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ANALYSIS OF THE POSSIBILITY OF SWITCHING TO AGROFORESTRY IN ZSELIC

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ABSTRACT

Agroforestry solutions offer better use of disadvantaged agricultural land. Steep slopes and the constant risk of game damage are not conducive to agriculture. On slopes, the cost of machine operating hours is higher than on plane areas, and machines also wear out faster due to higher loads. Varied topography, steep slopes and deep valleys characterize the examined Zselic hills. There is typical forest management on the steep slopes that results in higher opportunity for game damage in the agricultural areas surrounded by forests. There are steep slopes under agriculture cultivation too that involve high operating costs. In our article, we examined whether the actual steep areas under current agricultural cultivation (slope> 12%) are large enough to consider switching to agroforestry. We have found that a quarter of all agricultural areas included in the examination is located on steep slopes, where it is worth considering switching to game damage-resistant agroforestry.
Keywords: agricultural cultivation, steep slope, game damage, agroforestry, Zselic

INTRODUCTION

Agroforestry solutions

If we believe the forecasts, by 2050, the global food demand will have risen by 60%. Because of this, we must use sustainable technology for the agriculture to be able to supply the rising population with food (*van Kernebeek et al.*, 2016). The idea of agroforestry - which could be the tool for creating sustainable, environmentally friendly agriculture – is stated by the European Parliament as: „The agroforestry is a land use and farming system in which the woody vegetation is in conscious connection with the crops or with the grazing livestock on the same field while permanent forest stocks are not created. The trees can be placed scattered, in rows or in groups, while grazing is possible between them on the parcel (silvoarable (crops and forest), silvopastoral (grazing and forest), grazed or alley cropped fruit plantation) or on the edges of the adjacent parcels (tree rows and hedges)” (1305/2013/EU regulation).

These systems contribute to nature protection in a number of ways, such as integrating cropland with trees, creating a mosaic landscape structure, reducing soil erosion and deflation, promoting biodiversity, and binding carbon. (*Sharma et al.*, 2016)

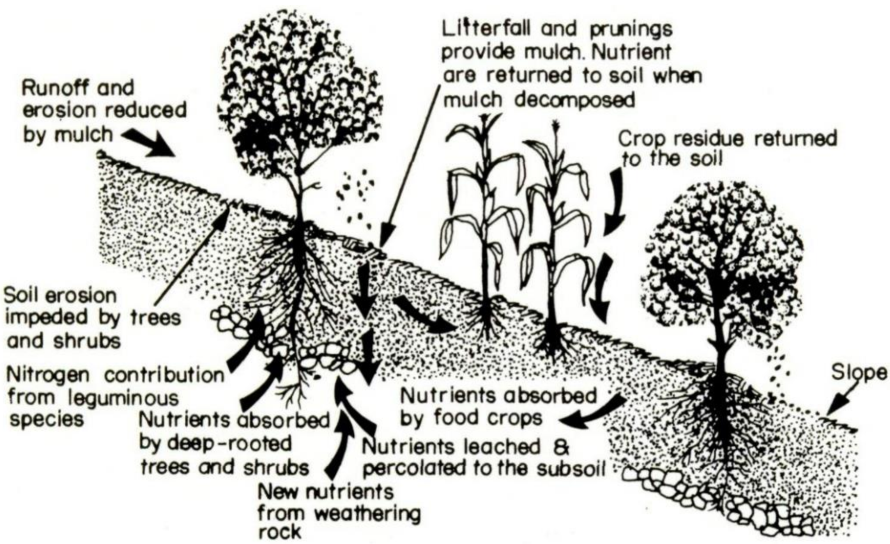
The practice of the combination of trees with agriculture or livestock measures an estimate of 1 billion hectares worldwide, of which 15.4 million hectares are agroforestry in the EU. In most of the areas, i.e. 15.1 million hectares, trees are combined with animal husbandry, while the remaining 358,000 hectares are integrated into arable crop production. (*Augère-Granier*, 2020) 38,100 hectares of Hungary is affected by agroforestry (*den Herder et al*, 2016).

Agroforestry on the slopes

The land may suffer serious damage if in the absence of proper protection and prevention it loses a part of its fertile soil: rainfall, wind, erosion all could cause scars on the topsoil, which can lead to the deeper absorption of the agricultural chemicals and fertilizers to the point where the crop cannot even reach it. Thus, the chemicals can reach further to the ground waters. The trees with their penetrating roots, however, not only protect the soil from erosion – holding the deep layers together – but also, as a safety net, gather the micro- and macro materials washed deep which the crop could not absorb. (*Zamożny*, 2018).

One of the first documented cases of alley cropping was published in Nigeria in 1983: in order to stabilize the soil on the steep croplands they planted rows of a ligneous mimosoid tree *(L. leucocephala)* between the rows of crops. Thanks to the fast growth of the mimosoid, it was possible to use the product of several annual prunings as mulch (*Figure 1*) (*Sumberg & Okali*, 1984). The ligneous mimosoid's deep roots bound the soil and the mulch used to cover the soil protected it from deflation and erosion. As the mulch degrades, it releases nutrients into the soil – or the mulch can also be used as forage (*Steppler & Nair*, 1987).

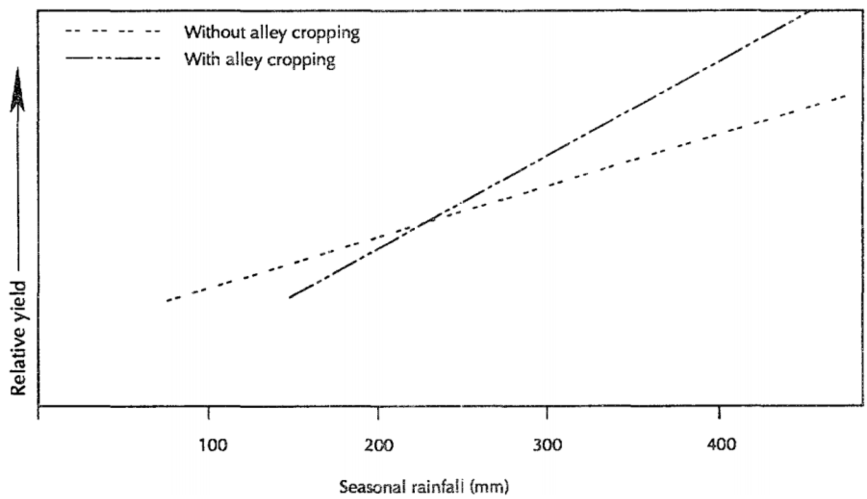
Figure 1: Schematic representation to show the benefits of nutrient cycling and erosion control in an alley-cropping system.



Source: *Kang et al.* (1986, p. 18.)

There are several factors which may limit the realization of positive effects. The most important of those is soil moisture. In the subtropical regions the higher annual rainfall and humidity leads to more potential harvests and green mass. In contrast, in the temperate zone the annual rainfall is unimodal and tends to fall over a 4-month period. Naturally, the rainfall has an effect on the relative yield which can be increased further with alley cropping (*Figure 2*). (*Nair*, 1993)

Figure 2: A generalized picture of crop (maize) yield, with and without alley cropping, in relation to rainfall during the cropping season under semi-arid conditions



Source: *Nair* (1990, 40. p.)

Characterization of slopes

The topography consists of an endless multitude of slopes. To characterize the slopes, the slope angle, i.e. the deviation from the horizontal position, can be given in degrees. In practice, the slope is usually given as a percentage. This is one hundred times the quotient of the slope height and the slope base, for example, if the terrain rises 10 meters at a distance of 100 meters, we are talking about a 10% slope (*Mélykúti*, 2010). In geodesy, 5 spatial categories are named as a function of percentage slope (*Table 1*).

Table 1: Classification of slope categories

Slope category	Slope gradient (%)	Classification
I.	0-5.0	plane
II.	5.0-12.0	slightly sloping
III.	12.0-17.0	sloping
IV.	17.0-25.0	slightly steep
V.	25.1-	steep

Source: *Márkus & Sárközy* (1986)

The machine cost of agricultural cultivation depends on the soil type and the slope of the field. The exact extent of this can only be determined by using values measured in precision farming. For costs without measurement, the current Government Decree (Government Decree 60/1992. IV. 1.) on the amount of fuel and lubricant consumption of road motor vehicles and certain agricultural, forestry and fishery power engines eligible without certification" provides guidance. The slope interpretation of the topography in the Decree is given in *Table 2*. Interestingly, although the values within the category are the same in both cases, the current regulation does not name slopes above 17.0 percent. Perhaps they did not want to specifically support farming in areas with higher slopes.

Table 2: Interpretation of topography by slope

Denomination	Slope gradient (%)
Flat area	0-5.0
Slight sloping area	5.1-12.0
Sloping area	12.0-17.0

Source: Annex 4 to Decree 60/1992. (IV. 1.) Government Decree.

The regulation establishes four categories depending on the slope and soil binding (*Table 3*). The legislator classified the soil binding in four categories based on Arany's binding number: loose, medium-bound, bound, highly bound soils.

Table 3: Interpretation of territorial categories

Territorial category	Topography and constraint
I.	flat, medium-bound soil
II.	flat, bound soil slight slope, middle bound soil
III.	flat, loose sand and very bound soil slight slope, bound soil slope of mid-bound soil
IV.	mild slope, loose sand, and well-bound soil sloping, bound and highly bound soil

Source: Annex 4 to Decree 60/1992. (IV. 1.) to the Government Decree

The cost of work performed by agricultural machinery is, at best, a value determined by instruments. Failing this, the value of the cost increases due to soil and topography can be calculated by using multiplication rates. The multiplication rates express how many times the cost is eligible for category I:

- The multiplier for area category I. is 1.
- The multiplier for area category II. is 1.12 for surface works and 1.16 for tillage.
- In area category III., the multiplier is 1.24 for surface works and 1.38 for tillage.
- In area category IV., the multiplier is 1.44 for surface works and 1.72 for tillage. (*Erdeiné Késmárki-Gally & Rák*, 2020)

In addition to increasing costs, environmental protection must also be an important consideration. Sloping areas also require more careful cultivation due to the risk of erosion, such as not plowing downhill.

Agroforestry solutions can be used to farm on larger slopes, which can have the added benefit of being less sensitive to game damage. In the Zselic settlements of Kaposvár Forestry, only about a third of all areas are suitable for agricultural cultivation. (*Barna et al.*, 2021) Due to the large, extensive forests nearby, game damage is also an increased threat. In addition, some of the arable land in the hilly area is on slopes. In this study, we examine the area in which it would be more appropriate to apply agroforestry solutions. For this, we recommend areas with a slope greater than 12%.

MATERIALS AND METHODS

In our study we analysed the settlements in the Zselic area of the Kaposvár Forestry (SEFAG Zrt. – SEFAG Forest Management and Wood Industry Share Co.): Bőszénfa, Cserénfa, Gálosfa, Hajmás, Kaposgyarmat, Sántos, Simonfa, Szentbalázs and Zselicszentpál (*Figure 3*).

For the analysis we used the download free map layers of Open Street Map (*Geofabrik GmbH*, 2021). From the Corine Land Cover database created by the European Union, the former FÖMI (now Lechner Tudásközpont – Lechner Knowledge Centre) produced an improved land cover map called CLC-50, which was also used (*Lechner Tudásközpont*, 2021), and SEFAG Zrt. provided a map of the area under its care.

For the topography characterization, we used the EUDEM 1.1 version, freely available in the European Union's Copernicus programme (*Copernicus Land Monitoring Service*, 2021). From this a slope map was produced.

A map of the Game Management Landscape Center (commonly known as the Deer Farm) area was produced in a previous study (*Barna & Nagy*, 2021).

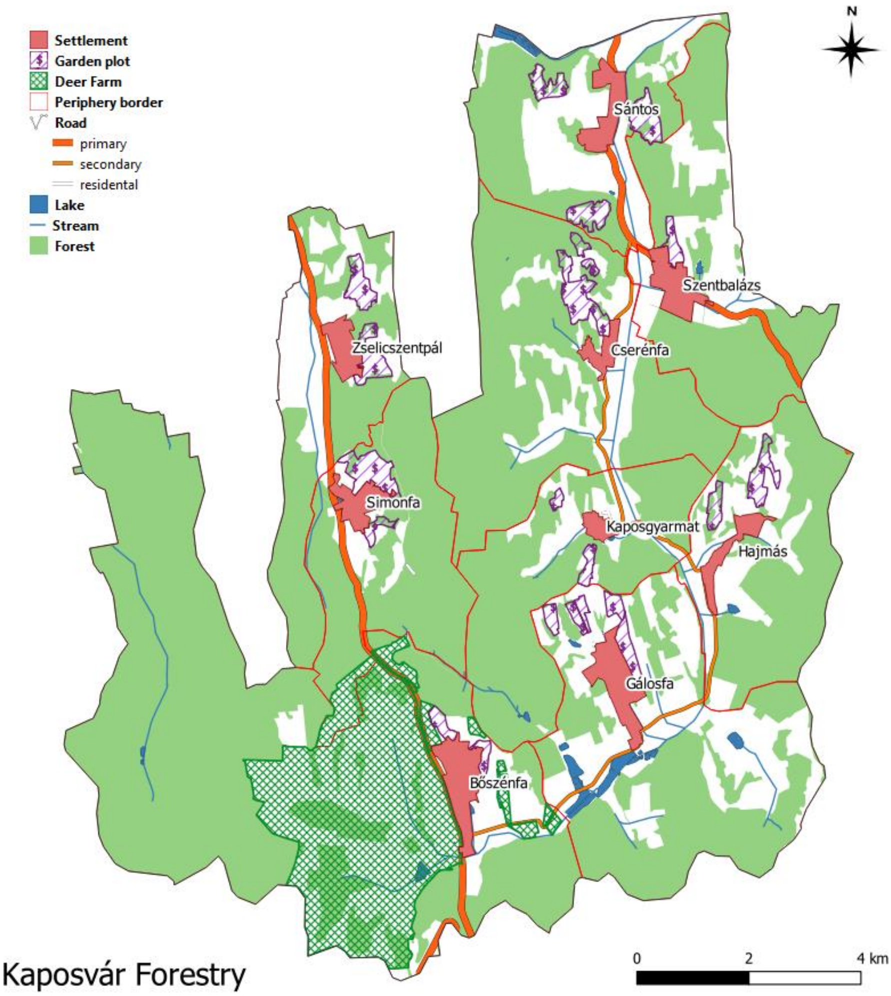
QGIS 3.16 software was used for spatial operations.

RESULTS

Only one part of the study area is suitable for agriculture. It is necessary to extract the inland areas, the enclosed gardens, the forests and the ponds from the total area. The Deer Farm (Game Management Landscape Center) also lies within the study area. Its area is subject to special farming practices that can be considered as agroforestry, so the area of the Deer Farm should be also extracted from the area suitable for agriculture. After these deductions, the remaining areas, marked in white on the map (*Figure 3*), are suitable for agricultural cultivation.

Figure 4 is a more transparent map created from *Figure 3*. The brown areas show which parts of the total area are suitable for agriculture. Although the map could be improved, as the dams among the fish ponds are still brown, the size of these dams is negligible and they do not significantly distort the results. Only 3188.18 ha (21.6%) remain after deductions as agricultural land from the total area of 14749.20 ha.

Figure 3: The map of study area



In the slope map of EUDEM, a special colour indicates slopes steeper than 12% (*Figure 5*). The map clearly shows the varied surface of the hilly landscape. The steeper areas are forested, but there are also quite a few agricultural lands steeper than 12%.

As a last step, the slope conditions of areas suitable for agricultural cultivation were examined. For this purpose, the map of agricultural areas and the slope map have been merged. The slope of the agricultural areas marked in pink in *Figure 6* is greater than 12%. While this is not the vast majority of agricultural land, it is still a large area overall.

The total area of agricultural land with a slope of less than 12% is 2350.80 hectares. The remaining 845.30 hectares with a steep slope represent 26.5% of the total agricultural area. Due to the steep slope, it is advisable to consider the application of agroforestry solutions on more than a quarter of the area currently under agricultural cultivation (*Figure 6*).

Figure 4: The areas which are suitable for agriculture

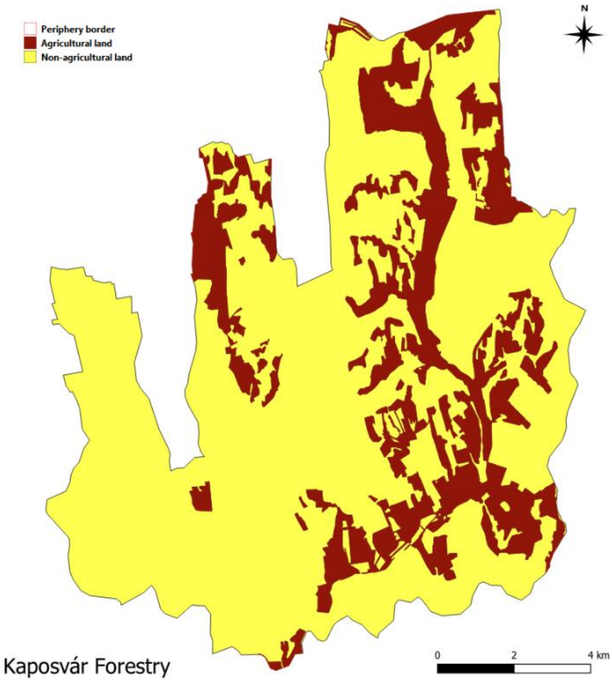


Figure 5: Slope map (%) of study area

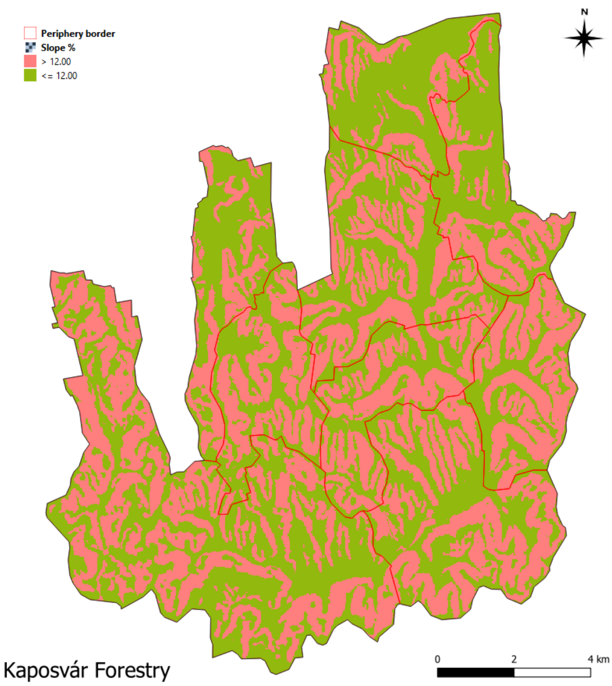
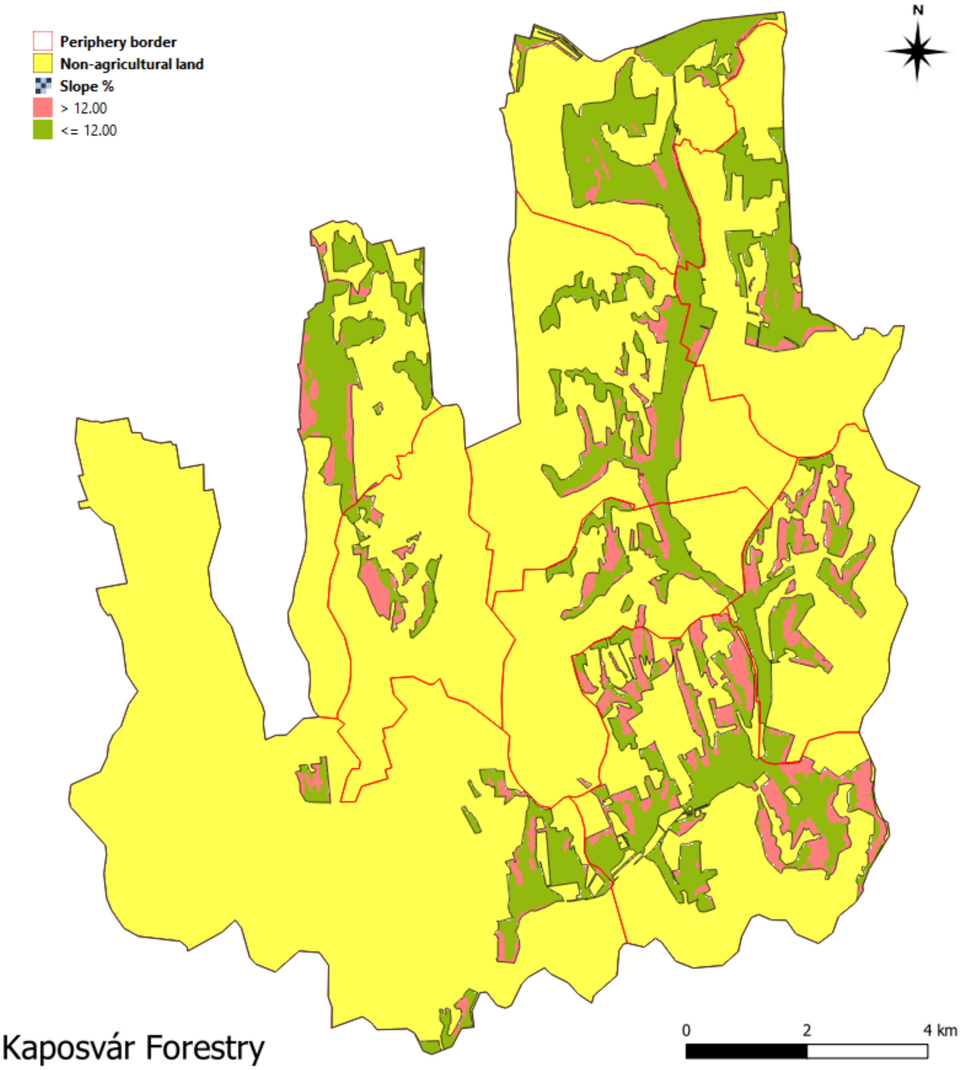


Figure 6: The areas proposed for agro-forestry management



CONCLUSIONS AND SUGGESTIONS

Steep slopes make up a significant part of the study area. They are mainly used for forestry, but more than a quarter of the areas suitable for agriculture are steeper than 12%. We suggest that farmers on such steep hillsides use agroforestry as a transition between forestry and agriculture. This would both reduce machinery costs and be environmentally beneficial by preventing erosion. Another argument in favour of the switchover is the high risk of game damage next to forested areas, which could be reduced by less sensitive crops.

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REFERENCES

60/1992. (IV.1.) Korm. rendelet a közúti gépjárművek, az egyes mezőgazdasági, erdészeti és halászati erőgépek üzemanyag- és kenőanyag-fogyasztásának igazolás nélkül elszámolható mértékéről. https://net.jogtar.hu/getpdf?docid=99200060.kor

Augère-Granier, M.L. (2020): Agroforestry in the European Union. European Parliamentary Research Service (EPRS), Members' Research Service, Briefing June 2020. European Union. https://www.europarl.europa.eu/RegData/etudes/BRIE/2020/651982/EPRS_BRI(2020)651982_EN.pdf

Barna R., Horváthné Kovács B., & Király, M. (2021). A vadkár adatainak térbeli elemzése a SEFAG Kaposvári Erdészeténél. In Horváthné Kovács, B., Barna, R. (Eds.), Agrárerdészet a vidékfejlesztés gyakorlatában (pp. 123-127). Magyar Agrár- és Élettudományi Egyetem, Kaposvári Campus.

Barna, R., & Nagy, J. (2021). A Vadgazdálkodási Tájközpont térképének elkészítése open source adatok felhasználásával. In Horváthné Kovács, B., Barna, R. (Eds.), Agrárerdészet a vidékfejlesztés gyakorlatában (pp. 95-98). Magyar Agrár- és Élettudományi Egyetem, Kaposvári Campus.

Copernicus Land Monitoring Service 2020 'EU-DEM v1.1' https://land.copernicus.eu/imagery-in-situ/eu-dem/eu-dem-v1.1

den Herder, M., Moreno, G., Mosquera-Losada, M.R., Palma, J.H.N., Sidiropoulou, A., Santiago Freijanes, J.J., Crous-Duran, J., Paulo, J., Tomé, M., Pantera, A., Papanastasis, V., Mantzanas, K., Pachana, P., Papadopoulos, A., Plieninger, T., & Burgess, P.J. (2016). Current extent and trends of agroforestry in the EU27. Deliverable Report 1.2 for EU FP7 Research Project: AGFORWARD 613520. 2nd Ed. 76 p. https://www.agforward.eu/index.php/hu/current-extent-and-trends-of-agroforestry-in-the-eu27.html?file=files/agforward/documents/D1_2_Extent_of_Agroforestry.pdf

Erdeiné Késmárki-Gally, Sz., & Rák, R. (2020).: Mezőgazdasági gépi munkák költsége 2020-ban. Gödöllő: NAIK MGI http://technika.gmgi.hu/uploads/termek_1855/mezogazdasagi_gepi_munkak_koltsege_2020_ban_20_04.pdf

Európai Tanács és Európai Parlament 1305/2013/EU rendelete (2013. december 17.) az Európai Mezőgazdasági Vidékfejlesztési Alapból (EMVA) nyújtandó vidékfejlesztési támogatásról és az 1698/2005/EK tanácsi rendelet hatályon kívül helyezéséről. https://eur-lex.europa.eu/legal-content/HU/TXT/PDF/?uri=CELEX:32013R1305&from=HR> [2021. 01. 12]

Geofabrik (2021). Download OpenStreetMap data for this region: Hungary. http://download.geofabrik.de/europe/hungary.html

Kang, B.T., van der Kruijs, A.C.B.M., & D.C. Couper (1986). Alley cropping for food crop production in the humid and subhumid tropics. In Kang B.T. & Reynolds L. (Eds.) Alley Farming in the Humid and Subhumid Tropics Proceedings of an international workshop held at Ibadan, Nigeria, 10-14 March 1986. https://idl-bnc-idrc.dspacedirect.org/bitstream/handle/10625/18668/IDL-18668.pdf

Lechner Tudásközpont (2021). A Nemzeti 1:50.000 méretarányú CORINE felszínborítás adatbázis (CLC50) letöltése. http://uj.lechnerkozpont.hu/doc/corine/CLC50.ZIP

Márkus B., Sárközy F. (1986). Geodéziai AMT. (Jegyzet), Budapest: Tankönyvkiadó
Mélykúti G. (2010): Topográfia 4. – Domborzattan I. Sopron: Nyugat-magyarországi Egyetem https://regi.tankonyvtar.hu/hu/tartalom/tamop425/0027_TOP4/ch01s04.html
Nair, P. K. R. (1990). The Prospects for Agroforestry in the Tropics; The World Bank Technical Paper Number 131. (pp. 77) https://documents1.worldbank.org/curated/pt/150761468741841900/pdf/multi-page.pdf
Nair, P. K. R. (1993). An Introduction to Agroforestry. Kluwer Academic Publishers, http://apps.worldagroforestry.org/Units/Library/Books/PDFs/32_An_introduction_to_agroforestry.pdf
Sharma, N., Bohra, B., Pragya, N., Ciannella, R., Dobie, P., & Lehmann, S. (2016). Bioenergy from agroforestry can lead to improved food security, climate change, soil quality, and rural development. Food and Energy Security 5(3) 165–183. https://doi.org/10.1002/fes3.87
Steppler, H. A. és Nair, P. K. R. (1987). Agroforestry a decade of development. Nairobi, Kenya: International Council for Research in Agroforestry, http://apps.worldagroforestry.org/Units/Library/Books/PDFs/07_Agroforestry_a_decade_of_development.pdf
Sumberg, J.E. & Okali, C. (1984). Linking crop and animal production. A pilot development program for small holders in southwest Nigeria. Rural Development in Nigeria (1) 23-29.
Van Kernebeek, H.R.J., Oosting, S.J., Van Ittersum, M.K., Bikker, P., & De Boer, I.J. (2016). Saving land to feed a growing population: consequences for consumption of crop and livestock products. The International Journal of Life Cycle Assessment. 21, 677–687. https://doi.org/10.1007/s11367-015-0923-6
Zamozny, G. (2018). Agrárerdészeti Ismeretek, Útmutató Környezetbarát és Jövedelmező Gazdálkodási Módszerekhez. https://mek.oszk.hu/18900/18937/18937.pdf

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