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# Vermicomposting in Silver Oak Plantation Areas for Sustainable Waste Management and Enhanced Livelihood: A Case Study of Kolli Hills, Tamil Nadu, India

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**ABSTRACT:** Silver Oak plantation on farmlands growing coffee and black pepper has gained importance in recent times in the areas surrounding the Kolli hills in the Namakkal district of Tamil Nadu, India. The Silver Oak trees shed significant quantities of dry leaves during the summer season which the local Malayali tribal community burns and/or leaves on ground. The current case study is based on an experiment of vermicomposting using local Silver Oak leaf litter, cow dung and earthworms. The results show that joint production of manure from agroforestry practices is an option in self-sufficiency for the rural communities and has the potential for a business model. Moreover, this ensures environmental sustainability by avoiding green-house gas emissions that are caused by the practice of burning leaves and/or leaving the mulch to rot. The present paper attempts to develop a sustainable model of vermicomposting in the Kolli hills region that can offer triple solutions encompassing organic manure production, environmental quality improvement and livelihood opportunity enhancement. Based on field surveys and physiochemical experiments in the Perungiraipatti village of the Kolli hills, the study presents a sustainable model of vermicomposting with specifications on nutritional quality, environmental sustainability and economic development.

**KEYWORDS:** Community, Environment, livelihood, Leaf litter, Plantation, Sustainability, Vermicompost, Silver Oak, Waste management.

## 1. INTRODUCTION

Agroforestry offers an effective tool for sustainable natural resource management by combining trees into agricultural farms, thereby enhancing social, economic and environmental benefits for local communities, who depend on agricultural farms as well as on the storable renewable forests. It is recognized as a land use option where trees provide marketable products and ecological services while cultivation activities produce agricultural outputs simultaneously. Agroforestry practices provide a practical opportunity to apply a variety of expertise and skills, based on technical knowledge as well as traditional practices that can develop sustainable rural production systems encompassing cultivation and forestry (Alao and Shuaibu, 2013). This two pronged production system helps in rehabilitating the degraded land and also in increasing the farm productivity (Dhyani*et al.,* 2017). Improvement in the existing practices and designing more efficient expansion paths for future may help the farmers to tapthe complete benefits of agroforestry. While it promotes the diversity of land use management, it can offer sustainable ecological and socio-economic solutions in the face of population growth, limited land and natural resource availability and other developmental problems.

Unsustainable management of large amounts of waste generated in the agricultural and forest sectors has been identified as a global environmental challenge in the present world. Biomass from fallen leaves and other woody residues is one major form of the lignocellulosic waste produced in mountain towns and rural villages in India. It is a daunting challenge for the village farmers, community workers and urban resource managers to manage the large amounts of such waste that has significant adverse impacts on the environment, if not disposed properly (Suthar and Gairola, 2014). Many of the dead leaf debris are either burnt in the open or disposed of at farms and/or landfills simply to rot. Such traditions not only lead to air pollution in the local region but can also be responsible for other greenhouse gases emission. Therefore, proper management and safe disposal of agroforestry waste is necessary to address such environmental problems (Singh *et al.,* 2021). Sustainable management of farm and forest waste may also help in reducing pressure on land by maintaining the right balance of moisture and fertility into the soil. Eco-friendly conversion of waste into useful products is a solution to this multitude of problems associated with these unsustainable waste disposal practices. Such projects are becoming increasingly more attractive worldwide, depending on the associated costs and the respective environmental requirements (Ntuli and Hapazari, 2012).

Sustainable natural resource management is central to sustainable development. Local community participation is vital for natural resource use and conservation because their livelihoods may be majorly based on forests. Agroforestry combines forest-based livelihoods, such as, timber plantation, growing medicinal plants, spices, bamboo etc., collecting honey, developing forest tourism and allied activities, with farm-based activities, such as, crop farming, horticulture, livestock, poultry and so on. Both may involve practices that are harmful for the environment and thus require interventions in additional and/or alternative livelihood projects with an aim to replace such activities with those having at least the same benefit and lower impact (Wright *et al.,* 2015). However, forest-based livelihood interventions are more beneficial for sustainable rural livelihood development and simultaneous forest conservation.

This paper is a case study of such an enhanced livelihood model for the farmers in small rural habitats in the hilly terrains of Southern India where Silver Oak plantation is rampant in the coffee and black pepper farmlands. The existing practice of burning and/or leaving the leaf litter on land is proposed to be replaced by simple techniques of vermicomposting. The model aims to have the triple benefits of sustainable waste management, environmental quality and enhanced livelihood for farmers arising out of the vermicomposting activity. The aims of the study are

a) to develop aphysio-chemical model of vermicomposting using Silver Oak leaf litter;
b) to compute the nutrient quality of Silver Oak compost and compare it with an alternative compost made of mixed leaves from traditional trees like jackfruit, guava, mango, coffee;
c) to estimate the environmental benefit of vermicomposting over the old practice of burning the residue;
d) to create a farmer-friendly enhanced livelihood option based on compost made of leaf litter and other local inputs, leading to a viable economic model.

## 2. METHODS AND MATERIALS

### 2.1. The study area

#### *2.1.1 Location of the study village*

The Kolli hills is a pristine hilly terrainat an altitude ranging from 700 to 1600 meters above sea level, in one part of the Eastern Ghats Mountain rangein the Tamil Nadu state of India (figure 1). It is a block in the Namakkal district, spread overan area of 65,730thousandacres (Census of India, 2011), located between $11^0 10'00''$- $11^0$ 30’00” N latitude and $78^0 15'00''$- $78^0 30'00''$E longitude (Vijayakanth*et al.,* 2017).The current study was conducted in a village named Perungiraipatti, situated in the Valavanthinadu Panchayat of the Kolli hills, situated 55 kms away from the Namakkal plains. The total area of Valavanthinadu Panchayat is 4,086.82 thousand acres (Census of India, 2011).

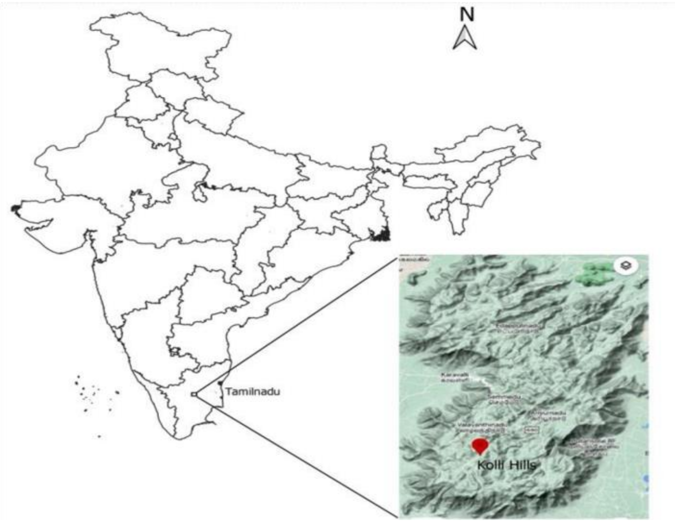


**Figure 1**: Map of the Kolli Hills

*2.1.2 The inhabitant community*

A tribal community called *Malayali*, meaning people who reside in hills in the Tamil language, are the inhabitants of the Kolli hills. They have been affiliated as a scheduled tribe by the

Government of India. The total population of the Kolli hills is 40, 479including 20,862 men and 19,617 women (table 1). The *Malayalis* practiced shifting cultivation around millets in the past and have shifted to pepper and coffee production in recent years. The primary occupation of this region is agriculture with some farmers tilling own land, some working as marginal farmers on the farms of big landowners and some as daily wage laborers under the Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA) scheme. Migration to the neighbouring state Kerala during agricultural off-season is also a regular annual feature. Other minor occupations of the region include running grocery shops for daily essentials, low-cost hotels and restaurants as this place is a tourist destination. The overall quality of life in the region is moderate to low and can improve through policy interventions designed for enhanced livelihood and additional occupations.

**Table 1:** Demographic patterns in Kolli Hills andValavanthinadu Panchayat

| **Region** | **Total Population** | **Males** | **Females** | **Schedule Caste** | **Schedule Tribes** | **Number of Households** |
|---|---|---|---|---|---|---|
| Kolli Hills | 40,479 | 20,862 | 19,617 | 668 | 38,678 | 10,910 |
| Valavanthinadu | 4,347 | 2,203 | 2,144 | 120 | 3,836 | 1,176 |

**Source**: Census of India, 2011

*2.1.3 The Silver Oak plantation*

The predominant vegetation of the region is dry deciduous forest with some patches of tropical semi-evergreen and moist deciduous forests. The major cultivation in the Kolli hills is that of black pepper and coffee, done in organic ways. The farmlands overlap Silver Oak estates, with the trees providing support for the creepers (figure 2). Other medicinal plants and traditional fruits, such as, banana, pineapple, guava, and jackfruits are also found in this region.

*Grevillea robusta*, commonly known as Silver Oak, and *Savukkumaram*in Tamil, is an eastern coastal Australian native species. It was introduced in India by the British particularly for the purpose of tea and coffee plantation. Dry rainforest and subtropical climatic conditions with an average annual rainfall of more than 1,000millimeters are best suited for its growth. Silver oak is a fast-growing evergreen tree with an average height between 5to 40 meters, with a non-slippery surface androbust structure. These features make Silver Oak suitable for being a supporting tree for growing black pepper and a shade tree for coffee and tea plantation. Almost 75% of sunlight can penetrate intercrops because of their narrow leaves and sparse branches. As pepper and coffee have become the dominant crops of Kolli hills, farmers of this area have started growing Silver Oak on a large scale. The total area under Silver Oak plantation in the study village is around 100 acres that host around 400 trees per acre. Plantation of single variety Silver Oak is likely to have an adverse impact on the biodiversity of the region.

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**Figure 2**. Silver oak farms, farmers plucking peppers in harvesting season, farmland and village

(picture courtesy: authors)

*2.1.4 Vermicomposting from Silver Oak for sustainable waste management*

Silver Oak trees shed dry leaves during the three months of April, May and June of the summer season. The generation of leaf litter is around 30 kilograms per tree during the season for the entire year. Farmers generally leave the large quantities of leaf litter on ground and the natural decomposition rate of silver oak is very slow due to its needle-like structure. Although farmers use some of the fallen leaves as mulch, they treat these leaf litter mostly as waste to decompose naturally. The more dominant practice is to burn the leaves, causing severe environmental pollution. The huge amount of leaf litter may be sustainably managed through vermicomposting, that offers a viable and eco-friendly technology to convert organic wastes into vermicompost through the joint action of earthworms and microorganisms (Domínguez, 2018). The current study examines vermicomposting as a technological model for Silver Oak plantation areas of village Perungiraipatti of the Kolli hills regionfor sustainable waste management. It is further scrutinised as a possible tool for arresting environmental damage andas an economic optionfor generating an additional occupation for the farmers.

**2.2. The study methods**

*2.2.1 The Data*

The vermicomposting experiment was done in village Perungiraipattiusing local raw materials, labour from the agricultural family farms and already existing infrastructure, equipment and utilities. The leaf litter was collected after the summer season of 2021 when the trees shed leaves, following which the vermicomposting experiment was carried out during the months of August and September. Local community was involved in the experiments and were interviewed for understanding their practices as well as getting their response towards the vermicomposting activity, both before and after the experiment through focused group discussions.

*2.2.2 Raw Materials*

Fallen leaves from the SilverOak tress were the primary raw material for the vermicomposting experiment. Leaves from other trees were also collected from the village farms in order to produce mixed leaf compost. Cow dung available in the farmer households was used for layering over leaves inside the pit. A local Indian variety of earthworms, *Lampitomauritii*, (family Megascolecidae, genus Lampito (Kinberg), species *Lampitomauritii*) was used in the process of vermicomposting (figure 3).

**Figure3**: Leaf litter of Silver Oak and Indian earthworm *Lampitomauritii* (picture courtesy: authors)

*2.2.3 The vermicomposting process*

The experiment was designed to produce vermicompost from Silver Oak leaves and mixed leaves parallelly in order to have a comparison of the quality and quantity of the output. Two cemented pits, already existing in the cow sheds of the households, were used for producing the two types of composts respectively. The pits were 1.5 feet deep, 4.2 feet long and 1.5 feet wide. Leaves were layered for 3 inches in the respective pits and 3 inches of cow dung were put on top for 10 days. The earthworm *Lampitomauritii*was released into both pits inside which the respective materials were mixed. 1 liter of water was sprinkled inside the pits to maintain the moisture level and insect-protection chemicals were put outside the boundaries of both pits to protect them from insects. The mixtures were left for the next 45 days to get the manure ready for harvesting. The manure was made fine through manual straining which also helped in removing the stones and undecomposed matters left after the harvest. The whole process took a total of 55 days for the final output to be ready for nutrient analysis (figure 4).


**Figure 4.** Compost pit and vermicompost outputs of Silver Oak and mixed leaves

(picture courtesy: authors)

*2.2.4 The associated environmental sustainability*

The vermicomposting model saves the burning and/or rotting of the huge quantity of leaf litter. The potential emission of pollutants due to the above may be considered as an indirect estimate of averting environmental degradation. Different types of pollutants, such as, carbon di oxide ($CO_2$), carbon monoxide (CO), nitrous oxides ($NO_x$) and particulate matters (PM) have been considered in calculating the potential environmental benefits of vermicomposting in the large Silver Oak plantation areas.

*2.2.5 The enhanced livelihood possibility*

A self-sufficient village with coffee and black pepper as cultivation output and compost from Silver Oak leaf litter can be considered as a joint production model in agroforestry. Additional input of cow dung is also available locally. Hence, the vermicompost can be considered as an output produced in a self-sufficient manner and available for self-consumption. Additionally, it may be packaged, transported, and sold to other areas. While the former model is selfperpetuating, the latter can be developed as a business model. Both enhance the economic wellbeing of the community through a sustainable waste management activity.

## 3. RESULTS AND DISCUSSION

### 3.1. The vermicompost output

A simple and short duration technology used in the experiment enabled the conversion of leaf litter into manure, based on indigenous raw materials which otherwise used to go waste and/or got burnt. The leaf litter waste mixtures converted into partially stabilized dark brown substances by earthworms which contain high values of soil nutrients (Suthar and Gairola, 2014). With approximately 400 Silver Oak trees per acre, there are around 40,000 trees in the 100-acre plantation area of the Perungiraipatti village. The average leaf litter is 30 kilogramsper tree during the three-month season of the year, resulting in an annual generation of almost 1200 tonnes of leaf litter in the study area.

The experimental model used moderate quantities of the three types of raw materials, namely, Silver Oak leaf litter, mixed leaf litter and cow dung. 10 kilograms of the two types of leaf litter were used along with cow dung of 50 kilograms and 30 kilograms quantities respectively. The requirement of cow dung was higher for Silver Oak because of its fern-like leaf structure that makes the litter rough and voluminous. On the other hand, mixed leaves from other plants are softer and less in volume. Moreover, Silver Oak contains more undecomposed matter than the mixed leaves. As a result, decomposition was easier and faster for mixed leaves than Silver Oak. The same amount of leaf litter (10 kilograms of each) required 5 timesmore cow dung for Silver Oak (i.e., 50 kilograms) and 3 times more for mixed leaves(i.e., 30 kilograms).

With minor differences, both types of leaf litter produced good amount of biofertilizers. The input-output ratio for Silver Oak turned out to be higher than that of mixed leaves. The resultant outputs were 1.83 times for Silver Oak and 1.75 times for mixed leaves over the total input per weight (table 2). Based on the input-output ratio obtained during the experiment, the annual output of Silver Oak vermicompost was estimated to be around 2196tonnes from the 1200 tonnes of leaf litter inputs. The total time taken was less than two months. Although mixed leaf compost has a comparable input-output ratio and lower requirement of cow dung, Silver Oak compost promises to be the dominant one because of the larger availability of leaf inputs in the region dominated by its plantation.

**Table 2**: Input, output and time of production of vermicompost

| **Type of Vermicompost** | **Amount of leaf litter** | **Amount of cow dung** | **Quantity of earthworm (*Lampitomauritii*)** | **Total yield (manure)** | **Time taken** | **Inputoutput ratio** |
|---|---|---|---|---|---|---|
| Silver Oak | 10 kg | 50kg | ½ kg | 110 kg | 10+ 45 days | 1.83 |
| Mixed Leaves | 10 kg | 30kg | ½ kg | 70kg | 10+ 45 days | 1.75 |
| Estimated annual production of Silver Oak compost from the study area | 1200 tonnes | 6000 tonnes | 60 tonnes | 2196 tonnes | 10+ 45 days | 1.83 (assumed) |

### 3.2. The nutrient analysis

The laboratory results of the nutrient analysis, using 20 grams of each type of the manure, revealed that the values of all physicochemical parameters, namely, the pH factor and electric conductivity (EC) and macronutrients, namely, nitrogen, phosphorus, and potassium (NPK) were good for both varieties (table 3).

**Table 3:** Values of physio-chemical parameters and macro-nutrients of vermicompost

| Vermicompost | pH | EC (mS/cm) | Nitrogen (%) | Phosphorus (%) | Potassium (%) |
|---|---|---|---|---|---|
| Silver Oak | 7.20 | 1.42 | 1.65 | 0.84 | 0.76 |
| Mixed leaves | 7.99 | 1.58 | 1.87 | 0.99 | 0.80 |

**Note.** The analysis was conducted at Abitek Testing Laboratory, Coimbatore

Barring some minor differences, both types of compost have proved to be rich in nutrients. Mixed leaf compost tested for marginally higher values, possibly because of the mixture of different species which have different chemical compositions (Ganiger*et al.*, 2019). While the macronutrient variation in vermicompost depends on the raw material, it also depends on the feeding habit of earthworms towards particular organic wastes in the biodegradation process (Crawford,1983); (Gaur and Singh, 1995). This result further seems to indicate that biodiversity is crucial in any region because variations in species impact the nutrient composition of soil. However, more detailed analysis is required for the same, which was beyond the purview of the present study.

### 3.3 Environmental benefits of vermicomposting

A huge amount of dry leaf litter is generated in the villages of the Kolli Hills. In the 100-acre Silver Oak plantation area of the Perungiraipatti village, the average annual generation of leaf litter is around 1200 tonnes. The natural decomposition rate of leaves of Silver Oak is slower than other species and are generally left and/or burnt. In the absence of oxygen at landfills, these dried leaves also hold a considerable amount of greenhouse gasses (GHGs), such as, $CO_2$(~30%), methane ($CH_4$ ~ 60%), and other gasses during their degradation (Polprasert, 2007). The layers of dried and fallen leaves at farms also result in depletion of water table and adversely impacts the moisture and fertility of the soil. Additionally, water and land use raise problems of resource efficiency, while monoculture ofSilver Oak strains bio-diversity.

The community practice of leaf burning is a serious environmental concern. Air pollution through emission of $CO_2$, CO, $PM_{2.5}$,$NO_x$ etc. may be detrimental to the environment and cause health concerns of the people who may be ignorant about it. The proposed solution of vermicomposting can avoid such emissions and thereby improve environmental quality (table 4).

The annual saving in $CO_2$ emission is to the tune of 1752 tonnes per 1200 tonnes of Silver Oak leaf litter in the study area. The corresponding saving in CO is around 72 tonnes while those of $NO_x$ and $PM_{2.5}$ are minor at 2.4 tonnes and 3.6 tonnes respectively. Although the quantities in the agroforestry sector are lower than potential emissions from agricultural waste like stubble, the figures are significant.

**Table 4.** Saving in emission of pollutants associated with leaf burning

| | $CO_2$ | CO | $NO_x$ | PM2.5 |
|---|---|---|---|---|
| Emission rate from agricultural waste (gram per kilogram) | 1,585 ± 100 | 102 ± 33 | 3.11± 2 | 6.26 ± 2 |
| Emission rate from burnt leaf litter (gram per kilogram) | 1,460 ± 100 | 60 ± 22 | 2 ± 1 | 3 ± 1 |
| Avoided emission from leaf burning due to vermicomposting of 1200 tonnes of Silver Oak leaf litter (ton per ton) | 1752 | 72 | 2.4 | 3.6 |

**Source**: Franka et al, 2012, Singh, 2018, Gupta et al, 2004 for the emission rates

### 3.4 The benefits of enhanced livelihood

Vermicomposting proved to be an easy technology of converting leaf litter, otherwise wasted, into a nutrient-rich manure based on indigenous raw materials including leaf, cow dung and earthworm. Participation of the local community in this activity is central to the model because the raw materials are local and the people need nothing more than some initial training about the process. The model promises to be self-sufficient because of its negligible cost and comparatively higher benefits (table 5).The study area houses 45 families with approximately 150 *Malayali* people who can develop this sustainable model of enhanced livelihood and/or additional income. The average holding of the farmers are within the range of 3-5 acres of Silver Oak farms.

A cost benefit analysis of vermicomposting involves several heads of cost, such as, raw materials, equipment, labour, structural construction, transportation, marketing etc. On the other hand, the major benefits come in the forms of having an organic product, saving chemical fertilizer and pesticides otherwise used, environmental quality and ecological balance (Adorada, 2007). The cost of raw materials is nil, for both types of leaf litter and earth worms in the case study. Since most of the farmers own cows, cow dung is available in the households. Cemented platforms and/or open areas in the cow sheds can be used as pits without any additional cost of construction. Use of equipment does not involve additional cost of purchase because these are standard tools available with farmers. Labour cost is implicit because it is part of the family farm labour. Operational expenses on water and electricity utilities are nominal and embedded in the major activities of the farm, namely agriculture, animal husbandry and forestry. No additional cost is to be incurred for land used for composting because it is within the household setup.

The only possible costs will be on account of packaging and transportation to markets in nearby towns, in case of developing business beyond the village. Eco-friendly packaging is best suited for an organic product like this. Indian consumers are expected to be aware of their responsibility for environmental protection and therefore likely to prefer products with eco-friendly packaging (Prakash and Pathak, 2016). Cloth bags can be procured at affordable prices (Rs 6 per bag of size 1 kilogram each and Rs 10 for the ones of 5 kilograms), with nominal printing charges (Rs 2.20 per bag) as observed in the market survey at the nearest Namakkal town. However, stitching and printing of bags may be promoted as an ancillary activity of the village folks in order to establish a self-sufficient economic model.

There is ample scope for the government and other non-governmental agencies to venture into this activity in several villages. Initial training will have to be imparted to the local farmers who may not be familiar with the vermicomposting technique. To impart training by experts in the field for one season at most, may be taken up as a policy priority. The associated costs may best be borne by the local governments and/or aided by the agencies as promotional expenditure.

**Table 5.** Costs and benefits of vermicomposting based on leaf litter

| Costs | Benefits |
|---|---|
| **Self-sufficient present model** | |
| Raw material expenses (initial earthworm stock, leaf litter) – indigenous | Production of vermicompost |
| Structural expenses (construction materials for compost pits and shades) – existing | Savings from fertilizer |
| Manpower expenses – family farm labour | Savings from pesticides |
| Equipment (shredder, mixers hand tools, etc.)- existing | Savings from not burning leaves |
| Operational expenses (water, electricity, land)- embedded | |
| **Future business model** | |
| Marketing expenses(packaging, printing) | Sales from vermicompost |
| Transport expenses (delivery of products) | |
| **Policy intervention** | |
| Initial training expenses - agency and/or government | |

In case the model is expanded with delivery to far away destinations, the transportation charges will have to be adjusted through additional charges, such as courier, or by developing the delivery system within the extended business model. The revenue generated from the sales of such high-quality compost can easily offset the cost of production, thereby making it a feasible economic option for the local community. This may result in a favourable cost-benefit ratio resulting out of several economic advantages (table 5). Beyond the sale of the compost, there will be saving in the form of use of fertilizers and pesticides, if used locally.

The proposed model offers enhanced livelihood opportunity for the local community. This joint production system may reduce migration of labour during agricultural off-seasons when vermicomposting may becarried out. Women may play a key role by participating and managing all manufacturing processes as it requires continuous monitoring and less hard manual labour. Women Self-Help Groups (SHGs) in the western region of Uttar Pradesh have actively participated in the collection and sales of vermicompost (Yadav, 2015). Village women may also find an additional livelihood opportunity in making cloth bags for the eco-friendly packaging of vermicompost.

## 4. CONCLUSION

Vermicomposting has been adopted worldwide as an efficient tool to protect natural resources through an environmentally friendly and economically viable technology (Singh and Singh, 2017). Several case studies in vermicomposting have been conducted in Kampala in Uganda (Lalander et al., 2015) and in the Indian states of Maharashtra, Puducherry and Andhra Pradesh (Pattnaik and Reddy, 2010; Gurav and Pathade, 2011; Venkatesham and Reddy, 2009) using various organic wastes like food waste, temple waste, etc. All results have shown vermicomposting as a simple, sustainable and eco-friendly tool for managing organic waste under community participation. Vermicomposting from the huge amounts of leaf litter generated in the Silver Oak plantation areas of the Kolli hills offers a promising model of environmental sustainability and economic viability. People of the *Malayali* tribe can make use of local raw material, household labour and existing infrastructure and equipment to produce high quality manure. In case the product is for personal use, it offers an eco-friendly solution that saves chemical inputs like fertilizers and pesticide at a micro level and cleaner environment at the macro level. Alternatively, it can provide a viable economic model, where costs of packaging and transportation can be imputed to sell the output at a nominal price. Family members not engaged in agriculture, such as, women and elderly can gain employment through such activity. The model offers the possibility of a self-sufficient rural model with options of additional livelihood in an environmentally sustainable way. The recent trend of monoculture in Silver Oak has detrimental impacts on local bio-diversity and leaf burning creates environmental problems. Converting its leaf litter into vermicompost addresses the latter. However, the former needs greater policy attention and change in practices. That the mixed leaf compost showed higher nutrient values, may be considered as an indication of the value of biodiversity.

The proposed model may be extended to areas beyond the Kolli hills. However, cost considerations may get altered in cases where the farmers do not own cows and have no cemented sheds. Purchase of cow dung and construction of pits will need to be included in the cost calculations. The distance to the market will also affect the transportation cost if sold outside the village. The model may be extended beyond village Perungiraipatti, and outcomes may be expected to be similar because of comparable socio-economic conditions, topography and vegetation. With due policy attention, involvement of the local administration and participation of the local community, vermicomposting from Silver Oak may grow as a joint activity with triple benefits in agroforestry in several parts of the region. It may set a viable model of sustainable waste management, pollution reduction and livelihood enhancement in rural landscapes with large scale tree plantation in farmlands.

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## DECLARATION

The authors declare that there is no conflict of interests.

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