

Introduction

Vegetable cultivation is a key sector in agriculture in terms of frugality and employment generation. Rapid growth experienced in the agricultural sector has led to resource degradation with an adverse impact on sustainability. A major form of environmental damage associated with agriculture is land degradation; particularly intensive vegetable cultivation practices have caused soil erosion on the steeply sloping lands of Central Hills. Policies and legislations protecting the land resources in the country were introduced following Independence.

Analysis

Both primary and secondary data was used. This study was conducted in the Central Province of Sri Lanka; a sample of 384 farmers was surveyed. The primary data collection tool was questionnaire survey. Multi stage sampling technique was applied to derive the sample. Descriptive and inferential statistics identified the factors that influence the farmers' soil conservation practices the logistic regression analysis was applied for the above purpose. Factor analysis was applied separately to each SLM practice and erosion category with profit. The farmers' pro-environmental behaviours related to their soil conservation

The existing institutional set-up lack vigor at the field level; hence capacity building of the institutions with strong policies can be effective in preventing further degradation of land and water resources. This study mainly focuses on identifying the factors instrumental in soil conservation, and investigating farmers' pro-environmental behaviours related to their soil conservation practices, in order to suggest policy measures to enhance the upcountry intensive vegetable cultivation in Sri Lanka.

practices were investigated by examining the relationship between variables. The effect of two variables "attitude" and "social pressure" on the variable "soil conservation concern", and analysing the effect of the variable "soil conservation concern" on "soil conservation behaviour" was investigated. The reliability of the questionnaire relevant to the objective was calculated using Cronbach's alpha test for the variables measured by the Likert scale. To examine the relationship between variables, Pearson correlation was primarily used. The path analysis was used to determine the explanatory power of the variables.

Results and Discussion

Existing soil and water conservation practices in upcountry vegetable cultivation

Majority of the vegetable growers are small scale intensive vegetable farmers. The majority's mainstay was

agriculture; most have over 15 years of experience in farming. In Kandy and Nuwara Eliya, majority of farmers had sole proprietorship of land, youth engagement in agriculture remains very low and farmers aged 51-60 years

constitute a major part of the farming population.

Soil conservation techniques practiced vary: biological, cultural and structural conservation techniques. Structural techniques and incorporating organic manure as amendments are popular. Adding organic amendments is a positive impression for soil health.

With regard to soil moisture conservation practices, half of the population does not conform to owing to varied reasons. Using descriptive and inferential statistics identify the factors affecting the soil conservation practices used by farmers. Soil conservation practices: adopted by farmers was observed according to the DOA recommendations under Sustainable land management practices (Agronomic practices, Vegetative methods, Structural methods and Cropping systems). Farmers follow combinations of mechanical such as terrace, drains and bunds, biological such as live fence and cover cropping and cultural methods such as contour farming, and crop rotation levels of soil conservation practices. Farming population (42%) follows an average level of soil conservation. Land slope has a direct effect on the cost of soil conservation practices and the cost of production.

In water application systems traditional methods such as the use of watering can and watering pipe are still popular. Adoption of advanced irrigation methods is not frequent. The use of high pressure water pipes accelerates soil erosion with soil particles detaching from soil surface.

Soil erosion control techniques used to conserving the water flowing out of the farm land (off-farm) is a very important activity in top soil conservation. Significant amount of soil eroded from the farm land due to the mismanagement of a proper drain system out of the farm field to the main water way. More than 70% of farmers in both districts used those methods. But still more than 25 % of farmers in both districts does not used these methods. This accelerates the top soil erosion. Popular control methods are gully control, bank conservation and main canal conservation. Silt trap is a very important method to collect the nutrient rich top soil. But farmers do not practice these methods.

Climate change is a dominant constraint. Farmers shifted to short-season crops, drought-resistant crops, change of irrigation methods, changing planting dates and planting trees to cope with climate change. The smallholder farmers have high responsiveness to rainfall, temperature and wind and taken appropriate measures to mitigate climate change impacts. In the Up-country region land productivity is suboptimal as.

In the Up-country region famers did not apply modern technology for tilling, watering, cultivating and harvesting, which makes the processes time consuming. A wide range of technologies are available for soil and water conservation in the cultivation activities. Farmers are unable to use the high machinery system due to land elevation. Therefore, the constraints in technology application have limited their land productivity to a great extent. When considering the problems face by vegetable farmers, nearly 90% of the

vegetable lands in Nuwara Eliya district and 45% in Kandy are under the sloping land category. In this category 46% in Kandy and 34 % from Nuwara Eliya, we have observed, the soil texture is clay. When irrigation water or rainfall slowly penetrates through soil it is evident the area is not well-drained. These characteristics can have a weighty influence on cultivating lands result in less crop production and difficult land management. Nearly half of the farming population follows an average level of soil conservation. It is highlighted from the findings land slope directly effect for the cost of soil conservation practices and the cost of production. Cost of production proportionately increasing with the increasing land slope. According to the analysis profit proportionately increasing with the soil conservation adoptability. High eroded areas with soil conservation practices offered a significant profit.

Recommendations

- **Restore soil health (soil condition) with organic amendments** is highly recommended to protect the top soil erosion. Using organic manure after harvesting should take place concurrently to restore soil health and improve physical, chemical, and biological properties of soil for soil condition regeneration, as fallowing period is not much popular among intensive vegetable farmers.
- **Increase water infiltration capacity of the lands.** Majority of the vegetable lands in Nuwara Eliya district belong to the steep slope and

The farmers' pro-environmental behaviours related to their soil conservation practices.

The results of the analysis regarding the effects of independent variables on the variables "soil conservation behavior" and "soil conservation concern" indicated that, among the variables affecting these two variables, the variable "attitude towards soil conservation" was the most powerful predictor of "soil conservation concerns" and the variable "social pressures on soil conservation" predicted farmers' "soil conservation behaviors" better. Additionally, the independent variables used in this research could predict 30% of the variance in terms of soil conservation concern and 20% of the variance in terms of soil conservation behavior. These findings can be practical and appropriate for executive officials since, instead of making efforts to direct change the behavior, they can first focus on conceptual changes and persuasive changes like changing attitudes towards soil conservation.

clay soil category. As a result, when irrigation water or rainfall slowly penetrates through soil the area is not well-drained, affecting land productivity level and land management.

- **Promote zero tillage.** Zero tillage at the land preparation stage is proven to be the best but rarely practiced soil erosion control technique for undulating landscapes in the study area. To this effect training should be provided on effective land preparation, with the help of the Department of Agrarian services.

- **Encourage practicing vegetative soil conservation techniques.** Vegetative soil conservation techniques (biological hedges, Grass hedges and Cover crops/ mulching) are not popular. As a basic, freely available, low cost practice, these should be encouraged at Agrarian Development Centers.
- **Engage in agriculture practice with more soil conservation practices in severe erosion areas.** Extreme care should be taken to avoid degradation of lands when agriculture is practiced in high, very high and extremely high levels of erosion hazardous areas. Effective soil conservation practices are vital to arrest the severe erosion presently occurring in these areas. Natural forests with high biological and hydrological value should be conserved as strict conservation forests. Other forests can be assigned for regulated multiple use.
- **Adopt modern eco-friendly input management techniques.** Soil nutrient management in intensive vegetable cultivation is effective in soil conservation. Soil-test based fertilizer application, organic matter application, and use of bio pesticides/botanicals/predator mites for pests and disease control are recommended with synthetic applications.
- **Utilize the total land area for intensive vegetable cultivation.** Since limited land extent is a constraint to expand Upcountry crop production the total land area should be brought under intensive vegetable cultivation to enhance the national production.
- **Facilitate micro irrigation systems to remote and high elevated areas.** Farmers of remote and high elevated areas are subject to inequity in water supply. Fewer farmers use lift irrigation, groundwater and agro wells for water supply. It is important to use these water sources efficiently and uniformly. This can be achieved by providing financial support by way of loan schemes to install micro irrigation systems for remote and high elevated areas.
- **Encourage off-farm water management.** Soil erosion control techniques used for conserving the water that drains out of the farmland is very important in topsoil conservation. This is a very important section we have observed during our data collection. Because significant amount of soil eroded from the farmland due to the mismanagement of a proper drain system out of the farm field to the main water way, it is important to developing an off farm - soil erosion control system at Agrarian Development Centers to conserve the water draining out of the farmland is timely for topsoil conservation.
- **Promote silt trap among farmers.** Silt trap is an important method to collect the nutrient rich top soil. Training can be provided on integrated soil conservation methods to educate the farmers on this method.
- **Apply conservation measures based on the model erosion maps.** Introducing appropriate site-specific interventions such as agroforestry, agronomic practices, enclosure of degraded lands, and conservation

measures based on model erosion maps is a viable solution towards sustainable environmental management.

- **Practice climate change adaptation measures.** Damage caused due to climate change can be minimized by climate change adaptation measures. The study found the need to resort to adaptation strategies by rural smallholder farmers to cope with climate change. Farmers shifted to short-season crops, drought-resistant crops, change of irrigation methods, changing planting dates and planting trees to cope with climate change. The smallholder farmers have high responsiveness to rainfall, temperature and wind and have taken appropriate measures to mitigate climate change impacts.

New technology can be used for soil and water conservation in the cultivation activities. The youth participation in agriculture can also be raised if modern technology becomes a part of this enterprise.

- **Design a cooperative system to collect vegetables.** Due to geographical formation of the land, transporting the produce to the market poses a great challenge. A cooperative system to collect the harvest would be a viable solution.
- **Update the extension service** to create awareness among the farmers. New knowledge can be provided on sustainable soil conservation practices for the best soil erosion control technique for undulating landscapes and potential yield, new technological improvement in their cultivation

field for water application using new technology, modern eco-friendly input management techniques and practicing climate change adaptation measures.

- **Raise awareness of soil conservation.** The present extension policies need to be strengthened to incorporate trends that recognize the critical role played by social environment of farmers and subjective norms in raising awareness of soil conservation.
- **Strengthen social capital.** A plausible approach to attain soil conservation is through inclusive strategies addressing local groups aimed at capacity building and social capital strengthening. Training of trainers in the community to upgrade local knowledge, leadership and innovativeness in the field of soil conservation is suggested. In addition, community participatory policies can play a major role in fostering cooperation in participatory action on management of soil resources.
- **Strengthen the current extension policies.** The degradation of land and water resources in the upcountry area has been a multi-dimensional issue, stemming from policy lapses occurred in the last few decades. In any corrective action, the critical role played by the social environment of the farmers and educating the farmers in soil conservation should be taken into account.