatic extremes (drought, flood). Thus, agroforestry has a positive effect on the ecosystem.

Agroforestry practices

The most common forms of agroforestry in Croatia are:

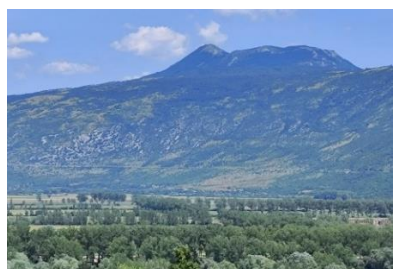
- Silvopastoral agroforestry
- Silvoarable agroforestry
- Windbreaks
- Forest farming

Silvopastoral agroforestry implies grazing of domestic animals in the forest or under the protection of forest trees. It is also the most common form of agroforestry in Europe, primarily due to the large areas in Spain and Portugal (Dehesa and Montado) where cattle are grazed in cork oak forests.

Silvoarable agroforestry implies the production of agricultural crops together with woody species (intercropped). This form of agroforestry is widely represented in tropical regions, but it is becoming more and more interesting in our region as it provides protection from more frequent climatic extremes and offers diversification of production.

Windbreaks are rows of trees that have the function of protecting agricultural land from wind erosion. They are very useful in coastal Croatia, where wind erosion and salt water greatly affect agricultural production.

Forest farming implies raising forest plantations for the purpose of growing culinary and medicinal plants.



Picture 1. Windbreaks



Picture 2. Silvoarable AF



Picture 3. Silvopastoral AF



Agroforestry in Croatia

Silvopastoral agroforestry in Croatia

Silvopastoral agroforestry in Croatia mainly refers to keeping pigs in the open semi forested areas, but also other types of domestic animals (horses, cattle, sheep, goats, donkeys) in forests or partially forested areas, including maquis and low forests in coastal Croatia.

Breeds of domestic animals suitable for silvopastoral farming are primarily traditional and autochthonous breeds such as Turopoljska pig, Black Slavonian pig, Banija šara pig and mangulica, Slavonian-Srijem podolac, Istrian boškarin, domestic goat, Pramenka sheep, Posavina cold-blooded or domestic donkey.

Due to their resistance and more modest needs, these domestic animals make good use of areas overgrown with forest vegetation and the food available to them there.

Pig keeping is mainly carried out in oak and beech forests and is seasonal (autumn and winter months), when there are enough fruits in the forests (acorns, beech trees, chestnuts, wild fruits, insects, gorse, etc.). If pigs are kept in forests throughout the year, then it is necessary to combine this system with pastures and stubbles and supplement feeding. The silvopastoral system implies constant monitoring of animals and mandatory confinement in pens overnight.



Picture 4-6. Silvopastoral system of Banija šara pig, Black slavonian pig and mangulica

The goal of the silvopastoral system is to enable animals to eat in free-range conditions, but without degrading forest and pasture areas. Therefore, the number of animals per unit area is limited, depending on the state and stage of the forest or pasture. The advantages of such systems are smaller financial investments in facilities and food, ecological acceptability and breeding in accordance with animal welfare criteria. Pigs are useful animals for the forest as they loosen the forest floor with their burrowing, spread the seeds of plants and trees, fertilize the forest floor, destroy harmful insects and prevent the forest from becoming overgrown. However, one of the biggest advantages of this way of holding is the improvement of the quality of muscle and fat tissue due to movement and feeding with forest fruits and grazing. Today, the most expensive pork and pork products in the world are obtained precisely from pigs kept in silvo-pastoral conditions.

The disadvantages of such a system are more difficult animal control, the possibility of damaging tree saplings, crossbreeding with wild pigs, and the possibility of transmission of infectious diseases.

In the continental part of Croatia, there is an initiative to support the breeding of autochthonous breeds of pigs that are kept outdoors with the aim of producing high-quality meat and meat products. These are the areas of Turopoljski lug (Turopolje pig), Banija and



Lonjsko polje (Banija šara pig) and the area of oak and beech forests as well as the pastures of eastern Croatia (black Slavonian pig and mangulica). However, due to cheap imported meat and relatively weak purchasing power, the meat of these breeds cannot reach the desired and adequate price that would ensure the profitability of farming in this way.

These two problems are the main obstacles in the future development of silvopastoral practice. If we manage to reduce the damage caused by grazing in olive groves and if the growers get an appropriate price for the meat produced from silvopastoral farming, we can expect the development of silvopastoral practices in Croatia. Although agroforestry as a practice is still not fully recognized in Croatia and there are many obstacles in the development of such systems, below we present several positive examples of silvopastoral agroforestry that can serve as a source of information.

- *Kumparička farm near Krnice in Istria*

Goats are bred at the Kumparička farm with the aim of producing goat cheese. About three hundred goats graze freely in the forest on an area of about 200 ha. Part of the forest land, about 160 ha, is leased by the owners of the agricultural farm from Hrvatske šuma d.o.o. with the aim of grazing livestock, and the rest is in their ownership. These are very inaccessible terrains, mainly oak forests and thickets, ideal for the development of goat farming. Goats give up to 500 liters of milk a day, and with careful processing, the result is world-renowned and awarded organic cheese.



Picture 7. Goats at Kumparička farm

- *Family farm Maliki at Nature park Učka*

The family farm Maliki has been producing sheep's cheese in the village of Pilati on Mala Učka for half a century. Their 600 sheep can be seen grazing freely in the forests and pastures of Učka during the season, and in winter they stay in Istria, near Vodnjan. It is about 68 ha of forest land that they have on lease from Hrvatske šuma L.t.d. Their Učka cheese has a certificate of organic production.



Picture 8. Sheep grazing at Nature park Učka



Silvoarable systems in Croatia

The eastern part of Croatia, often referred to as the bread basket of Croatia, during the centuries has been transformed from forest land to agricultural land. Trees, including hedges, were removed leaving a landscape of endless agricultural fields. In the 1960s, the Forestry Institute investigated the possibility of seeding field crops into young poplar stands. These tests showed that the profitability of seeding in the rows of poplar plantations is best for the first few years, i.e. after the fourth year, crop yields decrease due to the influence of shade, but also due to the absence of mineral fertilization (Bura, 1962) (Picture 9). Today, such sowing between trees can only be found when establishing permanent walnut plantations (picture 10). A walnut orchard can have a distance of up to 12 m between rows, which enables a longer period of inter-row seeding of field crops. The new law on short rotation coppice (SRC) also enables the establishment of rows of SRC at wider intervals and sowing between rows (Picture 2).



Sl. 4. Plantaža topola 1-214 u drugoj godini sa kukuruzom. »Španjolska ada«. S. G. Osijak. (Foto: ing. D. Bura)

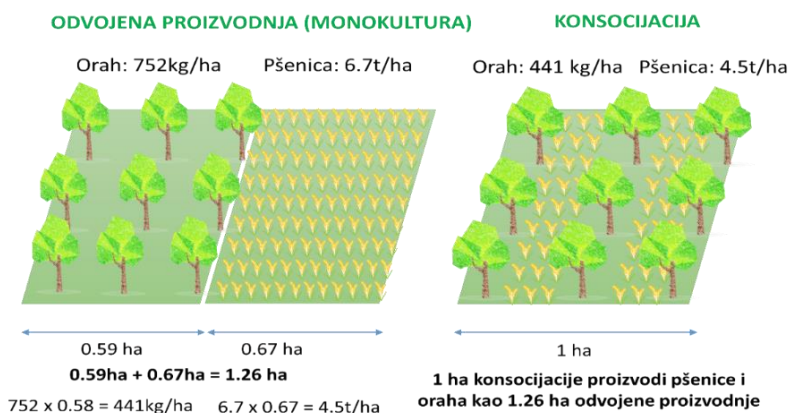
Picture 9. Alley cropping poplar/maize



Picture 10. Alley cropping walnut/wheat

In order for alley cropping to have an advantage over individual monoculture systems, the land equivalent ratio - LER must be higher than 1.

$$LER = \frac{\text{tree yield} - \text{alley cropping}}{\text{tree yield} - \text{forest}} + \frac{\text{crop yield} - \text{alley cropping}}{\text{crop yield} - \text{monoculture}}$$





Windbreaks

The coastal parts of Croatia are under frequent impact of strong winds (Bura and Jugo). In order to protect the agricultural areas from strong gusts of wind, windbreaks were erected. Windbreaks are installed as barriers made of rows of trees or bushes that are planted with the intention of reducing wind speed, reducing evapotranspiration, protecting against erosion and generally providing more favorable habitat conditions.

- *Sinjsko polje Windbreak*

The most famous example is the windbreak of Sinjsko polje, which was erected in the period between 1951 and 1971. In the ten-year period (1951-1961), about 42,000 poplar seedlings were planted in Sinjsko polje, with which numerous rows of trees were formed, with a total length of about 140 km (Figure 1). Today, these rows of trees have almost completely disappeared due to illegal logging and exposure to drought, and the tree lines have not been renewed (Tomašević, 1996.).

- *Čepić polje Windbreak*

The Čepić polje is located at the foot of the Učka mountain, next to the village of Polje Čepić in the municipality of Kršan. It was created in 1932 by the drying up of Lake Kožljačko. The ameliorative part used in agriculture is about 1,800 ha, and it was turned into arable field by building a system of drainage canals. Due to a strong wind-influenced soil erosion, in 1934 the planting of Euro-American poplars (*Populus x canadensis* Moench) was initiated. Most of the poplars were planted in the 1950s. Since poplars provide the best wind protection when they are grown in rotations of 25-30 years, and their average age today is over 60 years, it is evident that their physiological power is extremely weakened. Most of the poplars are in very bad condition and need to be replaced. It is estimated that around 2,000 new tree seedlings need to be planted. Likewise, it is considered that this species is not the best choice for this location because after its leaves fall, it no longer provides adequate protection from the wind in the winter months.



Picture 11. Windbreaks at Čepić polje



Forest farming

Forest farming agroforestry is the deliberate cultivation of edible, medicinal or ornamental plants in the ground layer of natural or planted forests, which are managed with the aim of producing both timber and ground crops at the same time. Forest management is carried out in such a way as to create more favorable conditions for the development of the ground layer through pruning, thinning or additional planting of trees. This makes it possible to generate additional short-term income on the same area while growing high-quality wood in parallel. There are 5 categories of crops that can be grown in the ground layer:

- food: mushrooms, vegetables, fruits, nuts, herbs, honey, edible flowers
- wood products: charcoal, firewood, special wood (eg for carving), garden mulch
- decorative products: decorative greenery (moss, fern, bear grass...), Christmas trees, plants for coloring
- medicinal plants: numerous plant species used in herbal medicine, production of medicines and essential oils
- handicrafts: materials for making baskets, poles

Agroforestry changes the forest ecosystem to a certain extent, but does not significantly affect its key features such as water filtration, influence on the microclimate, prevention of soil erosion and wildlife habitat. Examples of forest farming:

- *Truffles plantation near Buzet, Istra*

The Karlić family in the village of Paladini near Buzet was the first in Croatia to embark on a project of plantation cultivation of black truffles. About 15 years ago, they planted seedlings of three types of oak mycorrhized with black (*Tuber melanosporum*) and summer (*Tuber aestivum*) truffles. Mixed oak forests are the natural habitat of the black truffle. In total, they have planted around 2,500 mycorrhizal trees in several locations around Vrh. In addition to the truffles themselves, the plantation is also used for tourist purposes, as a location for demonstrative truffle hunting.



Picture 12. and 13. Truffle plantation Karlić

- *Production of honey from forest species in Family farm Koren and Šestan*

Family farm Koren is a farm from Katun Trviški that has been producing honey for three generations. They produce honey from forest species such as acacia, linden and chestnut, but



they also make flower honey and a honeypot. After the end of the acacia flowering, bee grazing is limited in Istria, so they transfer their beehives to grazing outside Istria, primarily for chestnut and linden honey. Grazing locations are most often rented from private forest owners, and sometimes they also use locations owned by Croatian Forests Ltd. On several occasions, they received gold medals for their honey. By establishing her own Family farm in Gologorica near Cerovlje, Lorena Šestan continues the family tradition of beekeeping.



Picture 14. Beehives at Cerovlje in Istria

Establishment of agroforestry systems

The trend of extreme temperatures requires adaptation of agricultural production to the upcoming climate changes. One type of production that can cope with such changes is the Agroforestry system, where the production of field crops and domestic animals is carried out under the protection of the crown of woody species. To build agroforestry systems, it is essential to understand the needs of agricultural crops and forest woody crops in order to build the most stable systems with the greatest potential.

Establishment of silvopastoral systems

As for incentives for keeping domestic animals in the silvopastoral system, they are indirect and it is possible to obtain relatively high subsidies. In these conditions, it is possible to keep only autochthonous and traditional breeds, and their breeding in Croatia is encouraged through grants for the preservation and improvement of these breeds of domestic animals. Also, this way of keeping ensures breeding that complies with most of the welfare criteria of domestic animals (keeping in the open, movement, access to fresh air, etc.), and these are the criteria through which relatively high amounts of support from European funds can be obtained. In Croatia, there is still no adequate legal regulation that would fully encompass and regulate this segment of livestock production.

Establishment of silvoarable agroforestry

When planting alley cropping systems with crops and trees, it is necessary to take care of the distance between rows of trees, which should be wide enough not to interfere with agricultural machinery. Also, it is important to harmonize the vegetation cycle of tree and field



crops. From field crops, it is best to choose winter crops whose vegetation does not overlap with the vegetation of woody species. Winter wheat and walnut are a great combination. Wheat is sown in the fall, when the leaves of the walnut have fallen, and in April, when the walnut leaves again, the wheat is already in the budding stage and the shade no longer bothers it. The yields of field crops in such systems are 10%-50% lower than on arable land without trees, but the loss of crop yield is compensated by the yield of wood so production in such systems is actually higher. From woody species, short rotation coppice (SRC) plantations can be established with tree rows in wider intervals. The establishment SRC plantations is included in green payments, which encourages agroforestry practices.

Table 1. SRC species approved by the Croatian legislation

Tree specie	Max rotation	Reproduction material
Alder	8	seedlings
Birch	8	seedlings
Hornbeam	8	seedlings
Miscanthus	1	Rhizons/seedlings
Poplar	2-5	seedlings, cuttings
Willow	2-5	seedlings, cuttings
Paulownia	1-4	seedlings, cuttings

Establishment of windbreaks

When establishing windbreaks, it is necessary to take into account the relief, the speed and direction of the winds, the biological and ecological characteristics of the species and the composition with other elements of the landscape. One of the main prerequisites for success in raising the belt is the use of indigenous tree species, adapted to the habitat conditions.

Depending on the location and type of soil, windbreaks are most often built from the following plant species: maple, linden, ash, poplar, mulberry, acacia, birch, hazel. These are trees that have a dense and high canopy. However, evergreen species are preferred, due to their functionality throughout the year. These can be, for example, cypress, pine, cedar, thuja. Plant species for constructing windbreaks should be fast-growing, adaptable, and in areas by the sea, resistant to salt. The root system must not spread too much laterally to avoid competition with cultivated crops, but at the same time must be robust to withstand gusts of wind. Shelter belts can be single-row or multi-row, and the maximum number of rows is 5. The number of rows depends on the strength of the wind in an area. The main or zonal windbreaks with the largest number of rows are placed at a distance of 200 to 300 m. Behind the main windbreaks come barriers with a smaller number of rows, up to single-row barriers. Many variations in the construction of windbreaks are possible, depending on local conditions, but the most important thing is that the main windbreaks are placed perpendicular to the prevailing wind. This means that, for example, in the entire Mediterranean part of Croatia, windbreaks should be placed perpendicular to local winds *bura* and *jugo*, i.e. northwest-southeast or northeast-southwest. On sloping terrain, planting takes place perpendicular to the slope, and in these cases, shelter belts also serve as protection against soil erosion by water.



Raising windbreaks is expensive, requires a long period of care and becomes effective after many years. However, with adequate maintenance and direction of growth and development, shelter belts will fulfill their many positive functions.

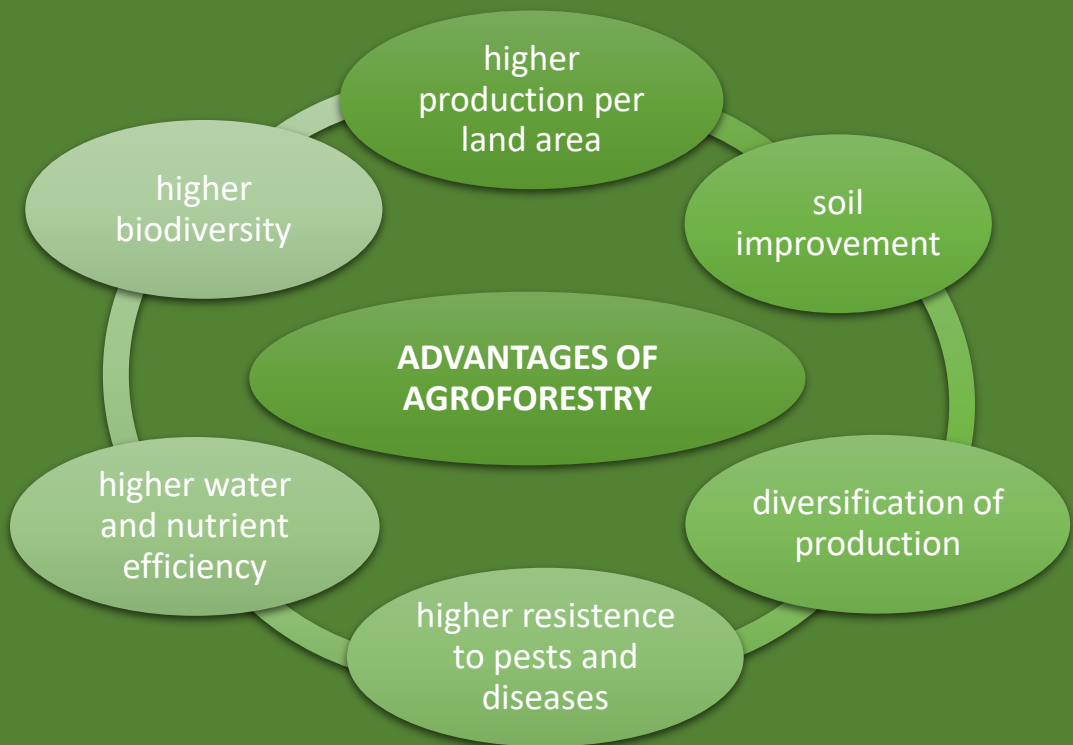
Establishment of forest farming

We will show the formation of forest farming through the example of a truffle plantation. The establishment of truffle plantations represents a combination of forestry and agricultural practices, as it involves raising plantations with inoculated seedlings of commercial forest tree species on agricultural land. In addition to agricultural land, inoculated seedlings can also be used in afforestation, but due to the absence of agrotechnical measures, they will be planted in this way for the purpose of increasing the stability of the forest ecosystem, when protecting forest areas from degradation, soil erosion, rehabilitation of landslides and burnt areas etc.

Forest economic tree species (oaks, hornbeams, hazels, pines, etc.) are inoculated with truffles from the group of black truffles (black, summer, late, winter, etc.), while inoculation with truffles from the group of white truffles is still the subject of numerous studies. Truffle plantations are established on agricultural land, depending on the type of truffle, on slightly acidic, neutral and alkaline soils. In addition to the pH reaction, a favorable soil structure is also required, so such soils will be carbonate soils, with a smaller proportion of clay and a larger proportion of dust and sand. The planting distance also depends on the type of truffle, and it can be from 3.5×3.5 m to 6×6 m. Irrigation with sprinklers is mandatory during the dry and hot summer months. In addition to inoculated seedlings, medicinal, aromatic and honey-bearing plants can also be planted on truffle plantations for the purpose of connecting the mycelium within the rows (e.g. rock roses) or as protection against infection by less valuable truffle species from the surrounding natural habitat (e.g. lavender). Such seedlings will contribute to soil aeration and reduction of its compactness. The management of truffle plantations must not be agrotechnically intensive in order to reduce the risk of damaging the roots and destroying the mycelium of the mushroom, and apart from occasional mulching, loosening the soil and the possible intake of calcium carbonate for the purpose of stabilizing the pH value, all large interventions characteristic to intensive agricultural production should be avoided. With a newly established truffle plantation, it is extremely important to monitor the development of mycelium by non-invasive methods (microscopy of a root sample or PCR and qPCR soil analyses), while the first truffle yield can be expected in the fifth or sixth year after the foundation of the plantation.

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