Agricultural Systems 165 (2018) 71–84

Contents lists available at ScienceDirect

Agricultural Systems

journal homepage: www.elsevier.com/locate/agsy

Sustainability assessment of ecological intensification practices in coconut production☆

Geraldo Stachetti Rodrigues[a,*], Carlos Roberto Martins[b], Inácio de Barros[c]

[a] Embrapa Meio Ambiente, Empresa Brasileira de Pesquisa Agropecuária (Embrapa), Rodovia SP-340, Km 127,5 - Tanquinho Velho, P.O. Box 69, 13820-000 Jaguariúna (SP), Brazil

[b] Embrapa Clima Temperado, Empresa Brasileira de Pesquisa Agropecuária (Embrapa), Rodovia BR-392, Km 78 - 9° Distrito, Monte Bonito, P.O. Box 403, 96010-971 Pelotas (RS), Brazil

[c] Embrapa Tabuleiros Costeiros, Empresa Brasileira de Pesquisa Agropecuária (Embrapa), Av. Beira Mar, 3250 – Jardins, 49025-040 Aracaju (SE), Brazil

ARTICLE INFO

Keywords:
Impact assessment
Economic performance
Environmental management
Sustainable agriculture
APOIA-NovoRural

ABSTRACT

Environmental impact and economic performance assessments are important subjects for the definition of strategies for sustainable management in agriculture. The objective of the present study was to assess such impacts in a set of reference farms dedicated to coconut production, conforming a gradient with respect to the adoption of technologies and ecological intensification practices. Ranging in scale from smaller family farms to larger corporate enterprises, and from coconut monocultures to diversified crops and integrated coconut-livestock systems, the six cases were studied through a multi-attribute utility model comprising 62 indicators related to five sustainability dimensions: (i) Landscape ecology, (ii) Environmental quality, (iii) Sociocultural values, (iv) Economic values and (v) Management and administration. Detailed cash flow analyses permitted a critical view regarding the influence of technology adoption, ecological intensification, and management for sustainability as criteria for economic viability. The results attest to the value of produce diversification as opportunity toward technology integration, which correlated positively with higher sustainability indices in all dimensions. Tradeoff analysis showed a negative correlation between socio-environmental performance indices and profitability, whereas none of the cases studied showed constrained economic viability, indicating that ecological intensification in coconut production can also entail social improvements, by promoting fairer share of revenues and benefits among stakeholders. Recommendations issued to farmers and management teams, related with agronomic factors and practices adopted in production intensification, favor the communication of appropriate mechanisms for technology adoption, translating farm-level sustainability assessments into action for sustainability.

1. Introduction

World trade of coconut-derived products is expected to increase in the years to come. Technavio's market research (Technavio, 2016a, 2016b) forecasts that, during the period of 2016–2020, the global market will show a compound annual growth rate (CAGR) of around 27% and 15%, for tender coconut water and coconut milk, respectively. In its turn, Europe projects to record a CAGR of 4.7% for coconut oil in the 2017–2022 horizon, and the market for this product is anticipated to grow to more than US$ 3 billion by 2022 (Fact, 2017). These market trends are being driven by increasing health-consciousness among consumers, as coconut water contains important electrolytes with strong indications for health promotion (Radenahmad et al., 2011; DebMandal and Mandal, 2011; Radenahmad et al., 2012). In this broader movement of consumers seeking out healthier food and hydration products with simpler ingredients, coconut water has attracted the interest of world's giant companies of the beverage industry, which by means of modern packing techniques to increase the shelf life up to 18 months, are promoting a beach-to-bench approach to expand the market for tender coconut water from 100 million liters in 2012 to 350 million liters by 2020 (CBI, 2014). Similar market trends are also expected for other coconut-derived products, such as desiccated coconut meat, that showed a 102% increase in the European market in the last five years (CBI, 2015a), and virgin coconut oil (CBI, 2015b).

☆ We wish to confirm that there are no known conflicts of interest associated with this publication and there has been no significant financial support for this work that could have influenced its outcome. We confirm that the manuscript has been read and approved by all named authors and that there are no other persons who satisfied the criteria for authorship but are not listed. We further confirm that the order of authors listed in the manuscript has been approved by all of us.

* Corresponding author.
E-mail addresses: geraldo.stachetti@embrapa.br (G.S. Rodrigues), carlos.r.martins@embrapa.br (C.R. Martins), inacio.barros@embrapa.br (I. de Barros).

https://doi.org/10.1016/j.agsy.2018.06.001
Received 26 January 2018; Received in revised form 24 May 2018; Accepted 4 June 2018

Table 1
Technical and managerial characterization of the rural establishments selected for sustainability analysis, according to their respective ecological intensification and technology adoption contexts.

Rural establishment	Climate	Total and coconut planted areas, cultivation year	Diversification aspects	Management type	Intensification level/technology	Main product
Case 1	Köppen-Geiger[1]: *Am* Mean T °C[2]: 24.8 Prec.[3]: 1791 mm	96 ha, 60 ha dwarf coconut[4], started in 1998/9	No, dwarf coconut monoculture, irrigated	Family business	Medium/micro sprinkler irrigation, mulching, chemical fertilizer, chemical control	Green coconut 'in natura'
Case 2	Köppen-Geiger: *Aw* Mean T °C: 23.8 Prec.: 919 mm	890 ha, 270 ha dwarf coconut, started in 1998	Yes, dwarf coconut, citriculture, diversified fruticulture, horticulture	Family business	High/micro sprinkler irrigation, organic fertilizer, restriction on the use of pesticides, Integrated Fruit Production and EurepGAP certification[7]	Green coconut 'in natura'
Case 3	Köppen-Geiger: *Aw* Mean T °C: 25.2 Prec.: 1209 mm	181 ha, 141 ha dwarf coconut, started in 1999	No, dwarf coconut monoculture, irrigated	Enterprise	Medium/micro sprinkler irrigation, mulching, chemical fertilizer, chemical control	Green coconut 'in natura'
Case 4	Köppen-Geiger: *Aw* Mean T °C: 27.5 Prec.: 1208 mm	4532 ha, 2594 ha coconut, started in 1982 with tall coconut[5] and hybrid coconut[6] introduced in 1988	No, coconut monoculture, 42% tall coconut without management, 33% rainfed hybrid coconut under ecological management, 25% irrigated hybrid coconut	Enterprise	High/systematic elimination of chemical control of weeds, using rotary tilling and mowing; mulching; liquid limestone and reduced P application; fertigation; biological control of insects (*B. bassiana*, Dipel), Rainforest Alliance certification	Industry, grated coconut and coconut milk
Case 5	Köppen-Geiger: *Aw* Mean T °C: 26.5 Prec.: 1194 mm	204 ha, 87 ha dwarf coconut, started in 1997	Yes, dwarf coconut, sugarcane, intensive integrated dairy production	Family business	High/micro sprinkler fertigation with liquid bovine manure compost, mulching, livestock integration, restriction in pesticide use, chemical fertilizers	Green coconut 'in natura'
Case 6	Köppen-Geiger: *Af* Mean T °C: 26.9 Prec.: 2547 mm	21,000 ha, 6000 ha coconut, started in 1976 (tall coconuts), replanted with hybrids coconuts in 1992/93	No, however with special attention to coconut breeding and genetic diversity	Enterprise	High/rainfed, chemical fertilizer, chemical control, reduction of chemical control of weeds, using mowing; mulching; Green manuring with kudzu; varietal diversification from own origin, focusing on productivity and plant health, animal traction harvest	Industry wide and diverse range of food products

[1] Köppen-Geiger stands for Köppen–Geiger climate classification system (*Am*: Monsoon, *Aw*: Wet savanna, *Af*: Rainforest).
[2] Mean T° C is the annual daily mean temperature in Celsius.
[3] Prec. Stands for the mean annual precipitation.
[4] Dwarf coconut: dwarf coconut cultivars.
[5] Tall coconut: tall coconut cultivars.
[6] Hybrid coconut: hybrid coconut cultivars (hybrids between tall and dwarf).
[7] EurepGAP is a common standard for farm management practice created by European supermarket chains and major suppliers. GAP is an acronym for Good Agricultural Practices.