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Agroforestry in France: benefits and issues

Agroforestry denotes a form of land use that combines trees with crops on the same plots. Under the second pillar of the CAP, the European Commission has instituted a European support measure for agroforestry covering the years 2007-2013 which will probably be carried forward into the following period, 2014-2020. According to initial estimates, agroforestry might cover up to 10,000 hectares in Metropolitan France by 2013[1]. But what are the real issues today where agroforestry is concerned? Clearly positioned as an agronomic approach rather than as disguised afforestation of farmland, agroforestry puts trees back at the heart of the production system, which has benefits at the level of the individual plot as well as at a broader level, in terms of landscape, biodiversity, adaptation to climate change, and so on[2].

Agroforestry, the association of trees and crops on the same plots of land, can be traced back to antiquity. Some traditional systems of this type can still easily be found in Normandy ("meadow orchards") and in the Dauphiné in south-eastern France (nut groves and intercropping). Agroforestry systems have also been developed in forested areas: examples that can be cited are meadow-woods in mountain regions and pasturage in extensive truffle grounds. In the present context we shall look only at the agroforestry systems developed on farmland. Researchers and ground-breaking farmers have designed modern systems better suited to the present agricultural context. In traditional agroforestry systems, the trees are frequently fruit trees, as in the meadow-orchards still to be found in France[3]. In modern versions, all types of tree – both fruit and forest species – are used in association with crops, the choice depending on the nature of the farming project and the constraints on production. The trees form alleys with a planting density of 30 to 200 per hectare, the precise figure depending on the type of production involved and the farmer's strategy[4]. Choosing to go into agroforestry is not simply to adopt a form of afforestation, but is genuinely a different approach to production on wooded farmland in which trees fulfil agroeconomic functions in the production system.

The current success of agroforestry is understandable given the way farming is evolving and the challenges it is facing. The modernisation and intensification of agricultural methods during the second half of the 20th century led to a leap forward in production, but the artificialisation of environments they entailed also resulted in a high level of dependence on inputs[5]. On the ground, farmers perceive the limitations of this model which are also highlighted by the research: stagnating yields[6], decline in organic matter in large-scale farming soils, regression in auxiliary fauna, increasingly resistant pests and adventitious plants, and so on. Faced with these agronomic issues, new forms of agriculture have emerged (organic farming, seeding under cover, agroecology). For these pioneering farmers, agroforestry can often seem to be a logical extension of their general approach.

For a proper comprehension of agroforestry, it is therefore necessary to assess the role of trees in upcoming developments (in agriculture, land use, the timber market, environmental challenges). This requires thinking for the long term because the added-value is not obtained immediately. Agroforestry can in fact be looked at from four standpoints: direct production (crops, wood, and biomass), the role of trees among agroecological factors of production (improvement of production capital and lower costs, reduction of environmental externalities), the role of trees in combating and adapting to climate change and, lastly, the place of trees in the rural landscape and enhancement of the image of farmers.

1 - Associating trees and crops can lead to more production

Contrary to what might first come to mind, competition between trees and crops is not necessarily something to be avoided. In every scientific study conducted in temperate environments this association turns

1. *Forêt Entreprise,* January 2011 issue.

2. To produce the present overview of goals and issues in modern agroforestry, the CEP has called upon the services of the Agroof specialist research unit and Frédérique Santi, a researcher at Inra Orléans.

3. Eichorn M.P., Liagre F. *et al.*, 2006, Silvoarable systems in Europe-past, present and future prospects, *Agroforestry Systems*, 67, pp. 29-50.

4. Dupraz C., Liagre F., 2008, *Agroforesterie, des arbres et des cultures* [Agroforestry, trees and crops], Éditions France Agricole.

5. Vert J., Portet F., (coord.), Prospective Analysis Agriculture Energy 2030. Agriculture and the challenges of energy, Centre for studies and strategic foresight, Ministry of Agriculture, Food, Fisheries, Rural Affairs and Spatial Planning, 2010.

6. Brisson N. *et al.*, 2010, "Why are wheat yields stagnating in Europe? A comprehensive data analysis for France", *Field Crops Research*, 119, pp. 201-212.

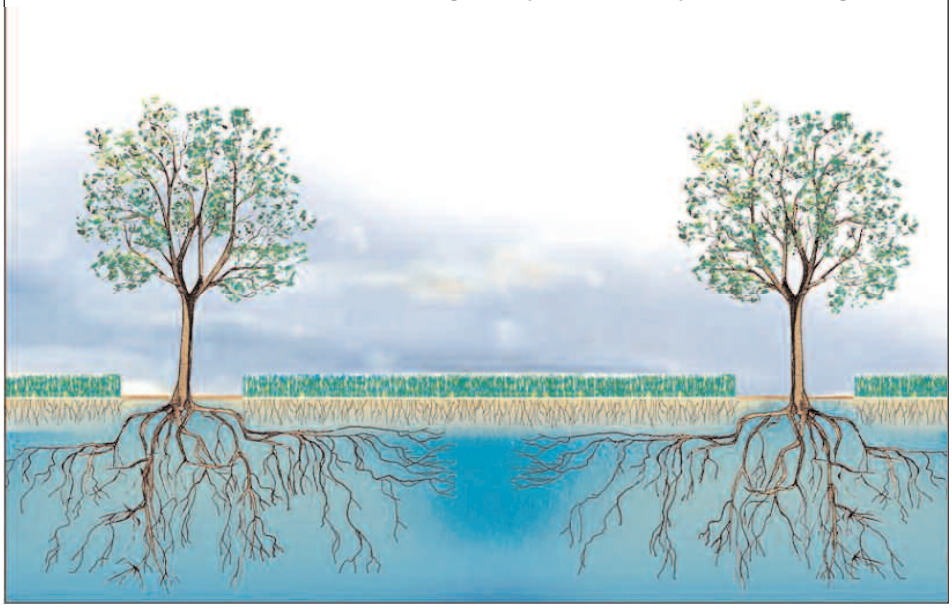
out to be more productive than segregation of crops and trees. A plot farmed using agroforestry methods can for example produce up to 60% more biomass when compared with land cultivated separately[7]. Properly managed competition for light can lead to sustained agricultural production and increased productivity for the trees, which are more deeply and effectively anchored in the soil (cf. figure 1). During the first phase of the trees' life cycle, crop yields are identical to an agricultural control plot. In the second phase, yields decline, more or less sharply according to the planting density. At a density of 50 trees per hectare, the crops remain profitable up to the point at which the trees are cut down.

The high productivity of trees in an agroforestry context, up to two or three times higher than their productivity in a forest, is a source of economic diversification for the farmer. Indeed, with fifty or so trees per hectare, the farmer potentially ends up with 40 cubic metres of timber that can be sold at between € 10,000 and € 20,000 the lot. Depending on the species involved, and especially the quality of the care given to the trees (thinning and pruning), long-term profitability can be enhanced compared with the zero-tree agricultural scenario[8]. This is all the more true given the encouraging future prospects for timber prices. Indeed, Europe continues to be the leading importer of timber. And while France is an exporter of rough timber, oak in particular, it also imports large quantities of logs and sawnwood. The annual trade balance for rough timber is in deficit to the tune of over € 500 million, and the overall trade balance for wood and its derivatives showed a deficit of € 6.4 billion in 2010[9], which is 12% of the overall French trade deficit. Given rising energy prices and growing demand for renewable materials not only in construction but also in industry generally, coupled with higher demand from emerging markets, there is likely to be increased pressure on the timber industry. Moreover, new markets are springing up around biomass, for both second-generation wood-energy and biocomponents for the chemical and other industries. Research into wood-based raw materials, plant fibres associated with polymers and plastics from renewable sources, is advancing at a rapid pace. For example, a recent study by the CGAAER (General Council for food, agricultural and rural areas) expects 4 million hectares of UAA to be put under dedicated energy crops, largely on the basis of Short Rotation Coppicing (SRC)[10], in order to meet this future demand. But the ECOBIOM project led by the FCBA (Wood technological institute) highlights the reluctance of the farming world to develop coppicing of this type[11].

Indeed, all these developments raise a recurrent issue of procurement of supply. Supplying 50% of the raw material for the chemical industry with biomass only would represent over one million tonnes in the case of France, a volume ten times greater than today[12]. Moreover, the use of crop residues, such as straw for example, obliges the farmer to export organic material that is important for soil fertility. We also know that during periods of drought, straw is a product much sought after by livestock farmers. In addition, devoting a whole area to a dedicated biomass crop brings with it a dilemma for the farmer whose preference is for agricultural products for sale, for which markets continue to be very buoyant. Most foresight analyses raise these two issues and highlight the fact that trees can be a source of supply of this lignocellulosic resource, but on condition that its production does not subtract from agricultural area, something made possible by agroforestry, unlike short-rotation coppicing.

There would then be advantages in exploiting the productivity of agroforestry plots, with two benefits: every time work is done on the crowns of the adult trees this will generate interim income for the farmer and provide renewed stimulus for the intercrop due to increased exposure to sunlight. Inra (National institute for agronomic research) simulations show that with 100 trees whose branches are harvested periodically (every five years on average), continuous intercrop production is possible right up to the point at which the trees are finally cut down[13]. Lastly, the configuration of agroforestry plots would make it possible to consider mechanisation, which is facilitated by the progress achieved on biomass harvesting machines (hydraulic cutter-crushers). Sales of this biomass might ultimately offset the loss in yield observed in the final years of an agroforestry plot. According to an ongoing study conducted by the French Agroforestry Association as part of the Intens&fix project of the ANR (French national research agency), the farmers questioned could be tempted by an agroforestry system for biomass production, and not by SRC which is subject to doubts, and conflicting demands on land use.

Figure 1 - **Competition for water forces trees to send down deep roots. This creates a root net conducive to the trees' procurement of water deep in the subsoil and it also limits nitrate leakage and promotes deep carbon storage**



Source: Dupraz and Liagre, 2008, drawing by N. Girardin

7. Dupraz C., Capillon A., 2005, L'agroforesterie : une voie de diversification écologique de l'agriculture européenne ? [Agroforestry, a way forward for ecological diversification of European farming?], *Cahier d'étude DEMETER*.

8. Dupraz C., Liagre F., Borrell T., 2005, "Economics of silvoarable systems using the Land Equivalent Ratio concept", in *Silvoarable Agroforestry For Europe) final Report*, available at: http://www.agroof.net/agroof_dev/documents/safe/Economics_silvoarable_systems_LER_approach.pdf

9. Rapport *Agreste 2011* available at: http://www.agreste.agriculture.gouv.fr/IMG/pdf_bois1110note.pdf

10. De Cherisey H., Roy C., Pouet J.C., 2007, *La valorisation de la biomasse*, [Making use of biomass], a study conducted on behalf of ADEME, the French environmental and energy savings agency.

11. Valenzisi M., 2008, *Une approche socio-économique et environnementale de l'offre de biomasse lignocellulosique* [A socio-economic and environmental approach to market supply of lignocellulosic biomass], ECOBIOM Report, Project ANR-05-PNRB-BIOE-18

12. Rinaudo M., 2008, « La biomasse végétale, source de molécules organiques » [Plant biomass, a source of organic molecules], *Actual. Chim., 319*, pp. 45-47.

13. Liagre F., report 2011on the ongoing CASDAR project: http://www.agroof.net/agroof_dev/agroof_casdar0911.html

2 - A different type of production: trees as a complement to modern agroecological approaches

Looking beyond its immediate direct economic use, trees also have a major agronomical role to play in that they foster the agroecological functioning of the production system. This is so because although adult trees block part of the available sunlight for crops, they have a gradually increasing positive impact on soil, water and biodiversity and this can compensate for competition for light over the medium term. Such externalities are factors of production in their own right. Associating trees and crops can therefore lead to a redesign of the production system.

Biological fertility

Due to their root systems, which are conducive to deep infiltration of water and air, breakdown of bedrock and nutrient assimilation, trees play a key role in the slow formation of soil. Agroforestry plots with trees at their full adult size show significantly good performance with levels of organic material often 50% higher than in control plots[14]. Additionally, a much higher level of mycorrhiza is observed around intercrop roots than when the crops are grown alone. Such endomycorrhiza play a fundamental role in the nutrition and health of the plants, as well as in their resistance to difficult weather conditions. These factors are a key element for the biological fertilisation of the soil, notably against a backdrop of rising mineral fertiliser prices.

Water quality

The trees in agroforestry systems have deeper root systems due to competition with the crops[15]. Such adaptations modify their role in soil hydrology, especially the capture of nutrients and pollutants by the deep roots[16]. This mechanism is highly effective in agroforestry when the trees' root systems are located just below the associated crop's own root zone[17]. When the trees are approaching their adult size, the root net in place is capable of limiting or even eliminating all nitrogen leakage from the system, which makes it an excellent tool for protecting water catchment areas. In addition to the savings on water treatment thus made possible, agroforestry can reconcile protection of water resources with maintenance of agricultural production.

Biodiversity

Right from the first year, agroforestry coverage of an area can be seen to have a positive impact for certain groups of crawling (carabids) and flying insects (pollinators, syrphids)[18]. In the medium term, various groups of organisms reoccupy an agricultural habitat previously lacking in biodiversity in many cases[19]. The reintroduction of alleys of trees provides shelter, food and refuges for the auxiliary organisms that play a dominant role in pest control. The aim is to arrive at a balance between pests and auxiliaries that will limit the risks rather than having to apply pesticides frequently, which leads to problems for both health and the environment.

Climate change

The subject of agroforestry and climate change can be addressed from two angles: mitigation and adaptation. In the first case, agroforestry can act as a carbon sequestration tool. Trees help reduce the carbon emissions of farmers or those engaged in emission-offset programmes. By sequestering between 1 and 4 tonnes of carbon per hectare per year, agroforestry is a serious option for helping achieve climate goals. An ambitious plan for 600,000 hectares of agroforestry for France would represent between 3% and 4% of the targets set for the period to 2020[20] (see table). Indeed, programmes are under way for the examination of agroforestry labelling for voluntary carbon offset markets. The development of agroforestry for carbon sequestration must however avoid the trap of promoting single-species plantations without applying agronomic logic or consulting farmers. The funding of agroforestry projects using carbon credits must therefore be subject to good agroecological practices and be used to supplement a sound agronomic approach in order to avoid any risk of speculation on projects that endanger the environment and destabilise the agrifood system.

14. Boukcim H., 2010, *Évaluation de l'impact de la gestion agroforestière sur la fertilité biologique des sols* [Assessment of the impact of agroforestry management on the biological fertility of the soil] CAS-DAR Agroforestry report 2011, 26 p.

15. Mulia R., Dupraz C., 2006, "Unusual fine root distributions of two deciduous tree species in southern France: what consequences for modelling of tree root dynamics?", *Plant and Soil*, 281(1/2), pp. 71-85.

16. Cadisch G., Rowe E., Suprayogo D. and van Noordwijk M., 2004, "Safety-nets and filter functions of tropical agroforestry systems", in D.J. Hatch *et al.* (eds), *Controlling Nitrogen Flows and Losses*, pp. 406-414. Rowe E.C., Hairiah K. *et al*, 1999, "Testing the safety-net role of hedgerow tree roots by 15N placement at different soil depths", *Agroforestry systems*, 43, pp. 81-93.

17. Allen S.C. *et al.*, 2004, "Safety-net role of tree roots: evidence from a pecan (Carya illinoensis K. Koch)-cotton (Gossypium hirsutum L.) alley cropping system in the southern United States", *Forest Ecology and Management*, 192(2-3), pp. 395-407.

18. Ongoing CAS-DAR Agroforestry project 2011.

19. Le Roux X. *et al*, 2008, *Agriculture et biodiversité* [Agriculture and biodiversity], Inra collective expert evaluation, 84 p.

20. Hamon X., Dupraz C., Liagre F., 2009 , *Agroforesterie, outil de séquestration du carbone* [Agroforestry, a carbon sequestration tool], available for download at: *http://www.inra.fr/la_science_et_vous/dossiers_scientifiques/changement_climatique/en_savoir_plus/ouvrages/l_agroforesterie_outil_de_sequestration_du_carbone_en_agriculture*

Estimates of land area convertible to agroforestry in France and potential carbon storage capacity by 2020 and 2050

Land use (Agreste 2007)	Area (hectares)	Adoption/conversion (hectares)		Storage level (C tonnes/ hectare^{-1}.year^{-1})	Potential storage (Mt CO_2 eq.year^{-1}) and % reduction targets	
		2020	2050		2020	2050
Arable land (a)	13,052,834	400,000 (3%)	1,300,000 (10%)	2	2.93 (2.6%)	9.53 (3.4%)
Grassland (b)	12,668,673	200,000 (2%)	600,000 (5%)		1.47 (1.3%)	4.40 (1.6%)
Total	**25,721,507**	**600,000 (5%)**	**1,900,000 (15%)**		**4.40 (3.9%)**	**13.93 (4.9%)**

(a) Grain crops (except rice), oilseeds, protein crops, annual forage crops (silage and forage maize).
(b) Temporary grassland and Permanent Grassland (PG).
Source: Agreste 2007

Where adaptation to climate change is concerned, agroforestry can provide a useful response to the main negative effects of global warming for major crops: shrivelling of grains and springtime hydric stress[21]. This is because agroforestry has a positive impact on the microclimate: trees improve the water balance, limit dehydration and provide protection during heat waves. The effect is enhanced if preference is given to trees with late budbreak and if the right planting density is chosen. According to Inra's simulations, these beneficial effects can even offset yield losses due to reduced sunlight exposure in poor weather years[22]. In forage systems, trees delay the drying out of meadows by two to four weeks in summer and hot weather. For crops such as vines, trees protect the vines by preventing excessively early ripening at the beginning of summer. Another additional effect is the impact of trees on soil humus content and biodiversity, which is conducive to good soil structure and, by the same token, improves water reserves. The effect is also positive for animals (reduction in heat stress and mortality, a possibility of additional fodder for certain species in dry weather). For example, a new CAS-DAR project coordinated by Itavi (Technical institute of poultry farming) and the Loire region chamber of agriculture has just begun with the aim of assessing the impact of poultry runs planted with trees on the behaviour and production of poultry raised under quality labels.

3 - Issues and future prospects

Although agroforestry undoubtedly offers benefits, its main problem is its time horizon and the change in farming logic it requires. Indeed, development of an agroforestry plot demands a medium- to long-term vision and an overhaul of the production system. To engage in agroforestry means more than just planting trees, it requires a grasp of the agronomic role of trees. It means learning anew how to produce with trees after an era in which the pressure was in quite the opposite direction - towards separation of trees and crops at every level from farming technique to regulations. This entails a necessary strengthening of teaching courses, the training of on-site advisors and provision of support to those with projects to carry forward. It also means that agroforestry must be included as a field for research, based on programmes appropriate to trees' rate of development and in close collaboration with farmers.

In fact, most current research work is carried out in pure crops conditions. Genetic, forestry and agricultural research has concentrated on improvements in pure crop conditions, often involving a single species and production with high levels of inputs (agriculture). The effectiveness of agroforestry can therefore be improved either by selecting crops suited to an agroforestry climate, or trees adapted to full light conditions. But it is also possible to envisage the selection of forest species on the basis of criteria other than timber production, this being a central focus for research in forestry. For example, selection of late-budbreak, easy cut-back or dense flowering species would provide a perfect fit for current issues relating to climate change, the biomass sector and declining biodiversity. In the face of climate change, one of the responses can be to ensure a high level of genetic diversity. Local forest species are preferable, without however ignoring the potential that can be offered by more "exotic" species (some of which may contribute to the range of species available for production and combating climate change, but also present a risk that the insect cortege may be more limited). In agroforestry, it is necessary to make a distinction between biodiversity in tree species (production and therefore desirability of improvement) and associated species (spontaneous herbaceous species, growth of macro- and microorganisms due to the presence of the alleys of trees). Research is for example ongoing at Inra in Orléans on the development of the initial work on species selection for agroforestry with a focus on participatory selection in partnership with farmers.

Much progress has been made at the regulatory level in the last ten years. The prospects for the next Common Agricultural Policy (CAP) are encouraging. A working group comprising the French Agroforestry Association, the French Association for Trees and Hedgerows, the permanent assembly of French chambers of agriculture, the Agroof research unit and the relevant ministries has helped formulate concrete proposals for the period 2014-2020 (first and second pillars). But although France is breaking new ground in terms of regulations, this movement needs to be supported by a European network if it is to be more effective and become a long-term component of the CAP. On 16 December 2011 a European Agroforestry Day took place in Paris under the auspices of the Ministry of Agriculture, with the aim of setting up a European structure and formulating regulatory proposals for consideration by the European Commission. One of the key objectives will be to include agroforestry in the definition of the agricultural plot as laid down in European regulations in order to facilitate its eligibility for future rights to payments on the same basis as any other farming system, and to extend the support measure for planting by adjusting it to include all configurations encountered in agroforestry (hedgerows, coppices and alleys).

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What is at stake for the future of agroforestry is still the need for greater consideration by official bodies and in agricultural policy, the recognition of the farmers engaged in it and the support of research and development work. This will also involve improved interfacing of on-site activities, research and the sectors that will use the plant biomass produced by agroforestry, with a view to making better use of agroforestry production. The operational challenge will be to obtain feedback from the field on what is expected and what farmers and concerned actors are proposing, and this at all levels: technical, scientific and regulatory. The radically new forms of technical collaboration and participatory research that are gradually forming around agroforestry to accomplish this are both a guarantee of the development of such systems and a source of inspiration for the dissemination of innovation in agriculture.

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21. Brisson N. *et al.*, 2010, *op. cit.*
22. Dupraz C., Liagre F., 2008, *op. cit.*

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