

VALUATION OF ENVIRONMENTAL SERVICES PROVIDED BY WOODLANDS
TO AGRICULTURE: the coffee example in Machadinho d'Oeste, RO, Brazil

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Everybody knows that the green of woodlands and forests generates benefits for biodiversity and for the planet's environmental balance. More than that, society demands the maintenance of this condition, especially from the production sector. But are woodlands a limiting factor for agricultural productivity? To what extent can woodlands be beneficial, and provide ecosystem services to agriculture and to farmers? What ecosystem services are provided by woodlands located near an agricultural plantation?

However, most people are unaware of the fact that areas regarded as forest reserves can contribute directly to agricultural productivity. One example is the coffee produced in a region of the state of Rondônia, Brazil, which was subject of a study carried out by the Brazilian Agricultural Research Corporation (EMBRAPA) in 2008. The study showed that the coffee that grows near the forests has a productivity increase of up to 20% in comparison to the coffee that grows in areas located farther from the reserves. This is a clear example of a benefit generated by the woodlands in coffee productivity (MANGABEIRA, 2010).

This pioneering research analyzes the capital accumulation path of the rural family producers in Machadinho D'Oeste, RO, Brazil, highlighting the ecosystem services provided by the native woodlands. These services included mainly pollination by native bees and the generation of a microclimate which reduced the abortion of coffee flowers at critical periods.

This work aimed at outlining the typology of the municipality's rural producers regarding their level of capital accumulation. The analysis, which comprised a period of approximately 22 years, aimed at defining the factors which led to the producers' different capitalization levels, as well as evaluating the role played by environmental services along this path. Environmental services are understood as those arising from the healthy operation of the ecosystems, either the natural ones or those modified by men. When these services are focused on agriculture, they can be translated into: deforestation reduction, atmospheric carbon absorption, water conservation, soil conservation, biodiversity preservation, fire risk reduction, among others.

The research was carried out in Machadinho d'Oeste's settlement project, which is different from other settlement projects in Amazonia in terms of its tracing because it does not obey the standard "fishbone" structure found in most of the region's projects. In Machadinho d'Oeste, private land plots were combined with communal forest reserves. The transport network took the region's topography and hydrographic network into account, and this concern with the landscape and hydrographic characteristics allows access to the most distant plots. This reduces maintenance costs, because the octagonal ("fishbone") scheme demands the construction of bridges and greater erosion control, which generally does not take place in the Amazon region. Since seasonality is an

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important variable which affects mobility, several farmers remain isolated during the rainy periods. Forest reserves, due to their block arrangement and the institutional dispositions established, have been kept rather well preserved, thus creating possibilities for the generation of environmental services.

The methodology used was based on geotechnologies (satellite images and geostatistics) and on multiple correspondence analysis (MCA). The results indicate the existence of five types of producers: capitalized (type 1), quite capitalized (type 2), moderately capitalized (type 3), poorly capitalized (type 4) and under-capitalized (type 5). Geostatistics, a tool that enables the identification of the spatial relationship between samples (VIEIRA, 2000), was used to analyze the spatial distribution of producer types in terms of their capitalization level and the distance of the properties from the reserves. Coffee is the main income-generating crop in the region, therefore coffee productivity and its relationship to the distance between rural properties and forest reserves were complementarily analyzed. Results show that farms in which coffee is planted near the woodlands present on average greater productivity and better performance. It has also been noticed that most capitalized farms are located near the reserves, which indicates the existence of environmental services provided by the woodlands.

The capital accumulation path in Machadinho d'Oeste revealed itself to be completely different from the usual standards for farmers in general when aspects such as access to credit, educational level, health condition, access to the city, distance to the urban center, soil fertility level, use of agricultural supplies and equipment, among others, were taken into account.

The most capitalized family farmers are very dependent upon the coffee crop income. Coffee (*Coffea canephora*, 'Conilon' and 'Robusta' varieties) crops in Machadinho d'Oeste currently face a serious problem: the occurrence of successive "Indian summers" at the coffee flowering period along the last ten years. Flowering, the formation of young fruits and the fruit development normally begin in September with the restart of the spring rains, which induce coffee plants' main flowering stage. High temperatures associated with water deficit along the flowering stage may lead to flower abortion. After fertilization, the young fruits appear and develop. Should a strong drought occur during this phase, water stress may impair fruit growth. It has been noticed that Rondônia has been presenting a lack of rainfall during the flowering season which causes losses due to flower drop and fruit drop at early development stages, thus reducing drastically the crops' production. The coffee produced in Machadinho d'Oeste is not very different from the coffee produced in the other regions of the state of Rondônia, and also uses low amount of agricultural supplies and mechanization. According to the local Technical Assistance and Rural Extension Company (Empresa de Assistência Técnica e Extensão Rural, Emater), to the local producers and technicians, coffee production has been low every year due to water deficit during flowering, which is caused by a temperature raise and leads to flower abortion.

Even though it is low in comparison to the national average, the productivity level in Machadinho d'Oeste is favorable to producers, since the production costs are also low and consist mainly of temporarily hiring a workforce to help during the harvest. If 'modern' supplies and mechanization were used, the production costs would be unfavorable to the producers because of the low price paid for the product and the distance to the consumer centers. The coffee produced in the region is not for export, but for producing a "blend" (combination of grains grown in different regions of the country) to be used in the production of soluble coffee consumed mainly in the South and Southeast regions of the country. The coffee producers whose farms are located near forest reserves suffer less from the "Indian summer" phenomenon.

Interviews with the producers, data analyses by high-resolution satellite images and geostatistics analysis showed the existence of the ecosystem services provided by the woodlands and of their benefits to the farmer, thus corroborating literature data. The studies examined in the literature show that the availability of native vegetation remnants has contributed not only to the production increase, but also to the improvement in coffee bean quality. The pollinators from the forest have increased coffee production in up to 20% within a 1-km range from the woodlands. The number of lower-quality grains was reduced in 27% (RICKETTS et al., 2004). De Marco Junior and Coelho (2004), as well as Ricketts et al. (2004), evaluated the effect of the availability of native fragments on the productivity of coffee plantations, within a maximum distance of 1 km, and verified that pollinators from these fragments contribute at average rates of 14,6% and 20% to the increase in fruit production and in coffee productivity respectively (FERREIRA, 2008). Thus, an average increase of 5% associated with the pollination service corresponds to 8.8 extra sacks of coffee per hectare for the producer if the woodlands are kept. If the price of a sack of coffee in the market is of approximately R\$ 245.00, the value of pollination as an ecosystem service for the producers located near native woodlands will be of R\$ 2,156.00 per hectare per year (FERREIRA, 2008).

Thus, this study has made it clear that the coffee crop is strongly favored by the availability of native woodland fragments, both in terms of productivity and quality. When planted near woodlands, coffee plants benefit from the pollination carried out by native bees and from the microclimate generated by these woodlands, which favors the germination of the fruits by reducing flower abortion. Besides, the microclimate created by the woodlands offers a more pleasant work environment, and thus increase the laborers' well-being.

One of the conclusions of this work was that environmental services play an important role in coffee productivity, which is higher near forest reserve blocks. The average productivity rate is approximately 20% greater in coffee plantations near the woodlands, which shows that these woodlands, by means of several ecosystem services, may be contributing to the increase in coffee productivity. Geostatistic tests show strong positive spatial correlation between capitalization level and the proximity of the coffee plots to the forest reserves. There is strong evidence that rural producers in Machadinho d'Oeste increased their capitalization level not only according to the conventional patterns of agricultural systems evolution dynamics. It can be stated, based on the results obtained by this research, that there is an ecosystem-services component contributing to the capital accumulation path in the agricultural production systems analysed. Therefore, this study suggests a new approach for researches on ecosystem services for agriculture.

The methodological approach of this research shows the importance and the operational potential of using high-resolution satellite images to assess subjective field information, that is, the consolidation of a precision methodology in information collection. The statistical instrument used (MCA) proved to be suitable to show the complexity and the differences between production systems. The spatial analysis of socioeconomic data performed by means of geostatistics was equally adequate for the socioeconomic research. The combination of multivariate statistics and geostatistics instruments enriches the socioeconomic analyses and the environmental services evaluation, and enables the correlation of Machadinho project's spatial design with the possible provision of environmental services for the improvement of the productivity in agricultural production systems.

The methodology used was consistent and adequate for the studies proposed for this work, and thus represents an interesting methodological path for future studies on natural resources surveys and environmental services evaluation, rendering a new dimension and value to woodlands– represented by legal reserves (LRs) or permanent preservation areas (PPAs) – within rural properties or around them. It also contributes to the evaluation and analysis of environmental, social and economical impacts of agriculture, to agricultural sustainability studies, and to spatial-temporal land-use researches. In an innovative way, this research also brings forward a new approach, which enables the analysis of the farmers' capital accumulation path with a broad focus, integrating geotechnology, multivariate statistics and geostatistics.

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