RESEARCH ARTICLE OPEN ACCESS

Assessment of Food Miles and Reduction of Greenhouse Gas Emissions Promoting Home Gardening

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Rapid urban city growth of the world has been identified as one of the critical challenge facing humanity. This unexpected growth has mainly caused to urban poverty and it is leading to the phenomenon of the "urbanization of poverty". Therefore, ensuring food security in urban households is a greatest problem and today, most of the world organizations have mentioned that the Home Gardens (HG) as the best way to improve food security in an urban environment. This research study mainly focused on greenhouse gas (GHG) emission in food production and transportation and related indicators such as food vehicle kilometers and fossil fuel use. Collection of primary data from selected HG was done using a structured questionnaire survey and data were collected from a random sample of ten peri- urban farms of Kesbewa Urban Council area. Using the information gathered by the survey, amount of GHG emitted within a month when one ton of each indicator crop produced and transported was calculated. All calculation was done on monthly basis. The results revealed that a huge quantity of vegetables are transported to Kesbewa in each month from distance markets. This activity consumes a large amount of fossil fuel and emits GHG to the environment. the average distance that one ton of a food item had transported was 173.135 Km and when food items with short shelf life such as vegetables were transported a long distance under ambient conditions their quality deteriorates rapidly. On average, a 5-ton lorry runs about 13 per liter of diesel. In order to transport one ton of food to Kesbewa 13.32 liters of diesel is required. This amount will increase over time along with the population increase. 12.1152 tons of GHG would emit if 60 tons of food items were transported to Kesbewa. Therefore, it can be justified the importance of promoting HGs in Kesbewa.

Keywords: Food Miles, Home Gardens (HG), Greenhouse Gas (GHG), Peri-urban, Kesbewa Urban Concil,

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II. INTRODUCTION

Over population, industrialization, congestion of automobiles, land scarcity and improper management of solid waste are some of the key problems facing by urban inhabitants. Migration to urban centers for employment, concentration of services, are some of the reasons for over population in urban centers. Under these circumstances food insecurity and poverty, health related issues and environmental pollution as well as environmental degradation are booming in urban areas especially in developing countries. In addition to that, food demand in urban centers is also increasing continuously. Because the majority of foodsitems sold in urban centers were the items transported from outside areas, food shortages and price fluctuations are common phenomena in urban centers. As such,the urban poor, net foodbuyers aresubjected to shocks of price fluctuations in food items (Maxwell, 2003). Thus, urban agriculture has identified as a way of reducing food insecurity in urban areas.

Urban agriculture can be viewed as the production of food and livestock within urban areas and it is a viable option in reducing food insecurity caused due to urbanization of poverty (Rovellion, Chen and Sangraula, 2007). Urban Home gardens (HGs) can produce a significant share of perishable food items such as fruit, vegetable and milk etc. that are subjected to high levels of wastages and quality deterioration when transported under ambient conditions for long distance. Urban agriculture also makes calorie available to the farmer while protecting the urban poor when food prices are high (Baker, 2008, Zezza and Tascietti, 2010).Food production in urban home gardens allows urban people toearn an additional income while to consume nutritious and varied diet. Thus, urban agriculture is important as it can stabilize household food consumption despite the fluctuations that could occur in the food market.

Urban environment should also be capable in absorbing greenhouse gasses emitted from various sources because the accumulation of these gases could cause unfavorable climatic changes (World Bank, 2010).Severe climatic changes could adversely affectthe food production and its availability leading to severe price escalations. This would restrict the urban poor's access tofood (Zezza and Tasciotti, 2010 andSattarthwaite, et. al, 2007). According to UN HABITAT (2009), urban agriculture improves urban environment, promotes adaptation to climatic changes, reduces food miles, recycles wastes, reuses wastes, reduces fertilizer and energy use in food production, enhances rainwater infiltration, reduces natural hazards and the development of urban heat islands and enhances carbon sequestration. Despite the importance of urban agriculture, empirical evidence on benefits and constraints of urban agriculture is scarce (Paring and Dubbling, 2011).

The primary aim of the research investigation wasto assess the impact of home gardens within the Kesbewaurban area andperi- urban farms surrounded inKesbewaon the reductionofgreenhouse gasemission and food miles. In order to achieve the overall objective, specific objectives were formulated as: [1]. Identify food flows and their magnitudesin KUC area, [2] Calculate food miles associated with food transportation, [3] Estimate GHG emissions associated with food milesand food produced in home gardens and peri-urban farms, [4] Compute the net environmental impact of home gardens and peri- urban farms.

III. METHODOLOGY

The methodology of this study has divided into three sections for easy explanation namely identifying of food flows, Calculation of food miles and estimation of GHG emissions.

3.1. Identifying Food flows

Due to the large number of food itemstransported to Kesbewait was difficult to include each food item in this study and thus, five leading food categories were identified. Those categories were Gourds and Cucumber, Eggplants, Okra, Chili and Capsicum and Leafy vegetables. Food items were categorized considering similarities of products and the cultural practices adopted in production. In order to calculatetotal distance of food miles of each food item transported was calculated on monthly basis.

Quantities of indicator crops reached to different markets in Kesbewaurban area were estimated through a market survey conducted in three-month intervals from June 2013 to April 2014. Information related to places of origin of indicator crops, quantities transported per month, distance between those markets and Kesbewa were collected. Quantity of each indicator crop transported to Kesbewa from various markets was expressed as a percentage of the total quantity of the indicator crop transported to Kesbewa in a month. As this survey was conducted in three-month intervals, average values were used in this analysis.

3.2. Calculation of Food miles

Food miles associated with food transport between distance markets and Kesbewa and between peri- urban farms and Kesbewa were calculated separately. Food miles associated with food transportation between distance markets and Kesbewawerecalculated in two steps namely: food transportation between farms and collecting centers and food transportation between collecting centers and Kesbewa.

Food miles related to food transport between farms and collecting centers were calculated dividing the total amount of a food items transported to collecting center by the capacity of the vehicle (1250 Kg[1]) to obtain the number of trips made. The distance between farm and collecting center was considered as 50[2] Km and because empty vehicle goes back to farm total distance covered in a trip was considered as 100Km[3]. The total distance traveled in transporting the food item was computed multiplying number of trips by 100.

Transportation between farms and collecting centers is not applicable to peri- urban farms because that activity had not taken place. Instead, traders from Colombo and Kesbewa markets had visited peri- urban farms almost daily to collect the harvest. Therefore, only this component was considered. Only product that was found in significant quantities was leafy vegetable. Because leafy vegetables should be handled with care traders had used small to medium size trucks in transportation.

3.3. Estimation of GHG emission

[1] As farmers had used vehicles with different capacities the average size was determined as 1.25 tons.

[2] Because farms are scattered in a large area around the collecting centers an average distance of 50 Km was used in this analysis since it is a fair judgment.

[3] Extra Km factor of 200%.

This was estimated in three steps: Green House Gas (GHG) emission associated with the production of one ton of each indicator crop in home gardens, GHG emission associated with the production of one ton of each indicator crop in peri-urban farms and GHG emission associated with the production of one ton of each indicator crop in commercial farms and the transportation of those crops to Kesbewa.All these calculations were done per ton per month basis using the average values of the findings of the field surveys.

3.4. Primary Data collection and Analysis

Collection of primary data from selected home gardens was doneusing a structured questionnaire survey with three months interval. Data were collected from a random sample of ten peri- urban farms. Palagama, Kindelpitiya, Halpita, and Jamburaliyawere the villages covered during this survey and were located in close proximity outside of the boundary of Kesbewa Urban Council area. Crops cultivated, cultural practices adopted, total production, distance transported to markets and mode of transportation were the information gathered during the field survey. Information related to input use and marketing were also gathered. Using the above information amount of GHG emitted within a month when one ton of each indicator crop produced and transported was calculated. All calculation was done on monthly basis.

Vegetables, fruits, rice, eggs and poultry meat were the food items habitually demanded by the inhabitance in KUC area. Rice and Fruits were excluded, as rice production is not a popular activity among the farmers monitored and there was no sufficient space in home gardens to cultivate perennial fruittrees, which need more land space. Though few types of fruits are possible to produce in home gardens farmers were not interested. Egg and poultry meat were excluded as there was no sufficient space to promote poultry in home gardens and farmers were reluctant to rare poultry in homesteads due to social, religious and environmental constraints.

Net environmental impact was calculated considering the difference between GHG emission in food transportation from distance markets and GHG emission in food production in home gardens and GHG emission in food transportation from distance markets and GHG emission in food production in peri-urban farms. This difference is the net reduction in tons of GHG emitted and it is the net environmental impact in terms of GHG reduction. Furthermore, net environmental impact was expressed as the amount of fossil fuel could be saved through food production in HGs and peri- urban farms.

Number of trips made to collecting centers was calculated dividing the total production per hectare in commercial farms by the capacity of the vehicle used. Production levels of commercial farms were extracted from the publications of the socio-economic census of the Department of Agriculture, Sri Lanka. The number of trips were multiplied by the distance between farms and collecting centers. Because empty vehicle returns to farm,an extra load factor was considered as 100% and extra kilometer factor was considered as 200%.

Number of trips made in transporting a food item=(Total production)/ (Capacity of the vehicle)

Distance travelled in transporting the total produce of a food item=(Number of trips made)(Distance transported)*2*

No extra load factor was considered as empty vehicle returned.

Distance transported between the collecting center and Kesbewaprocedure explained in above was adopted here and vehicle capacity was considered as 3.0[4] tons instead of 1.25 tons.
After distance transported between the farm and the collecting center and that between the collecting center and Kesbewa, those were summed to obtain the total distance transported.

Total distance transported (Km) = (Distance transported between farm and collecting center) + (Distance transported between collecting center and Kesbewa).

Food mile of each food items was calculated and summed to obtain the total value of food miles and this value was corrected for wastages multiplying it by 1.3[5].

Food miles (Km/ ton) = (Total distance transported)/ (Total quantity transported)
Value corrected for wastages= (Food miles)(1.3)*

Impact of home gardens and peri- urban farms was calculated subtracting the amount of GHG emitted in food production inhome gardens as well as in peri- urban farms from GHG emitted in commercial food production and transporting them to Kesbewa. Therefore, GHG emissions for crops produced in home gardens, peri- urban farms and commercial farms were calculated separately.

[4] Because traders had used vehicles with different capacities an average vale of 3.0 tons was used in this analysis.
[5] Wastage is 30% according to Wickramasinghe and Wijewardena (2008).

GHG emission associated in food production in home gardens was calculated considering composting, compost application, use of chemical fertilizers; irrigation, machinery use (in tilling the ground) and transportation were calculated.Because farmers have produced different crop in small quantities, GHG emission was calculatedconsidering cultural practices of all food items and that value was apportioned among different crops based on the quantity of each indicator crop produced.

GHG emission from HGs= (Emission associated with all inputs used in HGs)

Emission associated with a food item= (GHG emission from HGs) / (Total output of all food Items in tons) (Output of the food item concerned in tons)*

Net impact of HGs = (GHG emitted when a ton of indicator crop was transported to Kesbewa) – (GHG emitted when a ton of that crop was produced in HGs).

Total net impact of HGs = (Sum of net impact of each indicator crop)

Impact of peri- urban farms also calculated in the same way and net reduction in GHG was translated to amount of fossil fuel that could be saved through food production in HGs andperi- urban farms.

IV. RESULTS AND DISCUSSION

4.1.Food flow analysis

Based on the field information, five crop types were identified as very prominent and they were Gourds, Eggplant, Okra, Chili and Capsicum and leafy vegetables. The monthly amount received of indicator crops to KUC area, their origination and distance to the study area are givenin Table 1.

Table 1. Quantities (Tons) of food items transported to Kesbewa and distance transported

Market/Location	Distance (Km)	Gourds and Cucumber	Eggplant	Okra	Chili & Capsicum	Leafy vegetable
Manin market	275	16.48 (28.13)	13.51 (30.92)	10.33 (14.62)	22.92 (25.57)	6.98 (10.16)
Tissamaharama	128	6.12 (10.45)	-	40.00 (56.62)	15.00 (16.73)	1.32 (1.92)
Nuwaraeliya	180	12.51 (21.35)	-	20.00 (28.31)	13.67 (15.25)	-
Dambulla	165	11.93 (20.36)	17.11 (39.15)	-	20.56 (22.93)	-
Tambuttegama	185	6.65 (11.35)	6.70 (15.33)	-	17.50 (19.52)	-
Puttalam	150	-	6.38 (14.60)	-	-	-
Bandaragama	20	4.90 (8.36)	-	-	-	-
Kesbewa	10	-	-	-	-	42.68 (62.13)
Kahapola	20	-	-	0.32 (0.45)	-	-
Kahatuduwa	18	-	-	-	-	17.71 (25.78)
Total		58.59 (100.0)	43.70 (100.0)	70.65 (100.0)	89.65 (100.0)	68.69 (100.0)

Note: Percentages are given in parenthesis

Above information revealed that a huge quantity of vegetables are transported to Kesbewa in each month from distance markets. This activity consumes a large amount of fossil fuel and emits GHG to the environment. Emission in GHG could cause climatic changes and other unfavorable environmental problems as well. At the same time, some of the lands found in and around theKUC area were either underutilized or not utilized at all. If the productivity of unutilized lands were raised amount of food transported monthly to Kesbewa could be reduced. Because urban dwellers are net food buyers sudden changes in food availability and food prices could cause household food insecurity of poor city dwellers. Under such situations, food production in close proximity of the urban center is beneficial. At the same time, home gardening enhances people's access to food while providing them with an opportunity to have a varied as well as fresh chemical free diet.

In addition to above, stated micro benefits increased urban and peri- urban food production would generate several macro-benefits to a country like Sri Lanka. Because Sri Lanka is a net importer of fossil fuel promotion of urban and peri-urban agriculture would ease the heavy burden placed by the increasing demand for fossil fuel on the national treasury. Mitigation of adverse environmental impacts is another macro benefit, which is difficult to translate into monetary values.

4.2. Food miles estimations

Farmers had used vehicles with different capacities to transport food items between farm and collecting centeran average capacities of 1.25 tons was used while an average value of 3.0 tons was used in calculating food miles between collecting center and Kesbewa.Quantity of a food item transported to Kesbewawas adjusted for wastages multiplying the corresponding value by 1.3 because wastage was 30%. Thereafter, that value was divided 3,000 (Kg) to calculate the number of trips made. Since empty vehicle returned, the distance transported was considered as twice of the distance between the collecting center and Kesbewa.Food miles were calculated based on the average quantities transported from different collecting centers.

Food miles estimation were done in two stages. 1). Food miles between farms and collecting centers 2). Food miles between collecting centers and Kesbewa.

Food miles between farms and collecting centers were calculated as explained below.

(58.579/1.25*50*2)+(43.696/1.25*50*2) +(70.333/1.25*50*2)+(89.614/1.25*50*2)+(8.299/1.25*50*2) = 80.0 Km

Food miles between collecting centers and Kesbewawere calculated as explained below.

Gourds and Cucumber
[(16.476/3.0*275*2)+(6.117/3.0*128*2) +(12.508/3.0*180*2)+(11.928/3.0*165*2)+(6.65/3.0*185*2)+(4.9/3.0*20*2)] *1000= 123.613 Km

Eggplant
[(13.509/3.0*275*2)+(17.112/3.0*165*2) +(6.375/3.0*150*2) + (6.7/3.0*185*2] /43..696 =

Okra[6]
(10.333/3.0*275*2)+(40.0/3.0*128*2) + (20.0/3.0*180*2)+(0.315/3.0*20*2)/ 70.648= 109.1597m

Chili and Capsicum
(22.917/3.0*275*2)+(14.995/3.0*128*2) +(13.667/3.0*180*2)+(20.555/3.0*165*2) +(17.5/3.0*185*2)= 128.7508 Km

Leafy vegetables[7]

(6.978/3.0*275*2)+ (1.324/3.0*128*2)= 167.7043 Km

Totalfood miles involved between collecting centers and Kesbewa

(123.613+56.6791+109.1597 +128.7508+167.7043)= 585.906Km

Total food miles = (Food miles associated with transportation between farms and collecting centers)+ (Food miles associated with transportation between collecting centers and Kesbewa) = (80.0 + 585.906) = 665.906 Km

Total food miles after correcting for wastages = 865.678 Km

Food miles per ton per month (865.678/5) = 173.135 Km

Information reveal that the average distance that one ton of afood item hadtransported was 173.135 Kmand when food items with short shelf life such as vegetables were transported a long distance under ambient conditions their quality deteriorates rapidly. As a result, urban consumer gets low quality products on one hand and has to pay highprices , on the other hand. Hence, production of food in Kesbewa and its peripheries is beneficial as mean to provide quality food at affordable prices.

On average, a 5-ton lorry runs about 13 per liter of diesel. In order to transport one ton of food to Kesbewa 13.32 liters of diesel is required. This amount will increase over time along with the population increase. Sri Lanka being a net importer of fossil fuel,has to allocate a considerable portion of her scarce foreign exchange to provide fuel required for food transportation. Thus, promotion of food production in urban and peril-urban areas (reducing food miles) is highly beneficial to Sri Lanka.

[6] Quantity transported from Kahapola was excludes as it was negligible.
[7] Quantities transported from Kesbewa and Kahatuduwawere excluded because those were very short distances.

4.3. GHG emission

Present levels of production in Home gardens

It was assumed that, food produced in home gardens was not wasted as they harvest when and where necessary and thus, those values did not adjust for wastages.

a. GHG emission in Home gardens

Total quantity of indicator crops produced in home gardens =2.614Tons
Total production of Gourds and Cucumber =0.318Tons
Total production of Eggplant =0.092 Tons
Total production of Okra = 0.547Tons
Total production of Chili and Capsicum = 0.743 Tons
Total production of Leafy vegetables =1.194Tons

Compost production and use

GHG emission in compost production = (Amount f compost producedTotal amount of compost produced= 2.453 Tons

Rate of emission in compost production = 0.0622 Tons of CO2 eq./ Ton (RUAF,2002).

GHG emission in compost production (2.453*0.0622) = 0.1526 Tons

GHG emission in compost use = (Amount of compost used)* (Rate of GHG emission)

Amount of compost used= 2.453 Tons

Emission rate = 0.0477 Tons of CO2 eq./Ton (RUAF,2002).

GHG emission in compost use (2.453*0.0477)= 0.1170 Tons

Emission in production and use of compost = (GHG emission in compos production(+ (GHG emission in compost use)

GHG emission in compost production & use (0.1526+0.1170) = 0.2696 Tons

GHG emission per month (0.2696 / 3)8 = 0.0898 Tons/ Month

GHG emission in irrigation

Total number of hours used for irrigation = 134 Hours

Number of hours per month (134.5/3)9 = 44.8 Hours/ Month

Actual time used for irrigation (44.8*0.7510) = 33.6 Hours/Month

Wattage of the pump = 370 Watt or 0.00037 Mega Watts

Number of megawatt hours used (33.6*0.00037) = 0.0124

Rate of emission = 941 Kg of CO2 eq./MWh (RUAF,2013)

GHG emission in irrigation (941*0.0124) = 11.6684 Kg (0.0118 Tons)

GHG emission in irrigation per month (11.668/3) = 0.0039 Tons/Month)*(Rate of GHG emission)

GHG emission due to chemical fertilizers

8 Because data collection was done in three month intervals calculated value was divided by three to obtain a value per month.
9 Because data collection was done in three month intervals calculated value was divided by three to obtain a value per month.
10 It was assumed that farmers attend various activities while irrigating actual time used for irrigation as 75% of the total time used.

Amount of elementary nitrogen applied= 22.31 Kg

Rate of GHG emission =4.87Kg/Kg (RUAF,2013)

GHG emission due to fertilizer (22.31*4.87/1000/3) = 0.0362 Tons/Month

Total GHG emission =(GHG emission in production and use of compost (3))+(GHG Emission in fertilizer use (4))+ (GHG emission in irrigation)

Total G GHG emission from HGs (0.0898+0.0039+0.0362) = 0.1299 Tons/Month

GHG emission per month per ton of produce GHG emission of a crop = (Total GHG emission in tons)/(Total production in HGs)*(Production of the crop)

GHG emission from Gourd and Cucumber production(0.1299/2.614)*0.318=0.0168 Tons

GHG emission from Eggplant production (0.1299/2.614)*0.092 =0.005 Tons

GHG emission from Okra production (0.1299/2.614)* 0.547 =0.029 Tons

GHG emission from Chili ad Capsicum production (0.1299/2.614)*0.743=0.039 Tons

GHG emission from leafy vegetables production (0.1299/2.614)*1.194 =0.0593 Tons

b. GHG emission in Peri – urban farms

Farmers were not particular about intensifying their uplands, despite their availability, due to factors such as unavailability of water for irrigation, financial constraints, wildlife attacks, and low productivity. They prefer to produce leafy vegetables because leafy vegetables provide income throughout the year while fruits give income once or twice a year. Nevertheless, an intensified agricultural extension program that focused on fruit production may change the attitudes of the farmers in a favorable direction. Expansion of agricultural activities despite land availability has constrained by ownership right issues, floods and influx of salt water have restricted their use. Lack of land has constrained the expansion of peri- urban farms.

Farmers had neitherused water pumps nor transported leafy vegetables to markets.. They had used poultry manure and synthetic fertilizers. Traders transported poultry manure to the farm gate. Average extent cultivated was 0.1 hectare (total extent 1.0 hectare) and average yield was 33.0 tons per hectare. Average amounts of poultry manure and Urea used per acre were 0.862 and 0.066 tons respectively. Traders have transported produce in 2-5 ton Lorries to Colombo (75%) and Kesbewa (25%). Distance transported to Colombo was 25 Km while the distance transported to Kesbewawas 5 Km. Average distance that poultry manure was transported is 60 Km and that of Urea was 1 Km. Suppliers have used 10 ton lorries to transport poultry manure while farmers have used two- wheel tractors to transport Urea. GHG emission during the production and transport of leafy vegetables were calculated based on the above information. Almost all operations are done manually using family labor. Agrochemicals are applied when pest attacks were observed. Farmers have irrigated their crops manually from the nearby water source.

Plate 1. A healthy "*Mukunuwenna*" crop at harvesting stage

Plate 2. Harvesting (uprooting) a "*Sarana*" crop

Plate 3. A matured "*Mukunuwenna*" crop

Transportation of fertilizers and Manure

GHG emission in transporting 0.862 tons poultry manure (0.862*60[11] *2 *0.1757[12]*1[13]*/1000)

= 0.0181 Tons

GHG emission (0.0181/3) = 0.0060 Tons / Month

GHG emission in transporting 0.0 66 tons of Urea (0.066*2*2*0.32[14]*1/1000)=0.00008 Tons

GHG emission(0.00008/3) = 0.00003 Tons/ Month

Total emission in transporting fertilizer and manure(0.0060+0.00003)= 0.0063 Tons/ Month

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[11] Distance travelled was considered as 200% of one way distance because empty vehicle returns.

[12] RUAF (2013)

[13] Extra Km factor was used as 1 because empty vehicle goes back.

[14] RUAF(2013)

Application of synthetic fertilizers

Amount of elementary nitrogen from Urea =0.0303 Tons

Rate of GHG emission =4.87 Kg of CO_2 eq. / Kg (RUAF,2013)

Production of Leafy vegetables = 33 Tons / Hectare/ 3 Months

GHG emission associated with nitrogen fertilizer use (0.0303*4.87/33/3)= **0.002 Tons/ Month**

Application of poultry manure

Amount of elementary nitrogen from poultry manure =0.0259 Tons

Rate of GHG emission during application of poultrymanure = 0.0477 Tons /Ton[15]

GHG emission from compost (0.862*0.0477/33/ 3) **=0.0004 Tons / Month**

Total emissions associated with fertilizer and manure use (0.01366+0.0246)=**0.0383Tons**

Emission associated with product transportation

Amount transported to Colombo =8.25 Tons

GHG emission (8.25*25*2*0.25[16]*1/ 1000/8.25) **= 0.0125 Tons)**

Amount transported to Kesbewa =21.75 Tons

GHG emission (21.75*25*2*0.25*1/1000/21.75) **=0.0125 Tons**

Total emission due to transportation **= 0.025 Tons**

Emissions / Month (15/3) **= 0.008 Tons / Month)**

GHG emission associated with leafy vegetable production in peri-urban farms (0.006+0.0383+0.008) = 0.0523 Tons

[15] RUAF (2013)

[16] RUAF(2013)

c. Commercial farms

Commercial farms are located far away from Kesbewa. Produce of these farms are being collected locally at the collecting centers located in areas where the commercial farms are found. At these collecting centers, traders do purchase farm produce in bulk to transporters / traders and they transport them to Kesbewa. Most popular collecting centers were Bandaragama, Tambuttegama, Dambulla, Nuwaraeliya and Puttlam. Farmers of Kahapola, Kesbewa and Kahatuduwa have transported their produce directly to Colombo and Kesbewa. Therefore, GHG emission associated with transporting vegetables produced in those three locations to collecting centers was ignored and transporting to Colombo and Kesbewa markets were included in this analysis. Monthly quantities of different food items transported between Kesbewa and distance markets are presented in Tale 2.

Market	Gourds &Cucumber	Eggplant	Okra	Chili & Capsicum	Leafy vegetables
Bandaragama	4,900	-	-	-	-
Tambuttegama	6,650	6,700	-	17,500	-
Manin market	16,475	13509	10,333	22,917	6,975
Tissamaharama	6,117	-	40,000	14,995	1,324
Dambulla	11,928	17,112	-	20,555	-
NuwaraEliya	12,508	25,326	20,000	16,400	-
Puttlam	-	6,375	-	-	-
Kahapola	-	-	0.315	-	-
Kesbewa	-	-	-	-	42,676
Kahatuduwa	-	-	-	-	17,708
Total	58,579	43,696	70,648	89,614	26,007

Table2: Quantities of indicator crops transported to Kesbewa (Tons/ Month)

GHG emission in transporting food produces at distance locations to Kesbewa

i. Gourds & Cucumber

Total quantity transported within a month = 58.579Tons/ Month

GHG emission =(Quantity transported in tons)(Extra Km factor)*(Extra load factor)*(Emission rate)/1000*

Quantity transported from Bandaragama =4.9 Tons

Distance = 10 Km.

Quantity transported from Thambuttegama = 6.65Tons

Distance	= 185 Km
Quantity transported from Manin market	= 16.476 Tons
Distance	= 275 Km[17]
Quantity transported from Tissamaharama	= 6.117 Tons
Distance	= 128 Km
Quantity transported from Dambulla	=11.928Tons
Distance	= 165 Km
Quantity transported from Nuwara-eliya	= 12.508 Tons
Distance	= 180 Km
Rate of GHG emission (RUAF, 2013)	=0.25Kg CO_2eq/Ton /Km

GHG emission in transporting from Bandaragama =4.9*10*2[18]*1[19]*0.25 / 1000
=0. 0245Tons

GHG emission in transporting from Thambuttegama =6.65*185*2*1*0.25//1000
= 0.6151Tons

GHG emission in transporting from a Manin market =16.476*0.25*275*2*1/1000
= 2.2654 Tons

GHG emission in transporting from a Tissamaharama =6.117*128*2*1*0.25 /1000
=0. 3915 Tons

GHG emission in transporting from Dambulla =11.928*165*2*1*0.25/ 1000
=0. 0.0618 Tons

GHG emission in transporting from Nuwaraeliya =12.508*180*2*1*0.25/ 1000
=0.0675 Tons

Total GHG emission in transporting 58.579 tons of Gourds 7 Cucumber between collecting center and Kesbewa

(0.0245 +0.6151 +2.2654 +0. 3915 +0..0618 +0675) = **3.4258**Tons

Wastage during transportation = 30%[20]
GHG emission after correcting for wastages **=4.4535 Tons**
A total of 4.4535 tons of GHG has emitted when58.579 tons was transported to Kesbewa. So,
GHG emission in transporting one ton of Gourds & Cucumber from collecting center to Kesbewa
= 0.0760 Tons

GHG emission in transporting to collecting centers

GHG emission= (Quantity transported) (Emission rate)*(Distance)*(Extra Km factor)*(Extra load factor) / (Quantity transported)*

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[17] Gunasekara (2012) has stated that the distance between Kesbewa and Manin market is 275 Km.
[18] Total distance travelled was considered as 200% Extra Km factor).
[19] Because full lorry comes to market and empty lorry leaves the market an extra load factor was considered as 1.0.
[20] Wickramasinghe&Wijewardene (2008)

Quantity transported to collecting centers = 53.679[21] tons / month
Rate of GHG emission = 0.32 Kg CO_2eq/ton/Km(RUAF, 2013)
GHG emission in transporting one tonof Gourds and Cucumber between farm and collecting center (53.679*0.32*50*2*1/1000/ 58.579) **=0.032Tons**

GHG emission in transporting one ton of Gourds & Cucumber from farm to Kesbewa	
(0.0760+0.032)	**=0.108 Tons**

Machinery use

Number ofmachine hours required for tilling a hectare = 2.7[22]
Fuel consumption per hour = 2.5 Liters /Machine Hour[23]
Weight of one liter of diesel =0.925 Kg. (RUAF,2013)
Rate of GHG emission =3.6 Kg Co_2eq / Kg (RUAF,2013)
Yield = 37.5 Tons / Hectare/ Crop

GHG emission= (Machine hours)(Fuel consumption)*(Weight of a liter of fuel) *(Emission rate)/1000/(Total production)*

GHG emission due to tractor use (2.7*2.5*0.925*3.6/1000/37.5) **= 0.00002Tons**.

Fertilizer use

Amount of elementary Nitrogen fertilizer used =104Kg/ Hectare
GHG emission rate = 4.87 Kg CO_2 eq. / Kg
GHG emission= (Elementary Nitrogen used)(Emission rate)/1000/(Total production)*
GHG emission due to fertilizer (104*4.87/1000/37.5) **= 0. 0135Tons**

Irrigation

Number of hours reported for irrigation =60[24]
Fuel (Kerosene)consumption = 1.5[25] Liters/Hour
Total quantity of fuel used (60*1.5) =90 Liters
Weight of a liter of Kerosene = 0.0.817 Kg
Weight of fuel used (0.817*90) = 73.53 Kg
Rate of GHG emission = 3.61 Kg CO_2eq. / Kg (RAUF,2013)
***GHG** emission= (Weight of fuel)*(Emission rate)/1000/ (Total production)*
Emission of GHG (73.53*3.61/1000/37.5) **= 0.0071 Tons**

Total emission of GHG in production process is the sum of GHG emission in land preparation, fertilizer use and irrigation(0.00002 +0. 0135 +0.0071) **=0.0206 Tons**

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[21] Excluded the quantity produced in Bandaragama as it comes directly to Kasbewa and Colombo.
[22]Wijesinghe J.A,2014. Farm Mechanical Instructor (Personal communication), Farm Machinery Training Center, Department of Agriculture, Puliyalkulama, Anuradapura.
[23] -Do-
[24] Personal discussions with farmers

[25]Wijesinghe J.A,(2014).

Because crop lasts for 2 months farmer performs these activities during that period. Therefore, amount released during a month is one half of the total, that is, (0.0206/2) = **0.0103 Tons**

Total GHG emission in transporting one ton of Gourds and Cucumber from farm to Kesbewa is the sum of GHG emissions during production, transporting to collecting center and transporting to Kesbewa.

ii. Eggplant

Total quantity transported within a month	=43.696Tons
Quantity transported from Thambuttegama	=6.7Tons
Distance	= 185 Km.
Quantity transported from Dambulla	= 17.112 Tons
Distance	= 165 km
Quantity transported from Manin market	= 13.509 Tons
Distance	= 275 Km
Quantity transported from Puttlam	=6.375 Tons
Distance	= 150 Km
Rate of GHG emission (RUAF,2013)	=0.25Kg CO_2eq/ ton/Km

GHG emission in transporting from Thambuttegama
=6.7*185*2*0.25*1[26]/1000
= 0.6197Tons

GHG emission in transporting from Dambulla =17.112*165*2*0.25*1/ 1000
= 1.4117Tons

GHG emission in transporting from Manin market =13.509*275*2*0.25*1/1000
= 0.002 Tons

GHG emission in transporting from Puttlam =6.375*150*2*.25*1/1000
= 0.4781 Tons

GHG emission in transportation 43.969 tons of Eggplant between collecting center and Kesbewa(0.6197+1.4117+0.002+0.4781) = **2.5115 Tons**

Wastage during transportation = 30%

GHG emission after correcting for wastages ` **= 3.2649 Tons**

GHG emission in transporting one ton from collecting center to Kesbewa
(3.2649/ 43.696) **= 0. 075Tons**

GHG emission in transporting a ton to collecting center
(43.696*50*2*0.32*1/1000/43.696)
=0.032 Tons

GHG emission in transporting one ton of Eggplant from farm toKesbewa (0.075+0.032)
= 0.107 Tons

GHG emission per ton in production

[26] Because a full lorry comes to market and an empty lorry leaves the market an extra kilometer factor of 1.5 was considered.

Machinery use

Number of machine hours required for tilling a hectare= 2.7[27]
Fuel consumption per hour = 2.5 Liters /Machine Hour[28]
Weight of one liter of diesel =0.925 Kg. (RUAF,2013)
Rate of GHG emission =3.6 Kg Co_2eq / Kg (RUAF,2013)
Yield = 2.156 Tons / Hectare/ Crop

GHG emission= (Machine hours)(Fuel consumption)*(Weight of a liter of fuel) *(Emission rate)/1000/(Total production)*

GHG emission due to tractor use (2.7*2.5*0.925*3.6/1000/2.156) **= 0.0104 Tons.**

Fertilizer use

Amount of Nitrogen fertilizer used **=**176 Kg/ ac
GHG emission rate =4.87 Kg CO_2 eq. per Kg
GHG emission= (Elementary Nitrogen used)(Emission rate)/1000/(Total production)*
GHG emission due to fertilizer (176*4.87/1000/ 2.156) **=0.3976 Tons)**

Irrigation

Number of hours reported for irrigation =100[29]
Fuel (Kerosene)consumption = 1.5[30] Liters/Hour
Total quantity of fuel used (100*1.5) =150 Liters
Weight of a liter of Kerosene = 0.0.817 Kg
Weight of fuel used (0.817*150) =122.55 Kg
Rate of GHG emission = 3.61 Kg CO_2eq. / Kg (RAUF,2013)
GHG emission= (Weight of fuel)(Emission rate)/1000/ (Total production)*
Emission of GHG (122.55*3.61/1000/2.156) **= 0.2052 Tons**

Total emission of GHG in production process is the sum of GHG emission in land preparation, fertilizer use and irrigation (0.0104+0.3976+0.2052) =0.6132 Tons

Because crop lasts for 6 months farmer performs these activities during that period. Therefore, amount released during a month is one sixth of the total, that is, (0.6132 /6) **= 0.1022 Tons**

Total GHG emission in transporting one ton of Eggplant between farm and Kesbewa (0.107+0.1022) =0. 2092 Tons

iii. Okra (Ladies fingers)

Total quantity transported within a month =70.648 Tons

[27]Wijesinghe J.A,2014. Farm Mechanical Instructor (Personal communication), Farm Machinery Training Center, Department of Agriculture, Puliyalkulama, Anuradapura.
[28] -Do-
[29] Personal discussions with farmers

[30]Wijesinghe J.A,(2014).

Quantity transported from Manin market =10.333 tons
Distance transported = 275 Km
Quantity transported from Tissamaharama =40.0 Tons
Distance =128 Km
Quantity transported from Nuwaraeliya = 20.000 Tons
Distance = 180 Km
Quantity transported from Kahapola =0.315 Tons
Distance transported = 10 Km
GHG emission = (10.333*275*2*0.25*1)/1000+(40*128*2*0.25*1) /1000 +(20*180*2*0.25*1) / 1000+(0.315*10*2*0.25*1)/1000=.1.4207+2.56+1.8+.0.0016= 5.7823 Tons
Wastage during transportation = 30%[31]
GHG emission after correcting for wastages **= 7.5170 Tons**

GHG emission when one ton of Okra was transported between collecting center and Kesbewa
(7.5170/70.648) =**0.1064 Tons**

GHG emission in transporting a ton from farm to collecting center
(70.335[32]*50*2*0.32*1)/1000/70.335 **=0.032 Tons**

GHG emission in transporting one ton of Okra between farm and Kesbewa **(0.1064+0.032) = 0.1384 Tons**

GHG emission per ton in production process

Machinery use

Number of machine hours required fortillinga hectare = 2.7[33]
Fuel consumption per hour = 2.5 Liters /Machine Hour[34]
Weight of one liter of diesel =0.925 Kg. (RUAF,2013)
Rate of GHG emission =3.6 Kg Co_2eq / Kg (RUAF,2013)
Yield = 12.5 Tons / Hectare/ Crop
GHG emission= (Machine hours)(Fuel consumption)*(Weight of a liter of fuel) *(Emission rate)/1000/(Total production)*
GHG emission due to tractor use (2.7*2.5*0.925*3.6/1000/12.5) **= 0.0018 Tons.**

Fertilizer use

[31]Wickramasinghe and Wijewardena(2008)
[32] Quantity produced in Kapola was excluded as there is no collecting center.
[33]Wijesinghe J.A,2014. Farm Mechanical Instructor (Personal communication), Farm Machinery Training Center, Department of Agriculture, Puliyalkulama, Anuradapura.
[34] -Do-

Amount of elementary nitrogen fertilizer used	=31Kg
GHG emission rate	=4.87 Kg CO_2 eq. per Kg
GHG emission due to fertilizer (31*4.87/1000/ 12.5)	**=0.0121Tons**

Irrigation

Number of hours reported for irrigation	=60[35]
Fuel (Kerosene)consumption	= 1.5[36] Liters/Hour
Total quantity of fuel used (60*1.5)	=90 Liters
Weight of a liter of Kerosene	= 0.0.817 Kg
Weight of fuel used (0.817*90)	= 73.53 Kg
Rate of GHG emission (RAUF,2013)	= 3.61 Kg CO_2eq. / Kg

GHG emission= (Weight of fuel)(Emission rate)/1000/ (Total production)*

Emission of GHG (73.53*3.61/1000/37.5)	**= 0.0071 Tons**
Total emission of GHG in production process (0.0018+0.0121+0.0071)	**=0.021 Tons**

As this amount of GHG was emitted within2 months, amount emitted withina month (0.021/2) **=0.0105 Tons**

Total GHG emission in transporting one ton of Okra between farm and Kesbewa
(0.1384+0.0105) =0.1489 tons

iv. Chili and Capsicum

Total quantity transported within a month	=89.614Tons
Quantity transported from Tambuttegama	=17.5 Tons
Distance	=185 Km
Quantity transported from Manin market	= 22.915 Tons
Distance transported	= 275 Km
Quantity transported from Dambulla	= 20.555 Tons
Distance transported	=165 Km
Quantity transported from Nuwaraeliya	=13.667Tons
Distance transported	=180 Km
Quantity transported from Tissamaharama	=14.995Tons
Distance transported	=128 Km

GHG emission = (17.5*185*2*1*0.25)/1000+(22.915* 275*2*1*0.25) /1000 +(20.555*165*2*1*0.25) / 1000+ (13.667*180*2*1*0.25)/1000 +(14.995*128*2*1*0.25)/1000/89.614 = (1.6187+ 3.1508+ 1.6958+1.2300+0.9596)
= 8.6549 Tons

35 Personal discussions with farmers

36 Wijesinghe J.A,(2014).

Wastage during transportation	= 30%[37]
GHG emission after correcting for wastages	= 11.2514**Tons**

Because 11.2514 tons of GHG was emitted when 89.614 tons of chili and capsicum was transported between collecting centers and Kesbewa emission per ton

=11.2514/89.614 **= 0.1256 Tons**

GHG emission in transporting a ton to collecting center

GHG emission in transporting one ton of Chili and Capsicum from farm to collecting center

(89.614[38]*50*2*0.32*1/1000/89.614 **=0.032 Tons**

GHG emission in transporting one ton of Chili & Capsicum between farm and Kesbewa	
(0.1256+0..321)	**=0.4466 Tons**

GHG emission per ton in production

Machinery use

Number of machine hours required for tillinga hectare	= 2.7[39]
Fuel consumption per hour	= 2.5 Liters /Machine Hour[40]
Weight of one liter of diesel	=0.925 Kg. (RUAF,2013)
Rate of GHG emission	=3.6 Kg Co_2eq / Kg
(RUAF,2013)	
Yield	= 9.172 Tons / Hectare

GHG emission= (Machine hours)(Fuel consumption)*(Weight of a liter of fuel) *(Emission rate)/1000/(Total production)*

GHG emission due to tractor use (2.7*2.5*0.925*3.6/1000/9.172) **= 0.0025 Tons**

Fertilizer use

Amount of Nitrogen fertilizer used	**=127** Kg/ Ha
GHG emission rate	=4.87 Kg CO_2 eq. per Kg
GHGemission due to fertilizer (127*4.87/1000/9.172)	**=0.0674 tons**

Irrigation

Number of hours reported for irrigation	=100[41]
Fuel (Kerosene)consumption	= 1.5[42] Liters/Hour
Total quantity of fuel used (100*1.5)	=150 Liters
Weight of a liter of Kerosene	= 0.0.817 Kg
Weight of fuel used (0.817*150)	=122.55 Kg

[37]Wickramasinghe and Wijewardena(2008)

[38] Quantity produced in Kapola was excluded as there is no collecting center.

[39]Wijesinghe J.A,2014. Farm Mechanical Instructor (Personal communication), Farm Machinery Training Center, Department of Agriculture, Puliyalkulama, Anuradapura.

[40] -Do-

[41] Personal discussions with farmers

[42]Wijesinghe J.A,(2014).

Rate of GHG emission = 3.61 Kg CO_2eq. / Kg (RAUF,2013)

GHG emission= (Weight of fuel)(Emission rate)/1000/ (Total production)*

Emission of GHG (122.55*3.61/1000/2.156) **= 0.2052 Tons**

Total emission of GHG in production process (**0.0025+0.0674+0.2052**) **=0. 2751 Tons**

A 0.2751 tons of GHG was emitted in producing 6 tons of Chili and Capsicum and thus, GHG emission per month per ton of output (0.0722/6) **=0.0212 tons / ton.**

As this amount of GHG was emitted within 6 months, amount release per month (0.2751/6) **=0.0458Tons**

Total GHG emission in transporting one ton of Chili and Capsicum between farm and to Kesbewa (0.4466+0.0458) =0.4924 Tons

v. Leafy vegetables

Because the majority of Leafy vegetables was from peri- urban areas of Kesbewa, both Kahatuduwa and Kesbewa were excluded from this analysis.So, GHG emission when transported from Manin market and Tissamaharama was considered.

Total quantity transported within a month =6 Tons

Quantity transported from Manin market = 5 Tons

Distance transported = 275 Km

Transported from Tissamaharama =1 Tons

Distance transported = 128 Km

GHG emission in transporting6 tons of Leafy vegetables between collecting center and Kesbewa (5*275*2*.25*1)/1000 + (1*128*2*0.25*1/1000=**0.0642 Tons**

Wastage during transportation = 30%

GHG emission after correcting for wastages **= 0.0835 Tons**

A 0.0835 tons of GHG was released when 6 tons of Leafy vegetables was transported between collecting center and Kesbewa and so, GHG emission associated with transportation from one ton (0.0835 /6) **= 0.014 Tons**

GHG emission in transporting a ton to collecting center (6*50*2*0.32*1)/1000/6= **0.032 Tons**

GHG emission in transporting one ton of Leafy vegetable between farm and Kwsbewa (0.014 +0.032) =0.046 Tons

GHG emission per ton in production

Machinery use

Number of hours required for tilling an acre = 2.7[43]

Fuel consumption per hour =2.5 Liters /Hr[44]

One liter of diesel =0.925 Kg. (RUAF,2013)

[43] Wijesinghe J.A (2014).

[44] -Do-.

Rate of emitting GHG=3.6 Kg Co_2eq / Kg (RUAF,2013)
Yield = 53 Tons/ Ha
GHG emission due to tractor use (2.7*2.5*.925*3.6/ 1000 /53) **= 0.0004 Tons**

Fertilizer use

Amount of Nitrogen fertilizer used =66Kg
GHG emission rate =4.87 Kg CO_2 eq. per Kg
GHG emission due to fertilizer (66*4.87/1000/53) **=0.0061 Tons**

Irrigation

Farmers had irrigated manually and only one farmer had used a pump. Therefore, this aspect was excluded.

Total emission of GHG in production process
(0.0004 +0.0061) **=0.0065 Tons**
A 0.0065 tons of GHG was emitted in producing 6 months and thus,
GHG emission per month per ton (0.0065/ 6) =0.0042 tons / ton
GHG emission per month 0.0042/6[45] = **0.0011 Tons**

Total GHG emission in transporting one ton of leafy vegetables between farm and Kesbewa (0.046+0. 0011) =0.0471 Tons

GHG emission per ton per month of indicator crops is presented it Table 3.

Table 3. GHG emission per ton per month

Indicator crop	GHG Tons/Ton/Month
Gourds & Cucumber	0.1183
Eggplant	0.2092
Okra	0.1489
Chili & Capsicum	0.4924
Leafy vegetables	0.0471
Total	1.0096 per 5 Tons
	0.2019 per Ton/Month

[45] Because certain vegetables uproot in two months awhile some other vegetables kee for one year, at least, the average age was considered as 6 months.

It is evident that, 0.2019 tons of GHG is emitted per month when one ton of indicator crops were transported. All these indicator crops, except leafy vegetables, do emit considerable amounts of GHG in transportation. As all these crops can grow in this area, there is a huge potential in Kesbewa and peri-urban areas to reduce GHG emission.

HGs and peri – urban farms

In order to understand the contributions of HGs and peri –urban farms in mitigating environmental impacts it is possible to use the net impact of HGs and peri- urban farms in reducing GHG emission. Total GHG emission per ton per month of indicator crop is 0.2019 ton.Production of all indicator crops, except leafy vegetables, in HGs is beneficial. Therefore, taking actions to promote vegetable production in HGs is necessary. Leafy vegetable production in either HGs or peri- urban farms reduced GHG emission in small quantities. Production of leafy vegetables in HGs is not profitable may be due to low yield (Table 4). In general, food production in HGs and peri –urban farms has successfully contributed to reduce GHG emission. Therefore, it is possible to mention that urban and peri-urban agriculture has contributed positively to mitigate adverse environmental impacts.

Despite the benefits of HGs, farmers who maintained HGs were de-motivated. Therefore, a strong agricultural extension program is necessary. The financial returns of HGs could be minimum because farmers irrigated their crops with the water sullied for domestic uses. Therefore, it is necessary to develop a program to intensify activities of HGs incorporating techniques to conserve soil fertility and soil moisture. Activities such as HG competitions, providing production inputs eitherfree of charge or at a subsidized price, taking farmers to see other successful farmers, taking steps to attach them a social value would motivate be useful in motivating the farmers. During the field visits, it was understood that some of the farmers are not interested to maintain HG due to attitudinal problems. Such farmers think about the direct financial returns rather than the overall benefits of HGs. Attitudes of such farmers could be changed trough sound extension program with a component to address attitudinal issues.

Table 4. GHG emissions under different production systems

Crop category	GHG in HGs (Tons/Month)	Peri- urban farms (Tons/ Month)	Transporting food from outside markets (Tons/Month)	Impact of HGs (Tons/ Month)	Impact of Peri-urban farms (Tons / Month)
Gourds &Cucumber	0.0168	-	0. 1183	0.1015	-
Eggplant	0.005	-	0.2092	0.2087	-
Okra	0.029	-	0.1489	0.0260	-
Chilli& Capsicum	0.039	-	0.4924	0.4534	-
Leafy vegetables*	0.0593	0.0523	0.0471	-0.0122	-0.0052
Total	0.1201	0.0523	1.0159	0.8958	

•Note: Net impact of leafy vegetables is negative because only a small quantity had transported from distance markets

There is a potential to promote and diversify production in peri- urban farms. The insufficient exposure to modern technologies in agriculture is one constraint. That could be solved through the introduction of an intensive agricultural extension program. Land ownership issues, legal restrictions, frequent floods, intrusion of salt water into fields, unavailability of lands etc. were identified as issues that hinder the expansion of peri- urban farms. Relevant authorities should take necessary actions to remove these constraints.

Annual impact

At present, 59 ,44, 71, 90 and 26 tons of Gourds and Cucumber, Eggplant, Okra, Chili and Capsicum and Leafy vegetables are transported to Kesbewa in a month. If this trend continues the annual requirement of these vegetables will be 708, 528, 852, 1080 and 312 respectively. If present production trend of HGs is continued, the maximum amounts of Gourds and Cucumber, Eggplant, Okra, Chili and Capsicum and Leafy vegetables could be produced would be 4, 1, 7, 9 and 14 respectively (Table 5)

Table 5. Annual requirement of vegetables

Food category	Requirement (Tons/Year)	Production in HGs (Tons/Year)	Deficit (Tons/Year)
Gourds & Cucumber	708	4	704
Eggplant	528	1	527
Okra	852	7	845
Chili & Capsicum	,1080	9	1,071
Leafy vegetables	312	14	298
Total	3,480	35	3,445

Data presented in Table 5 depict the huge potential available for HGs to increase food production. This information also confirms the argument that HG program in Kesbewa should be strengthen further.

Table 6. GHG emission per ton per month

Indicator crop	GHG (Tons/Ton/Month)	GHG (Tons/Tons/Year)
Gourds & Cucumber	0.1183	1.4196
Eggplant	0.2092	2.5104
Okra	0.1489	1.7868
Chili & Capsicum	0.4924	5.9088
Leafy vegetables	0.0471	0.5652
Total	1.0096 per 5 Tons	12.1152 per 60 tons
	0.2019 per Ton/Month	

Table 6 indicates that 12.1152 tons of GHG would emit if 60 tons of food items were transported to Kesbewa. Because total food requirement is 3480 tons per year, when that amount was transported 703 tons of GHG will emit and it is a huge amount. This also justifies the importance of promoting HGs in Kesbewa.

City wide scenario

Current production in HGs is 2.614 tons and that amount could reduce (173.135*2.614) 453 Km of food miles.At present, only 6260 M^2 were cultivated and total land available is 1,063,248 M^2. If all available HGs were cultivated to indicator crops, total production would be 444.0 tons and that would reduce food miles by 76,179 Km. If 50% and 25% of available HGs were cultivated associated reduction in food miles would be 38090 and 19045 Km respectively. Because a lorry with a 5 ton capacity can run 13 Km per one liter of diesel possible fossil fuel saving through HGs is presented in Table 7.

Table 7. Possible reduction in food miles savings in fossil fuel

HGs under cultivation	Reduced food miles (Km)	Amount of fossil fuel could save (Liters)
Current extent(6260 M^2)	2,263	174
25 % of available HGs	96,041	7,388
50% of available HGs	192,181	14,783
100% of available HGs	384,361	29,566

Average production levels of Gourds and Cucumber, Eggplant, Okra, Chili and Capsicum and Leafy vegetables in HGs were 2.6, 0.4, 4.1, 6.2 and 11.2 tons per Ha[46] respectively. Present yield levels of crops grown in HGs are lower than those of commercial farms (Table 8).

Table8. Average yield of HGs and Commercial farms

Food category	Yield (Tons / Ha)	
	HGs	Commercial farms
Gourds & Cucumber	2.6	37.5 (7)
Eggplant	0.4	2.2 (18)
Okra	4.1	12.5 (33)
Chili & Capsicum	6.2	9.2 (67)
Leafy vegetable	11.2	53.0 (21)

- **Note: Figures in parentheses indicates production in HGs as a percentage of production in commercial farms.**

Data presented in Table 8 shows the possibility of increasing output of HGs. If output level was increased by different percentages the possible reduction in food miles and fossil fuel consumption are presented in Table 9

Table 9. Possible reduction in food miles and fossil fuel consumption

Production level (Tons)	Reduction in food miles (Km)	Fossil fuel saved (Liters)
Current level of production	2,263	174
5% increase in production	2,376	183
10% increase in production	2,489	191
15% increase in production	2,602	200
25% increase in production	2,829	218

[46] Crop yield was estimated dividing the total output by the area cultivated and multiplying that value by 10,000 because there are 10000 square meters per Ha.

According to data presented in Tables 7 and 9 it is clear that food miles as well as fossil fuel use could be reduced by promoting food production in HGs. Promotion of compost use through HGs is another objective of the project. As solid waste is used in compost production increased use of compost would reduce the environmental problems associated with improper disposal of solid wastes while producing healthy food.

V. CONCLUSIONS

Conclusion of this study is twofold.

Technical and attitudinal issues

Farmers in peri-urban area are reluctant to produce fruits and vegetables other than leafy vegetablesdue to their unfavorable attitudes. A sound agricultural extension program that could change the negative attitudes of the farmers would diversify agricultural production in these areas. Such a diversification is beneficial in terms of reducing GHG emission and food miles. Reduction in GHG emission and food miles will maintain a favorable urban environment while reducing the demand for fossil fuel.Potentials for livestock production in peri- urban areas is very remote

Present levels of production in home gardens are at a low level and thus, agricultural extension programs coupled with motivational activities should be introduced to people who maintain home gardens.

As some of the farmers having home gardens are concerned about only financial returns of HGs it is necessary to launch an educational program on direct and indirect benefits of home gardens. Agricultural extension programs occupied with strategies to motivate farmers to maintain home gardens, and soil and moisture conservation are mandatory.

Policy issues

Land ownership issues, land scarcity, intrusion of salt water, frequent floods are some of the burning issues facing by the peri –urban farmer. Therefore taking prompt actions to find solutions to these questions would motivate peri- urban farmers.

Food production in risky environment is difficult if the farmer is not access to modern production technology. As this is a deficient area, in order to promote peri-urban agriculture extension activities should be strengthen.

Crop insurance activities should be strengthened in peri- urban areas to minimize the risk faced by the farmers. Create necessary legal environment to cultivate abundant paddy lands in the peri-urban area.

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