

1	SUSTAINABILITY ASSESSMENT OF ECOLOGICAL INTENSIFICATION
2	PRACTICES IN COCONUT PRODUCTION
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7	INTRODUCTION
8	Currently, Brazil is the fourth largest producer of coconut in the world, with around 2.8
9	million tonnes harvested in about 287,000 ha (FAO, 2014). Although present in different
10	regions of the country, more than 90% of the planted area occurs along the coast of the
11	Northeast and part of the North. Coconut production is an important employment and income
12	generating activity, contributing significantly to the development of the producing regions.
13	Even if part of the harvest is typically extractive, coconut cultivation demands high
14	technological levels to achieve adequate productivity, and high production costs have caused
15	recurring crises in the industry, indicating the exhaustion of the conventional production
16	model (MARTINS AND JESUS JUNIOR, 2014).
17	The costs associated with the necessary adoption of technologies to enable agriculture
18	in general, and coconut production in particular, require that increases in production must
19	come from higher levels of productivity, increasing efficiency by the intensification of
20	cultivation practices (TILMAN et al., 2002). In the past agricultural intensification was
21	characterized mainly as a result of breeding, associated with increases in the use of inputs
22	such as chemical fertilizers, pesticides, irrigation and mechanization, a model that has shown
23	adverse effects on the environment. Today, by contrast, 'agricultural ecological
24	intensification' has been proposed, defined as the "maximization of primary production per
25	unit area without compromising the system's ability to maintain its productive capacity"
26	(FAO, 2009), or as "producing more food from the same area of land while reducing the
27	environmental impacts" (ROYAL SOCIETY OF LONDON, 2009).

28 Thus, 'Ecologically Intensive Systems' (EIS) have been a central reference to promote diversification of agricultural activities, as well as for the development and adoption of 29 integrated techniques and management practices aimed at producing food in line with the 30 31 environmental conditions and the local availability of natural resources, focusing on economic

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32 profitability, with parsimony in the use of external inputs and lower production costs. The 33 purpose of this study is to analyze the environmental performance of coconut production in 34 different technological contexts, as to identify the conditions and factors by which changes 35 towards ecologically intensive practices have had greater potential to promote sustainability.

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MATERIAL AND METHODS

38 A wide variety of methodological approaches have been developed to meet a growing international demand for sustainability indicators (SANCHEZ AND MATOS, 2012; OLDE et 39 40 al., 2016.). In this research, we seek to identify the technological intensification contexts in 41 which the highest environmental performance gains are observed in coconut production, 42 favoring the recommendation of management practices that promote sustainability. For this 43 purpose, the APOIA-NovoRural indicators system has been applied (RODRIGUES AND 44 CAMPANHOLA, 2003) as an adequate environmental assessment tool, applicable onto the 45 variety of production contexts and technology adoption levels observed, and considering the 46 diversity of environments and local coconut production characteristics.

The APOIA-NovoRural system consists of 62 indicators grouped in five sustainability dimensions, namely: (i) Landscape ecology, (ii) Environmental quality (air, water and soil), (iii) Socio-cultural values, (iv) Economic values and (v) Management and administration. Organized into a set of multi-attribute weighting matrices (scale normalized from 0 to 1, with baseline modeled in 0.7), the integrated indicators allow quantitative and objective analysis of environmental performance, in field inspections carried out with analytical instrumentation and management data obtained with the farmers (RODRIGUES *et al.*, 2010).

For the current study, six reference rural establishments partners with Embrapa in technology development and transference programs were selected to carry out case studies. These reference farms showed different levels of intensification and diversification, varied technology adoption capacities, and entrepreneurial strategies from family businesses to large-scale enterprises. Field data surveys took place between July 2013 and November 2014, and results from each case study were reported back to the rural establishment managers in 'environmental management reports', containing all documentation on environmental conditions and recommendations towards sustainable production.

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RESULTS AND DISCUSSION

The analysis of the six case studies pointed out the great influence of environmental conditions, particularly climate and soil fertility constraints, on the environmental performance of farms (Figure 1). Main recommendations included adjustments and 66 parsimony in the application of fertilizers, as to avoid excesses that result in financial losses 67 (case of phosphorus) and water contamination risks (case of nitrogen). Also, corrections and 68 increase in the supply of organic matter, to correct natural deficiencies and improve nutrient 69 and water retention capacity in the naturally very sandy soils.



Figure 1 - Results of environmental indicator analyses in reference coconut production farms.
The four rural establishments characterized as 'ecologically intensive' are highlighted (red
frame), and cases studies are identified for the Management and administration dimension.

74 In general, the other indicators related to the Environmental quality dimensions were 75 suitable in the studied farms, such as compliance with landscape management requirements, 76 excellent water quality and lack of noticeable atmospheric emissions. The Economic values 77 dimension proved to be generally quite adequate, although with a situation of negative 78 performance due to particularly severe drought in recent years. Socio-cultural values 79 indicators were rather favorable, given the provision of training to employees, very good 80 employment and benefits conditions, and access to basic services. The Management and 81 administration dimension proved to be closely dependent on the entrepreneurial and 82 productive contexts of the studied establishments, both for those dedicated to coconut monocultures as well as the diversified ones. 83

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CONCLUSIONS

86 A close correlation was observed between the Management and administration dimension and the integrated sustainability indices (see trend line, highlighted in Figure 1). 87 88 This result supports the hypothesis according to which the sustainability of rural activities in 89 general, as well as for coconut production in particular, can be strongly favored by the 90 adoption of environmental management tools, such as the APOIA-NovoRural system. By the 91 same token, the environmental performance of the rural establishments dedicated to coconut 92 production was much improved when the productive context was more diversified and 93 integrated, attesting to the value of technology adoption and ecological intensification as 94 strategies to improve sustainability.

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