

Eco-control for Sustainable Agriculture Management in Commercial Tea Industry

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1. Introduction

There is a tendency for the agricultural sector to embrace sustainable agriculture management practices due to the growing concerns on food safety and consumer health, employee welfare and impacts on eco-systems, whilst ensuring profitability. Thus, sustainable agricultural systems should use resources efficiently when satisfying human food needs, enhancing quality of life for farmers and society as a whole even as upgrading and preserving environmental quality (Farm Bill, 1990). Sustainable agricultural systems demand effective weed control owing to various economic and environmental reasons. However, controlling weeds only confined to chemical weeding would lead to the development of herbicide resistant weed species and numerous other spill-over effects on the environment, vigor of crop plants and to the human health as well. Further, the present spectrum of herbicides in use are greatly ineffective on controlling targeted troublesome weeds, particularly in the tea plantations in Sri Lanka (Peiris and Nissanka, 2016). Hence there are growing economic, environmental and social demands to use alternative weed management practices, such as integrated weed management (IWM), which uses a combination of alternative long-term weed management strategies such as cultural techniques, genetic characters, mechanical removal, biological agents, and chemical control etc. In spite of the growing interest on IWM, there is a scarcity of studies that evaluate the long term effectiveness of practicing IWM strategies by analyzing triple bottom line perspectives particularly in developing countries that rely on the agriculture and plantations sectors heavily. By using an eco-control approach, this study demonstrates the triple bottom line benefits of Herbicide Free Integrated Weed Management (HFIWM) over traditional chemical weeding in the commercial tea industry in Sri Lanka.

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The rest of the paper is organized as follows. Section Two of the paper covers a brief literature review followed by the research method in section Three. Section Four presents the analysis and discussion of the study based on the eco-control approach we adopted. Finally, Section Five offers the conclusions.

2. Literature review

The most commonly used definition of the United Nations Commission on Environment and Development (UNCED) (1987) defines sustainable development as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (page 07). Sustainable development has then become a central issue in political and scientific bodies (Lichtfouse *et al.*, 2009) and a notable latest milestone in this regard is the agreement of the Sustainable Development Goals (SDGs), in September 2015 by more than 190 countries (United Nations-UN, 2016). Feeding more than seven billion population has created increasing pressure on the global eco system whilst achieving sustainable development goals. These concerns inevitable exert tremendous pressure on agriculture industry to adopt sustainable agricultural systems.

Sustainable agriculture which has been defined numerously (refer Lichtfouse *et al.*, 2009; Francis *et al.*, 1987 for more details), addresses social concerns and environmental protection while emphasizing the ability of the agricultural systems to maintain crop productivity in the long run by adapting to changes. In managing sustainable agricultural practices, weeds that cause huge economic damage to a farm pose a challenge despite the technological advancements available (Auld, 2004). Control of major weeds in a plantation is crucial to maintain healthy crop yield and to protect humans, soil and machines. Currently, there are growing economic, environmental and social demands to use alternative weed management practices, such as integrated weed management (IWM) (Pannell, 1990; Auld, 2004). Integrated Weed Management (IWM) is the use of a combination of alternative weed management strategies such as cultural techniques, genetic characters, mechanical removal, and chemicals means to reduce the reliance on one technique (Swanton and Weise, 1991).

However, the transition to IWM is not smoother due to many reasons such as planter's unfamiliarity with different weed control options, difficulty in predicting long-term of impacts of multiple control options and challenges in isolating impacts of individual treatments within an integrated strategy, (Pannell *et al.*, 2004). Hence it is essential to evaluate the effectiveness of IWM strategies over long term in the economic, social and environmental dimensions. This is where sustainability and environmental management accounting systems become crucial in providing requisite information to facilitate effective decision making. The next paragraphs explain sustainability and sustainability management accounting (EMA) including eco-control approach.

EMA, by focusing on environmental and sustainability matters, provides two types of information for decision making, i.e. a) physical information and b) monetary information (Burritt *et al.*, 2002). By encompassing a wide array of accounting tools and techniques EMA provides a broad set of principles and approaches for the successful implementation of environmental strategies (International Federation of Accountants - IFAC, 2005). Eco-control, as a useful approach in EMA, uses integrated environmental information for environmental management. It helps firms to measure, control and disclose the environmental performance through formalized procedures and systems that use of financial and ecological information to maintain/alter patterns in environmental activity. Schaltegger and Burritt (2000) suggest five procedures in implementing eco-control as (1) formulating goal and policy;(2) managing information (environmental performance information);(3) supporting decisions;(4) steering and implementing; and(5) communicating internally and externally. Collection of the relevant and useful information for the "right" decision making is important to continuously improve the cycle of eco-control procedures (Gunarathne and Lee, 2015).

The next section presents the method we deployed to collect and analyze data in our study.

3. Method

We chose the case study method in this study in order to provide an in depth analysis of the phenomenon (Yin, 2009). The case setting was Hapugastenne Estate (referred to as Tea Estate hereafter sometimes) that belongs to Maskeliya Plantations PLC in Sri Lanka, which is a listed

company in the country's stock exchange. All the estates of Maskeliya Plantations, including Hapugastenne Estate, are Rainforest Alliance certified. The Tea Estate has a Rainforest Alliance Training Centre, the only such centre in the country. In addition, an HFIWM system has been experimented in the Tea Estate from 2012. Currently a prototype demonstration plot cum farmer training centre too is in operation at the Tea Estate. Further to these reasons, accessibility to information was another compelling reason to select this tea estate.

Primary data collection for the study was done using several semi-structured interviews with the Superintendent of the Tea Estate (who is a co-author in this study), country's Consulting Programme Coordinator of Rainforest Alliance and tea buyers at random. The secondary data for the study were collected from various sources such as internal company records, news paper articles, email communications, media reports, web sources including social media. The collected data were analyzed based on the five procedures in implementing eco-control as suggested by Schaltegger and Burritt (2000). The next section of the paper presents the data analysis and discussion.

4. Analysis and discussion

The analysis and discussion of the study is presented based on the five step procedures in implementing eco-control.

(1) Goal and policy formulation

The first step in adopting eco-control to develop an HFIWM method in the Tea Estate had been initiated accidentally as a therapy to cure severe deterioration of tea bushes showing symptoms of exposure to "*plant killer chemicals*" (herbicides). The traditional remedy for such a situation in the tea industry is uprooting the affected tea areas in blocks, rehabilitation of soil and replanting, a process takes over five years. But the significant cost involved in replanting and loss of crop for several years compelled the Tea Estate to make an effort to find alternative ways to recover the debilitated tea bushes. Driven by these motives a few tea land blocks were initially selected to conduct an experiment to understand the viability of HFIWM to merit trying at a commercial scale. It is the sustainability oriented process optimization to reduce costs and resource

consumption (Bansal, 2005; Windolphet *al.*, 2014) that drove the goal and policy formulation in eco-control in the Tea Estate.

(2) information management (environmental performance information)

With a view to generating “right information” for decision making in eco-control (Gunarathne and Lee, 2015), in the experimental areas, a complete clearing of the undergrowth beneath tea bushes was done by manual uprooting whilst ceasing chemical weeding completely and allowing Natural Regeneration of Vegetation to establish as a ground cover over the soil (Treatment). A tea area next to above said field was declared as the chemically weeded Non-IWM (Control) section, where weed control was exclusively done by using herbicide chemicals. Observations were recorded there onwards, whilst monitoring the performance and the variations exhibited by both experimental areas periodically. In generating information for decision making in eco-control, physical environmental information such as plant species diversity was surveyed first. The initial survey found that there were around 80 different plant species present in tea fields and only 25-30% of them could cause economic crop damage to commercial tea and the rest was innocent (Peiris, 2016). In order to generate comparative information in eco-control, data from HFIWM extent was compared against the data collected from adjacent control plots of non-IWM tea area in the tea garden. There it was revealed that well established natural ground cover consisting of *innocent weeds* specific to tea, is capable of controlling repeated growth of *harmful weed species* specific to tea (Peiris and Gunarathne, 2015).

(3) Decision support and implementation

Confirmed by the information generated from the initial experiment, as the next step in eco-control, the experimental area was extended to cover over 20,000 tea bushes in-situ. It was expected to get broader representation of almost all possible conditions found in tea plantations in the district in order to achieve more applied and justifiable solutions for the industry based on more reliable information.

Although the initial objective set in the eco-control approach was to develop an effective alternative way of managing troublesome weed species in commercial tea, additionally the HFIWM plot displayed a way ahead performance compared to non-IWM area in many other

lines as well. These notable areas were the green matter produced and resultant compost yields (refer Table 1 for more details from year one to year three in terms of cost of weeding, compost cost saved and crop value in the two land blocks).

Table 1: Total annual benefits/cost analysis of HFIWM section Vs. non-IWM section

		First year		Second year		Third year	
			Savings /(additional cost/loss)		Savings /(additional cost/loss)		Savings /(additional cost/loss)
Cost of weeding	HFIWM	43,463		51,744		33,502	
	Non-IWM	91,188	47,725	69,504	17,760	63,000	29,498
Compost cost saved	HFIWM	125,202		230,020		54,524	
	Non-IWM	26,593	98,609	23,580	206,440	7,817	46,707
Crop value	HFIWM	94,124		83,630		58,832	
	Non-IWM	96,537	(2,413)	79,648	3,982	54,474	4,358
Total			143,921		228,182		80,563

Source: Peiris and Gunarathne, (2015)

Thus, the commercial scale implementation of the HFIWM approach in eco-control revealed that HFIWM has an incomparably greater ability to improve soil conditions which boost plant growth in commercial tea. The HFIWM strategy enriches the overall performance of plantations in the long run while enhancing the land productivity and soil environment. As there are broader benefits as per eco-control approach, there is a need to consider wider factors such as soil environment in addition to weeding cost, etc when evaluating the financial viability of using traditional or innovative weed management strategies.

Apart from economic benefits at estate level, moreover, it was revealed that an increment in tea crop availability increases net earnings of a tea plucker substantially. Thus, the HFIWM approach exhibits many indirect social benefits over chemical weeding in terms of public health, environment and the socio-economic factors such as improvements in drinking water quality.

(4) Internal and external communication

In the eco-control approach, internal as well as external communications play a crucial role. The Tea Estate had to take a number of actions in communicating its results of the HFIWM since the concept and its findings, at times, were against the decades/centuries old teachings and beliefs ingrained in the plantations sector. Not surprisingly, there was strong resistance from some individuals in the community in acceptance of the results which made the communications crucial as highlighted in the eco-control approach. In gaining legitimacy through communicating the results, the Tea Estate was eager to conduct the experiment according to the accepted methodology and also in a commercial scale, gather data on a regular basis and keep proper records. This provided a solid basis for the results being communicated. In soliciting legitimacy from a scientific community, the findings were presented at reputed international science forums and conferences with solid facts and figures. Moreover, trial plots were maintained as prototypes and demonstration sites at the Tea estate for stakeholders in providing firsthand experience. All these various internal and external communication strategies adopted have been mostly successful in gaining legitimacy for the results while overcoming the some of the resistances to change.

6. Conclusions

The eco-control approach followed in the study suggests that the HFIWM approach could be a sound solution to alleviate many of the constraints faced by the present day commercial plantations industry in Sri Lanka and in developing countries in general. The HFIWM strategy offers many direct and indirect benefits over chemical weeding. These benefits can be derived in the lines of crop productivity, cost of inputs, public health, environment and the social well-being. Further, this study suggests that the support and commitment of various stakeholders will be needed to win over the 'hard to tangibalize' benefits to the plantation sector on a systematic basis. Hence, pursuance of the five step procedure in the eco-control would be a promising approach in demonstrating the benefits of alternative sustainable agricultural practices. Further, the findings of this study strongly confirm that the importance of dealing with proper socio-cultural context of an innovation or any breakthrough technology through pure/applied science research in order to gain social acceptance and successful commercial implementation.

Finally the authors are of the view that the findings of the study may be difficult to generalize (Yin, 2009), due to certain limitations inherent in the study such as the unique location, limited time period of three years and many other factors. Furthermore, these limitations call for future studies under variety of soil and climate conditions, different perennial crop varieties, etc to identify and generalize the findings.

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