# The Influence of Export Agriculture and Domestic Agricultural Practices on Water Resources in Up country

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## Introduction

The total land area of Sri Lanka is approximately 6.5 million ha. Sri Lanka is divided into 3 regions based on the elevation. They are Low country with elevations from 0-300 m amsl, Mid country from 300-900 m amsl and Up country with elevations higher than 900 m amsl. The Up country encompasses four administrative districts namely, Nuwara-Eliya part of Kandy, Matale and Badulla.

The natural resources in the Up country play a very dominant role in the socio-economics of the country. Further, it has several perennial water falls, springs, catchments and reservoirs, which sustains the hydrological cycle of the country. Substantial amount of hydro-power is also generated from the above sources. The Up country is, traditionally, a source of export agriculture and tea has been the main export agricultural crop grown in the Up country. Apart from tea, paddy, horticultural crops and tobacco are also cultivated in the Up country.

Up country consists of a central mountainous land mass formed by the upheaval of the land from the surrounding lower level surface during different times of the geological history of the Island. The main land forms found in the Up country are Ridges and Valleys, Mountains and mini Plateaus and Benches. These land forms are ideal to store water with least construction costs. Hence, they are used to generate hydropower with the presence of required head.

## Water resources in the Up country

Water resources can be categorized as surface and ground water. Surface water occurs in the form of rivers, streams, lakes, marshes, reservoirs and ponds. Sri Lanka receives vertical precipitation (rainfall) from two seasonal monsoons *i.e.* South-West

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and the North-East. Further, there is rainfall during intermonsoons brought by convectional winds. Occasionally, rainfall is also received due to the depression in the Bay of Bengal and cyclonic winds. The rainfall from all above contributes to the water resource of the Up country. In addition, Up country also receives horizontal precipitation at very high elevations (>1000 m amsl) on very windy days. But, the amount received is very much less than the vertical precipitation. The amount of rainfall varies between Eastern and Western slopes of the Up country. The western slopes have a distinct bi-modal pattern of rainfall while Eastern slopes have predominantly a unimodal pattern of rainfall. The bi-modal pattern in the Western slopes is due to the influence of both South-West and North-East monsoons.

In Sri Lanka, majority of rainwater (65% in wet zone and 37.5% in the dry zone) received is reported to be lost by runoff. It has been estimated that Sri Lanka receives about 132,000 million cubic meters as annual rainfall. The average annual runoff from all the river basins was estimated to be 47000 million cubic meters (Gamage, 1996).

The highland massif in the south central region is the principal geographical determinant of water resources in Sri Lanka. The monsoonal winds intercepted by the hills give rains to the island. Surface water from the high watersheds is transported by 103 natural river basins that cover 90% of the water resources (Ministry of Forestry and Environment, 2000). Of the 103 watersheds in Sri Lanka, the 4 major rivers Mahaweli, Kalu, Walawe and Kelani, that are greatly fostered by upland vegetation cover around 27% of the island's land area. Mahaweli River is identified to be the only perennial river traversing the northern dry zone (National Atlas of Sri Lanka, 1988). Under Mahaweli Scheme, three major reservoirs, Victoria, Kotmale and Randenigala reservoirs were built mainly for hydro power generation. Further, many rivers and streams that originate from the central highland of the island feed major reservoirs built for electricity generation, irrigation and human consumption.

Many of the waterfalls that attract local as well as foreign tourists are originated from the rivers and streams fed by the central highlands. In addition, there had been about 428 micro hydro units in operation in stand alone mode in tea and rubber estates until late sixties, majority of which were in the central highlands. Now only a few of these estate-micro-hydros are in operation (ADB, 1994). Hence, Up country region is considered to be one of the most important and sensitive areas influencing the availability of water resources for sustenance of flora and fauna.

## Cultivation of perennial and other crops

Forests or *patna* grass forms the ideal vegetation cover to conserve soil and water in the Up country. However, during the colonial ruling period, part of the forest lands

was replaced initially by coffee and later by tea. Planting of coffee and tea was the major land use change occurred in the Up country in the latter part of the 18th century. In addition to tea, presently, vegetable and paddy are also cultivated in the Up country. Tea is found to be the most suitable plantation crop for Up country because tea grows well in acidic and well drained soils found in the Up country. Large areas of forests were cleared for planting tea. Initially, seedling tea (originated from seeds) was planted up and down the slopes. Though the mechanical soil conservation methods were in place, they were more helpful to take excess water out of the land than to conserve soil. This has led to heavy soil erosion. However, during the middle part of the 19th century, with the advent of high yielding vegetatively propagated tea (cultivars), the planting system was changed from that of up and down to a contour planting system.

The terrain in which the crops are cultivated are mainly hilly, mountainous and to some extent rolling. The slopes of the hilly terrains are 15-30% while those of the mountainous terrains are greater than 30%. The rolling terrains have a slope of 8-15%. By nature, the cultivation of crops in these terrains is conducive for soil erosions. Apart from the slope of the terrain, the erosive storms on exposed ground also cause soil erosion. It has been reported that the Up country region is receiving less erosive rainfall (erosive rainfall >25 mm $hr^{-1}$) than Low country *i.e.* percentage of erosive rainfall in Nuwara Eliya was 4% compared with 62% in Galle (Krishnarajah, 1985).

De Alwis *et al.* (1980) reported a land suitability classification for tea based on slope, soil depth, rockiness, gravel content and soil type. Accordingly, Red Yellow Podzolic soils having a slope less than 25%, soil depth more than 90 cm, rockiness less than 10% and gravel less than 10% in the top 90 cm (as a percentage by volume) are suitable for better establishment and growth of tea. In addition, the Reddish Brown Latosolic soils with slopes of 25 - 70%, soil depth of 50 - 90 cm, a rockiness of 10 -20 % and a gravel percentage of 10 - 50 % are also categorized as moderately suitable for cultivation of tea. Such categorization and land suitability classification helps farmers to maximize land productivity with minimum soil related problems.

## Issues created by upstream people affecting downstream users

The impact of upstream land use changes on the down stream users are mainly due to sedimentation of water bodies by eroded soils, reduced off-season stream flow due to reduction of the size 'sub-surface reservoirs' and influence on quality of water. The sedimentation results in the loss of hydro power generation capacity, reduction in the extent of irrigated agricultural lands and their productivity, losses in water quality and reduction in aquatic life. In addition, there is an increased probability of floods and land slides. At present 40% of the country's electricity requirement of 8 million KWH is supplied by the hydropower.

## Effect of agriculture on water resources

The Meteorological Department of Sri Lanka has indicated that there is a reduction of rainfall of 10-20% between periods of 1931-1960 and 1961-1990.These values vary from district to district. Hydrologists who were involved in the Mahaweli Development Program also noted that there was a decline of 500 mm of rain from 1880 to 1940. In Nuwara Eliya district, the annual rainfall of 2500 mm in 1870 has declined to 2000 mm in 1970 (Manthritillake, 1997). This period coincided with the expansion of tea plantation and decrease in forest cover in Sri Lanka. It was also observed that the decline of rainfall has stabilised after 1940s. However, there is also an opposing argument that the rainfall in Sri Lanka is not governed by the vegetation cover but by developments over the Indian Ocean and land mass of the Asian continent. The general belief is that tree cover increases the runoff. However, the studies conducted elsewhere reported decreased water yield with increased tree cover. This is seen very well in forest plantations with fast growing tree species. Bosch and Hewlett (1982) showed that 10% increase in forest cover (pines and Eucalyptus) decreases the annual flow by 10% and vice versa. A study conducted in Kenya had shown that conversion of rainforest to tea resulted in small increase in total stream flow during the early period of the conversion. However, 5 years later, the differences became insignificant. The declining rainfall has a negative impact on the runoff from the catchment areas.

The forest cover of Sri Lanka in 1900 was about 70% and presently it is around 22%. Clearing of forests as a result of population increase has adversely affected water resources in Sri Lanka. Natural forests in the Up country wet zone are more important in conservation of water resources. Due to heavy soil erosion, high incidence of land slides is reported from the central hills of Sri Lanka where forest cover is about 9% of the land (ADB, 1994). Clearing of forests for cultivation of export agricultural crops and vegetables on steep lands has been detrimental to the environment and water resources. Poorly managed tea lands give rise to soil erosion. Manipura *et al*, (1969) reported that clean weeded tea plot in one month of rainy weather eroded 45 mt of soil/ ha whereas it was about 0.07 mt/ha for the mulched tea plot.

Besides forest, well managed tea also forms ideal cover to conserve soil and water. Unlike annual crops, soils under a perennial crop like tea are protected adequately by crop canopy and surface litter from large quantities of leaf fall so that soil degradation is minimum. However, soil under tea may get exposed to varying degrees depending on the type of tea (whether seedling or vegetatively propagated tea), planting density, type of planting, periodic pruning and extent of manual weeding by using scrapers *etc*. Apart from above, soil is exposed during the period of uprooting, beginning of soil reconditioning and replanting until newly planted tea forms a fully developed ground

cover. The tea crop forms a good ground cover few years after planting and has an economic life span of 30 years or more. Tea canopy reduces the terminal velocity of erosive rains and therefore, effectively minimize soil erosion. Further, the good cultural practices adopted in these plantations to form a quick ground cover also helps to minimize erosion. However, absence of proper conservation measures and adoption of poor agricultural practices in some of the old seedling tea lands over the past few decades have led to varying degrees of soil and bush debilitation (Basanayake, 1985).

It has been reported that about 55% of the Upper Mahaweli Catchments is under tea cultivation. An estimated sediment yield of 115 mt/ha/yr has been reported from these catchments (Gamage, 1996). It has also been reported that the major land use patterns contributing to severe soil erosion in the Up country regions are poorly managed seedling tea and tea smallholdings, tobacco cultivation and vegetable (including potatoes) gardens (Zijestra, 1989, Gamage, 1996). Tobacco cultivation contributes to soil erosion of about 70 mt/ha/yr in the highland area (ADB, 1994). Gamage (1996) has shown that rapidly increasing population, poverty and unemployment increases demand for land and the lack of an effective extension service backed by research has been responsible for the poor performance of soil conservation.

## Effect of agriculture on watersheds

Use of forests and steep lands for agriculture and other human activities cause disturbances to the watersheds. In Sri Lanka, two segments of watersheds have been identified by the Watershed Management Policy formulated in 2004. They are segments that hold the natural resources and service the lower segments and the lower segments that make use of the resources made available from the upper segment for economic development (irrigation, hydro power *etc*). The policy identified watersheds above 300 m amsl are most critical and needed greater protection. Careful management of upper watershed is a must to protect biodiversity, water resources, aesthetics and environmental quality (watershed Management Policy, 2004). Some of the important issues related to watershed management in the Up country are resettlement of farmer families in degraded lands, lack of incentives and resources for soil conservation, encroachment of stream banks and reservations of reservoirs and cultivation of steep lands without proper attention to soil conservation (Gamage, 1996).

## Use of agrochemicals on water resources

Agrochemicals are used in the plantation sector mainly for the control of weeds, pests and diseases. With the shortage of workers and high cost of manual operations, plantations are heavily dependent on herbicides for the control of weeds. Usually, most of the herbicides are used during early stages of establishment of plantation crops and

during recovery after pruning (tea). Weed growth is profuse during rainy seasons, thus there is a tendency to use more herbicides with the commencement of monsoons. This poses threats of contaminating water bodies downstream and also leaching to the deeper soil layers. It has also been common to misuse chemicals without paying much attention to the recommended rates and frequencies and also due to lack of knowledge and skills of the workers spraying chemicals. Use of pesticides is very common with vegetable cultivation. Vegetable growers use more insecticides and fungicides than herbicides. Due to cultivation of crops on the slopes mostly that exceed the recommended slopes, pesticides and other fertilizers are washed away with run-off water polluting the water resources. Use of agrochemicals is generally high with tea than with other two major plantation crops (rubber and coconut). However, with the food safety regulations and requirements of consuming countries, presently, tea growers are compelled to use pesticides more rationally and carefully. Ever rising cost of inputs has also kept growers away from the frequent use of pesticides on tea, thus reducing water pollution by agrochemicals.

## Eutrophication of water bodies

Agriculture in the uplands also has a great impact on the water quality. Fertilizers and pesticides used in agricultural lands often find their ways into water bodies posing threat to the water quality. Frequent use of fertilizers on erosive and steep lands can lead to problems of eutrophication of water bodies *i.e.* accumulation of nutrients in water bodies in excess of naturally available levels. Sivapalan (1992) showed that algal bloom reported in the Kotmale reservoir fed by Kotmale river and associated streams run through tea and vegetable cultivations was a consequence of eutrophication. Much of the fertilizers added to poorly managed plantations and vegetable/tobacco cultivations find their ways into streams and rivulets feeding the major reservoirs through run-off water and as a result phosphate and aluminum are accumulated in these water bodies. Such losses of nutrients are more pronounced in degraded and acidic soils. Increase in phosphate concentrations in water has been beneficial for the rapid multiplication of algae covering large areas of the water body. Heavy growth of algae consumes available oxygen and poison the water with toxic materials. This makes water unsuitable for human consumption and for aquatic life as well. Moreover, these algal blooms can also interfere with the hydropower turbines and the general water supply systems (Sivapalan, 1992)

## Effects of diverting plantation lands to other uses on water resources

Due to high cost of tea cultivation and processing and the poor productivity of tea lands, some of them have been diverted to other agricultural uses. As an alternative to pure tea cultivation, planting of timber, mixed cropping and vegetable cultivation have

been practiced by tea growers. Diversification of unproductive and erosive tea lands into more productive and soil conserving uses such as cultivation of timber and mixed cropping of tea with other export crops such as spices have been encouraged over the last two decades. However, some tea growers have leased out their lands for vegetable cultivation in order to secure a better income. Use of such uplands and sloping areas for short term high intensity crops such as potatoes and vegetables can accelerate land degradation and cause offsite environmental problems such as soil erosion, water pollution and silting of water bodies. Much of the environmental problems are occurred due to intensive soil cultivation, heavy use of pesticides and fertilizers and lack of proper ground cover. Such shifting of cultivation has been commonly found near the perennial streams for the purpose of ensuring adequate water for irrigation. Under such situations, water pollution and silting becomes inevitably more serious. Due to addition of pesticides and removal of top soil by erosion, these lands may not be suitable for planting other crops and soil rehabilitation will also not be an easy task. As per the Water Shed Management Policy, 2004, critical watersheds above 1500 m amsl should not be used anything other than conservation and natural restoration.

## Pollution of water resources due to anthropogenic activities

Unlike in smallholdings, large plantations usually have resident labour for their day-to-day field and factory activities. It is customary to provide them with houses within the estate for ease of management. In the past, the conditions and maintenance of these houses and some basic facilities such as toilets, water and electricity *etc* have been poor. Due to isolation, daily work in the estate and poor education, their living standards and social habits were substandard. However, due to recent investments by the companies, foreign funded projects and NGOs, they have received more facilities and health benefits and some are given separate plots of lands for housing. Hence, pollution of water bodies around worker houses has been greatly reduced. Further, migration of workers to suburbs, opening of foreign and local job opportunities and better education among the youth and children have also been attributable to the reduction of water pollution. However, poor maintenance of toilets and drainage systems of the worker houses and vegetable cultivation in some areas where worker houses are located close to the streams and water bodies can still pose environmental threats such as water pollution. The more effective community participation is of paramount importance in the conservation, protection and management of watersheds and water resources (Watershed Management Policy, 2004).

Wijayawardhana (2006) found that the agriculture and anthropogenic activities have a significant influence on the water quality. His study covered Bellihul Oya and Kotmale Oya. The areas adjacent to Bellihull Oya are relatively uninhabited and therefore,

anthropogenic activities are negligible. However, in areas adjacent to Kotamale Oya with tea, there are anthropogenic activities of varying intensities. This study, however, revealed that the concentrations of the ions ($Ca^{2+}$, $Mg^{2+}$, $Na^{+}$, $K^{+}$, $NO^{3-}$, $PO_4^{3-}$, $SO_4^{2+}$, $Cl^{-}$) in the down streams of Bellihul Oya and Kotmale Oya are below the upper limits set by WHO and Sri Lanka Standard Institution (SLSI) for drinking water. Further, forest area (upstream) showed the lowest concentration of the nutrients and the highest was found near final observation point of the mainstream (downstream). This study also revealed that nutrient addition due to anthropogenic activity was higher compared to natural biological and geological processes.

## Measures to be taken to minimize impact of agriculture and anthropogenic activities on water resources in the Up country

Hilly regions in the Up country are considered as the heart of water resources of the country. Much of the area is exposed to heavy monsoons thus providing water to the major rivers, forests and large reservoirs that sustain the nation's agricultural productivity and life of people. Such streams and reservoirs provide water to the agriculture and other industries, electricity generation and more importantly for human consumption (drinking water). Hence, it is extremely important that, agriculture and other human activities in the Up country region are planned in such a way that water resources are protected and not polluted. With the forest cover in the highlands being depleted, they are being used for agriculture and other industries and with increasing population, it is extremely important to take appropriate measures to safeguard the water resources in the Up country. Following guidelines provide useful tools to minimize adverse impact of agricultural practices on water resources in the Up country. In order to ensure successful implementation of some of these measures, it may be necessary to provide financial assistance in the event that they require high capital cost and return to investment is not immediately felt.

- ***Adherence to land use policies and soil and water conservation measures***
  Presently, there are many land use policies/acts and plans for the use of lands in the Up country for agriculture and other purposes. In these policies special reference has been made to watershed management and also for soil conservation. Hence, such policies need to be strictly adhered to when sloping and erosive lands are used for agriculture in environmentally sensitive areas. In this context, capacity of government departments should be strengthened to implement soil conservation act and other land use management policies. It is extremely important to protect stream reservations in the Up country when such lands are used for agriculture.

- ***Provision of incentives and subsidies for soil conservation and watershed management***

  Clearing of uncultivated and forest lands for agriculture and other industrial purposes should be banned. Considering the long term benefits and cost of implementing some soil conservation and watershed management efforts, farmers should be adequately subsidized for implementing such environment protecting and conservation programmes with great national importance. Implementation of soil conservation measures in plantation crops is markedly better than that in the other agricultural sectors in uplands. Hence, farmers should be encouraged to plant tree crops in their agricultural lands in the central highlands.

- ***Reforestation and crop diversification***

  It is a well known fact that the removal of the forest cover has greatly influenced the water resources in the island. In the Up country tea growing regions, a large extent of unproductive old seedling teas are found. With escalating cost of production and lack of labour, such lands will receive less inputs and also maintenance of the crop become less viable. Hence, such lands should be used for reforestation, timber and fuel wood plantations or mixed cropping. This will improve land productivity conserving soil and water resources.

- ***Proper planning and maintenance of labour houses***

  In order to minimize pollution of water bodies by various activities of resident plantation workers, it is necessary that labour houses are located in appropriate locations possibly away from the streams/reservoirs and they should be provided with adequate sanitary facilities (toilets *etc.*).

- ***Awareness and training programmes***

  It is extremely important to educate those who are engaged in farming in the upland areas especially the plantation managers and workers on the value of water resources and adverse effects of water pollution. Further, they should be made aware of consequences of soil erosion, proper soil conservation measures, contamination of water by misuse of pesticides and fertilizers and watershed management policies. Soil conservation, watershed management and land use policies *etc.* needs to be included as subjects in the school curriculum.

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