Modelling and optimisation of Indian traditional agriculture supply chain to reduce post-harvest loss and CO₂ emission

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Abstract

Purpose – The purpose of this paper is to reduce the post-harvest loss occurring through respiration and CO_2 emission produce by the selected produces, during logistics. This paper proposes a supply chain (SC) structure for the Indian traditional agriculture SC planning model to reduce post-harvest loss and mixed closed transportation to reduce CO_2 emission.

Design/methodology/approach – The Indian agriculture SC structure is modeled and solved by genetic algorithm using a MATLAB Optimization toolbox. The respiration rate is measured by a static method. These values are applied in an SC planning model and the post-harvest loss and its corresponding CO_2 emission are estimated.

Findings – This paper proposes a supply structure for the Indian traditional agriculture SC to reduce the post-harvest loss; the experiments measured the respiration rate to estimate the CO_2 emission. The mixed closed transportation method is found to be suitable for short-purpose domestic transportation.

Research limitations/implications – The optimized supply structure leads to unemployment through eliminating the intermediaries. Therefore, further research encourages the conversion of intermediaries into hub instead of eliminating them.

Practical implications – This paper includes implications for the development of Indian traditional agriculture SC by an optimized supply structure and novel transportation method for the selected agriculture produces based on compatibility.

Originality/value – This paper identified that the agriculture produces respiration can also emit the CO₂. The closed transportation method can reduce the CO₂ emission of produces respiration than traditional open transportation.

Keywords Transportation, Carbon dioxide emission, Post-harvest losses, Respiration, Supply chain planning

Paper type Research paper

Nomenclature

Sets		D	Demand or production	
n	Produces	Q	Supply quantity	
f	Farmers	T	Transport quantity	
g	Agents	W	Loss quantity	
a	Auctioneers	PQ	Supply percentage	
l	Whole sellers	PW	Loss percentage	
r	Retail store	С	Carbon dioxide emission	
е	Customer			
-	Agents Auctioneers Whole sellers Retail store	W PQ	Loss quantity Supply percentage Loss percentage	n

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Indian traditional

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agriculture supply chain



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IMDS	Decision v	ariables	PW_{nfe}	Loss percentage of produce <i>n</i> during
117,9	D_n	Demand or production of n		transport from farmer to customer
-) -		produces	PW_{nga}	Loss percentage of produce n during
	PQ_{nfg}	Supply percentage of produce n		transport from agent to auctioneer
		from farmer to agent	PW_{ngl}	Loss percentage of produce <i>n</i> during
	PQ_{nfa}	Supply percentage of produce n		transport from agent to whole seller
1818		from farmer to auctioneer	PW_{ngr}	Loss percentage of produce <i>n</i> during
	PQ _{nfl}	Supply percentage of produce n		transport from agent to retail store
		from farmer to whole seller	PW_{nge}	Loss percentage of produce <i>n</i> during
	PQ_{nfr}	Supply percentage of produce n		transport from agent to customer
		from farmer to retail store	PW_{nal}	Loss percentage of produce n
	PQ _{nfe}	Supply percentage of produce n		during transport from auctioneer
		from farmer to customer		to whole seller
	PQ_{nga}	Supply percentage of produce n	PW_{nar}	Loss percentage of produce <i>n</i> during
		from agent to auctioneer		transport from auctioneer to
	PQ_{ngl}	Supply percentage of produce n		retail store
		from agent to whole seller	PW_{nae}	Loss percentage of produce n during
	PQ_{ngr}	Supply percentage of produce n		transport from auctioneer to
		from agent to retail store	DIV	customer
	PQ_{nge}	Supply percentage of produce n	$\mathrm{PW}_{\mathrm{nlr}}$	Loss percentage of produce <i>n</i> during
		from agent to customer		transport from whole seller to retail
	PQ _{nal}	Supply percentage of produce n	DW	store
		from auctioneer to whole seller	PW_{nle}	Loss percentage of produce <i>n</i> during
	PQ _{nar}	Supply percentage of produce n		transport from whole seller to customer
		from auctioneer to retail store	C	Carbon dioxide emission rate of
	PQ _{nae}	Supply percentage of produce <i>n</i>	C_n	produce <i>n</i>
		from auctioneer to customer		*
	$\mathrm{PQ}_{\mathrm{nlr}}$	Supply percentage of produce n	Other para	
	D 0	from whole seller to retail store	$Q_{ m nf}$	Capacity of farmer
	PQ_{nle}	Supply percentage of produce n	$Q_{ m ng}$	Capacity of agent
	DO	from whole seller to customer	$Q_{\rm na}$	Capacity of auctioneer
	$\mathrm{PQ}_{\mathrm{nre}}$	Supply percentage of produce n	$Q_{\rm nl}$	Capacity of whole seller
	DW	from retail to customer	$Q_{\rm nr}$	Capacity of retail
	PW_{nf}	Loss percentage of produce <i>n</i> at famer	$Q_{ m nfg}$	Supply quantity of produce n from
	PW _{ng} pw	Loss percentage of produce n at agent	0	farmer to agent
	PW_{na}	Loss percentage of produce <i>n</i> at auctioneer	$Q_{ m nfa}$	Supply quantity of produce n from farmer to auctioneer
	PW_{nl}	Loss percentage of produce n at	$Q_{ m nfl}$	Supply quantity of produce <i>n</i> from
	1 W nl	whole seller	₩nfl	farmer to whole seller
	PW_{nr}	Loss percentage of produce n at	$Q_{ m nf}$	Supply quantity of produce <i>n</i> from
	1 to nr	retail store	Whi	farmer to retail store
	PW_{nfg}	Loss percentage of produce <i>n</i> during	Q	Supply quantity of produce n from
	1 to mg	transport from farmer to agent	enie	farmer to customer
	PW_{nfa}	Loss percentage of produce n during	Qnm	Supply quantity of produce n from
	ma	transport from farmer to auctioneer	viiga	agent to auctioneer
	$\mathrm{PW}_{\mathrm{nfl}}$	Loss percentage of produce n during	$Q_{\rm nol}$	Supply quantity of produce n from
		transport from farmer to whole seller	• 1161	agent to whole seller
	$\mathrm{PW}_{\mathrm{nfr}}$	Loss percentage of produce <i>n</i> during	$Q_{ m ngr}$	Supply quantity of produce n from
		transport from farmer to retail store	0-	agent to retail store

$Q_{ m nge}$ $Q_{ m nal}$	Supply quantity of produce n from agent to customer Supply quantity of produce n from auctioneer to whole seller	$W_{ m nl}$ $W_{ m nr}$	Loss quantity of produce <i>n</i> at whole seller Loss quantity of produce <i>n</i> at rotail atom	Indian traditional agriculture
$Q_{\rm nar}$	Supply quantity of produce n from auctioneer to retail store	$W_{\rm nfg}$	retail store Loss of produce <i>n</i> during transport from farmer to agent	supply chain
Q _{nae}	Supply quantity of produce n from auctioneer to customer	$W_{\rm nfa}$	Loss of produce <i>n</i> during transport from farmer to auctioneer	1819
$Q_{ m nlr}$	Supply quantity of produce <i>n</i> from whole seller to retail store	$W_{\rm nfl}$	Loss of produce <i>n</i> during transport from farmer to whole seller	
$Q_{\rm nle}$	Supply quantity of produce <i>n</i> from whole seller to customer	$W_{\rm nfr}$	Loss of produce n during transport from farmer to retail store	
$Q_{\rm nre}$	Supply quantity of produce <i>n</i> from retail to customer	$W_{\rm nfe}$	Loss of produce n during transport from farmer to customer	
$Q_{\rm ne}$	Customer	$W_{\rm nga}$	Loss of produce n during transport	
	quantity of produce n	'' nga	from agent to auctioneer	
$T_{\rm nfg}$	Transport quantity of produce n	$W_{\rm ngl}$	Loss of produce n during transport	
1 nig	from farmer to agent	,, ngi	from agent to whole seller	
$T_{\rm nfa}$	Transport quantity of produce <i>n</i>	$W_{\rm ngr}$	Loss of produce n during transport	
- ma	from farmer to auctioneer	ligi	from agent to retail store	
$T_{ m nfl}$	Transport quantity of produce n	W_{nge}	Loss of produce n during transport	
	from farmer to whole seller	8-	from agent to customer	
$T_{\rm nfr}$	Transport quantity of produce n	$W_{\rm nal}$	Loss of produce <i>n</i> during transport	
	from farmer to retail store		from auctioneer to whole seller	
$T_{\rm nfe}$	Transport quantity of produce n	$W_{\rm nar}$	Loss of produce n during transport	
	from farmer to customer		from auctioneer to retail store	
$T_{\rm nga}$	Transport quantity of produce n	$W_{\rm nae}$	Loss of produce n during transport	
0	from agent to auctioneer		from auctioneer to customer	
$T_{\rm ngl}$	Transport quantity of produce n	$W_{\rm nlr}$	Loss of produce n during transport	
-	from agent to whole seller		from whole seller to retail store	
$T_{\rm ngr}$	Transport quantity of produce n	$W_{\rm nle}$	Loss of produce n during transport	
	from agent to retail store		from whole seller to customer	
T_{nge}	Transport quantity of produce n	Carbon Di	oxide Emission CO2	
	from agent to customer	$C_{ m nf}$	Carbon dioxide emission of produce	
$T_{\rm nal}$	Transport quantity of produce n		<i>n</i> at farmer	
_	from auctioneer to whole seller	$C_{\rm ng}$	Carbon dioxide emission of produce	
$T_{\rm nar}$	Transport quantity of produce n		<i>n</i> at agent	
T	from auctioneer to retail store	$C_{\rm na}$	Carbon dioxide emission of produce	
$T_{\rm nae}$	Transport quantity of produce n		<i>n</i> at auctioneer	
T	from auctioneer to customer	$C_{\rm nl}$	Carbon dioxide emission of produce	
$T_{\rm nlr}$	Transport quantity of produce <i>n</i>		<i>n</i> at whole seller	
T	from whole seller to retail store Transport quantity of produce <i>n</i>	$C_{\rm nr}$	Carbon dioxide emission of produce	
$T_{\rm nle}$	from whole seller to customer	~	<i>n</i> at retail	
		$C_{\rm nfg}$	Carbon dioxide emission of produce	
	uantity of produce n	C	<i>n</i> at agent	
$W_{\rm nf}$	Loss quantity of produce n at famer	c_{nfa}	Carbon dioxide emission of produce	
W_{ng}	Loss quantity of produce n at agent	C	<i>n</i> from farmer to auctioneer	
$W_{\rm na}$	Loss quantity of produce <i>n</i> at auctioneer	$C_{\rm nfl}$	Carbon dioxide emission of produce <i>n</i> from farmer to whole seller	
	aucuoneen		n nom farmer to whole seller	

IMDS	$C_{\rm nfr}$	Carbon dioxide emission of produce	$\text{CW}_{\rm nfg}$	Loss Carbon dioxide emission of
117,9	0	<i>n</i> from farmer to retail store	OW	produce <i>n</i> at agent
	$C_{\rm nfe}$	Carbon dioxide emission of produce	CW _{nfa}	Loss Carbon dioxide emission of
	0	<i>n</i> from farmer to customer		produce n from Farmer to
	$C_{ m nga}$	Carbon dioxide emission of produce		auctioneer
1000	0	<i>n</i> from agent to auctioneer	CW_{nfl}	Loss Carbon dioxide emission of
1820	$C_{ m ngl}$	Carbon dioxide emission of produce		produce n from farmer to whole
		<i>n</i> from agent to whole seller		seller
	$C_{ m ngr}$	Carbon dioxide emission of produce	CW_{nfr}	Loss Carbon dioxide emission of
	_	<i>n</i> from agent to retail store		produce <i>n</i> from farmer to retail store
	$C_{\rm nge}$	Carbon dioxide emission of produce	CW_{nfe}	Loss Carbon dioxide emission of
		<i>n</i> from agent to customer		produce n from farmer to customer
	$C_{\rm nal}$	Carbon dioxide emission of produce	CW_{nga}	Loss Carbon dioxide emission of
		n from auctioneer to whole seller		produce n from agent to auctioneer
	$C_{\rm nar}$	Carbon dioxide emission of produce	CW_{ngl}	Loss Carbon dioxide emission of
		n from auctioneer to retail store		produce <i>n</i> from agent to whole seller
	$C_{\rm nae}$	Carbon dioxide emission of produce	CW_{ngr}	Loss Carbon dioxide emission of
		<i>n</i> from auctioneer to customer		produce <i>n</i> from agent to retail store
	$C_{ m nlr}$	Carbon dioxide emission of produce	CW_{nge}	Loss Carbon dioxide emission of
		n from whole seller to retail store		produce n from agent to customer
	$C_{ m nle}$	Carbon dioxide emission of produce	$C_{\rm nal}$	Carbon dioxide emission of produce
		n from whole seller to customer		n from auctioneer to whole seller
	$C_{\rm nre}$	Carbon dioxide emission of produce	$C_{\rm nar}$	Carbon dioxide emission of produce
		<i>n</i> from retail to customer		n from auctioneer to retail store
	Carbon (dioxide Emission CO2 produced by loss	$C_{\rm nae}$	Carbon dioxide emission of produce
	CW _{nf}	Loss Carbon dioxide emission of		n from auctioneer to customer
	C I I III	produce <i>n</i> at farmer	CW_{nlr}	Loss Carbon dioxide emission of
	CW _{ng}	Loss Carbon dioxide emission of		produce <i>n</i> from whole seller to retail
	C W ng	produce <i>n</i> at agent		store
	CW_{na}	Loss Carbon dioxide emission of	CW _{nle}	Loss Carbon dioxide emission of
	C w na	produce n at auctioneer		produce n from whole seller to
	CW_{nl}	Loss Carbon dioxide emission of		customer
	C w nl	produce n at whole seller	CWnre	Loss Carbon dioxide emission of
	CW _{nr}	Loss Carbon dioxide emission of		produce n from retail to customer
	C w nr			-
		produce <i>n</i> at retail		

1. Introduction

As the population increases, agriculture production and supply must increase to meet the increasing demand (Alexandratos and Bruinsma, 2012). In a supply chain (SC), increasing demand can be satisfied only by efficient logistics (Lummus *et al.*, 2001). Hence, agriculture commodity has to be transported efficiently from farmers to the consuming regions, where agriculture supply chain management (ASCM) plays a prominent role (Ahumada and Villalobos, 2009; Etemadnia *et al.*, 2015). Traditionally, ASCM is viewed as a process where the agricultural produces are converted into value-added final products, and then delivered to the consumer and this process involves harvesting and consumption of the natural resources (Beamon, 1999). It is consequential to note that environmental sustainability and food security have become important issues to business practice (Kumar and Chandrakar, 2012).

The strategy of improving environmental quality reduces poverty, and brings about economic growth, with resultant improvements in health (Bhateja *et al.*, 2011; Jang and Klein, 2011). According to Syahruddin and Kalchschmidt (2011), in recent years, several measures have been made toward improving environmental hazards in ASCM in the developed countries, with the developing countries like India are yet to initiate this process. The Indian ASCM ignores some of the important issues like environmental damage, food safety, social and sustainability issues, which are driven by external factors such as customer and market demand (Syahruddin and Kalchschmidt, 2011). The environmental issues of ASCM are caused by the post-harvest losses (PHL) occurring at various levels of the SC (Hodges *et al.*, 2011).

If the PHL are reduced, then the cost of agriculture produces will reduce instantly (Murthy *et al.*, 2007). Around 30-40 percent of total produce gets wasted in India due to improper ASCM (Negi and Anand, 2015b). These PHL cannot be reduced without improving the infrastructure and awareness of the intermediaries in the ASCM on PHL (Parfitt *et al.*, 2010; Ratinger, 2013). Therefore, it is most important to plan the supply and estimate PHL quantity at every level in the agricultural SC. The supply and PHL quantity of Indian traditional ASCM can be optimized and planned by mathematical modeling (Mula *et al.*, 2010).

The mathematical model of Indian traditional ASCM is complicated, because intermediaries increased the echelon of traditional ASCM (Dalei and Dutta, 2015). Figure 1 shows the self-descriptive way of traditional ASCM that concise of many intermediaries and direct market. The purpose of this paper is to construct an optimum mathematical planning model for complex Indian traditional ASCM, and adopt a meta-heuristic genetic algorithm (GA) to solve this model. The objectives of this paper are to optimize the supply structure to reduce PHL and modify the transportation method to reduce the environmental impacts.

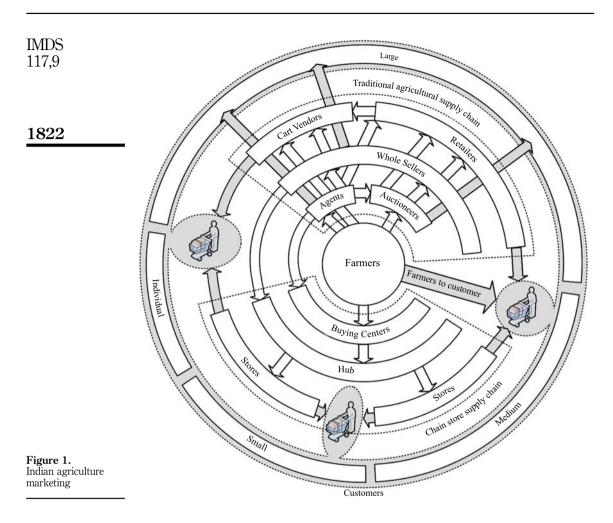
2. Literature review

In the recent years, there has been an increased attention in using GA to solve single- and multi-objective problems in production and operations management (Dimopoulos and Zalzala, 2000). GA is chosen as it is the most popular meta-heuristic algorithm within the context of SC planning and optimization (Fahimnia *et al.*, In press). This paper uses the GA as a meta-heuristic algorithm to optimize the supply structure of the Indian ASCM to reduce the PHL. According to Shukla and Jharkharia (2013), very little attention is given to the reduction of PHL. They listed various factors affecting ASCM as globalization, technological innovations, trade agreements, consumer awareness, environmental concerns, etc. In addition to that the PHL transpires due to many intermediaries. The PHL occur in the ASCM because they relate to wasteful behavior of intermediaries, retailers and customers (Parfitt *et al.*, 2010; Gustavsson *et al.*, 2011).

Elimination of intermediaries from the ASCM will improve its efficiency (Jansen, 1996). However, few authors (Klerkx and Leeuwis, 2008; Amrutlal, 2010) suggested to integrate the intermediaries in ASCM to optimize their supply structure. Therefore, in this research paper, intermediaries are retained for SC modeling for optimizing the SC while estimating the PHL and its CO_2 emission. Since recent years, many researchers have been focusing on environmental sustainability (Vorst *et al.*, 2010) because the agriculture sector is contributing 14 percent in total toward global CO_2 emissions (UNEP, 2012); if the agriculture sector's emission gets reduced, consequently, the overall emission will reduce (Blok *et al.*, 2001). The CO_2 emission sources in the agriculture sector are direct emission and indirect emission (Schils *et al.*, 2005).

The emission of CO_2 by the produces or land use is direct emission and the emission of CO_2 by the fuel burnt during transportation is indirect emission (Schils *et al.*, 2005). Indirect emission by the fuel burnt during transportation has attracted attention from many agriculture and automobile researchers. The less concentrated area in indirect emission

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includes respiration releases of CO_2 after produces have been harvested (Blok *et al.*, 2001). Proper packing can maintain the quality of the produce as the CO_2 generated while packing is at an elevated level (Kader and Rolle, 2004). All agriculture produces should be properly packed before transportation.

2.1 Indian agriculture SC

The Indian ASCM has become more complex and improper due to the imbalance between demand and supply (Joshi *et al.*, 2009). This complexity of ASCM and improper handling by the intermediaries plays a major role in ASCM and its PHL (Negi and Anand, 2015b). However, Indian traditional ASCM has more potential to satisfy the demand than a chain store SC; hence, it needs more research concentration (Bala, 2014). Figure 1 shows that Indian ASCM consists of two SCs: first is private retailers following the chain store SC, and second is traditional ASCM which includes many intermediaries like agents, auctioneers, wholesalers and retailers (Gigler *et al.*, 2002; Negi and Anand, 2015a, b).

The produces, which are produced by the Indian farmers, take two possible routes, namely, the agents and auctioneers, and from there, produces move to customer through

whole sellers and retailers. This method is called traditional ASCM. Alternatively, depending on the quantity and cost, the produces may change the route to reach the customer directly through whole sellers and retailers in traditional ASCM (Negi and Anand, 2015a, b). The most efficient and less-practiced route is the direct market. In direct market, the produces reach the customer directly without any intermediaries like agents, auctioneers, whole sellers and retailers (Rajkumar and Jacob, 2010). The Indian farmers mostly practice traditional ASCM, which supply the agriculture products to the consumer through the intermediaries (Bahinipati, 2014).

The past research works clearly indicate the need for planning and optimizing the Indian ASCM. Since Indian agriculture transportation transports the produces through open craters (FAO, 2005; Vigneault *et al.*, 2009; Bhushan, 2013), it leads to continuous emission of CO_2 through respiration of the agricultural produces (Snowden, 2010). Therefore, this paper identifies an alternate transportation method to reduce the CO_2 emission and investigates PHL from field to plate of selected agriculture produces.

3. Adopted approach

The Indian traditional ASCM is modeled by considering all intermediaries and assumes PHL in various percentages. The percentages of PHL of different produces were estimated by many researchers such as Gangwar *et al.* (2007) and Sharma and Singh (2011). Those PHL percentages lie in between 10 and 50 percent. Therefore, the assumed percentage of losses at the first level of ASCM is 10 percent, and ends at 50 percent with an increment of 10 percent, because 10 is the lowest percentage of loss and 50 is the highest percentage of loss. In this paper, loss is nothing but non-consumed produces, which is a previous stage of degradation. According to respiration the degraded and non-consumed produces are different. Respiration was measured through the experimental setup to calculate the CO_2 emission as shown in Figure 3.

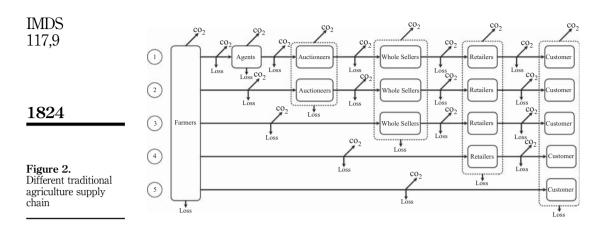
The CO₂ emitted by agricultural produces through the respiration was estimated for those PHL and also the CO₂ emissions of all undamaged supplied products were measured. The respiration of selected agriculture produces was measured in the non-degraded condition of the produce. The agricultural produces like potato and tomato were purposively selected based on their compatibility with ASCM and availability. The CO₂ evolutions of potato and tomato were measured using the respiration to estimate the respiration rate. The CO₂ evolution is applied to the overall production of respective produces to measure the overall CO₂ emission. These CO₂ evolutions were applied to the PHL quantity to measure its CO₂ emission. Therefore, this research paper formulates a mathematical model to plan the supply, estimate PHL and CO₂ emission for various optimized supplies.

3.1 Loss and emission source proposed model

Many PHL are available in this traditional ASCM like packing and transportation (Gigler *et al.*, 2002; Sharma and Singh, 2011); these PHL were intended by a mathematical model along with overall losses and loss of CO_2 emission. Figure 2 classifies Indian traditional ASCM into five different SC models and shows the PHL and CO_2 emission sources at every level. PHL are shown in Figure 2 as loss, which happens during transportation. In addition, there are two CO_2 emission sources considered in this paper which are unconsumed and fresh produces emission.

Therefore, the PHL and CO_2 emissions are high in ASCM due to the presence of multiple supply stages or the presence of intermediaries such as agents, auctioneers, whole sellers, and retailers. The produces are transported from farmer to customer through these intermediaries by open transportation in trucks (Ashby, 2008; Rajkumar and Jacob, 2010). As proper loading and unloading is not followed in the open truck transportation (Vigneault *et al.*, 2009), it leads to exploitation of farmers by the intermediaries (Ashby, 2008; Rajkumar and Jacob, 2010).

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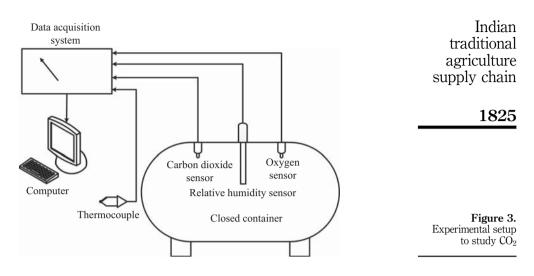
The agricultural produces respire continuously during open truck transportation. The produces start respiration immediately after harvest until it is consumed or degraded. The static and closed method is used to measure the CO_2 emission released by produces during respiration (Yahia, 2009). Experiments were conducted individually and also mixed together to know how much CO_2 is produced. During this experiment, the produces are experimented in a closed container and respired for six hours.

3.2 Experimental setup

The agriculture produces are selected based on local production and are grouped based on their storage properties. The O_2 consumption and CO_2 evolution are measured by the static method in atmospheric temperature without any external aid. The static method can measure the respiration in a closed container (Fonseca *et al.*, 2002). The respiration of the selected agriculture produces is measured by gas sensors for the sample time of one hour and six hours. In this static method, the relative humidity of the selected produces for the reason of respiration produces water droplets after six hours; therefore, the experiments were conducted for six hours.

The sensors used in this experiment are the Vernier O_2 sensor in the range of 0-27 percent (0-270 ppt), the Vernier CO_2 sensor in the low range: 0 to 10,000 ppm and high range: 0 to 100,000 ppm, the Vernier relative humidity sensor in the range of 0 to 95 percent, and the *t*-type thermocouple in the range of 0 to 350°C. These sensors were interfaced with a computer through national instrument ELVIS II. Figure 3 shows the experimental setup. The O_2 sensor value changes with respect to the relative humidity value; therefore, the relative humidity was measured for O_2 sensor. Two produces, namely, potato and tomato were selected to measure their respiration levels as individual produces as well as mixed quantities were studied for their O_2 consumption and CO_2 evolution.

Initially, the individual agriculture produces' respiration rates were measured by the experimental setup as shown in Figure 3. In addition, two vegetables were combined and measured by this experimental setup. The agricultural produces like potato, tomato, and their combinations were experimented in the weight of 100, 200, and 300 g. Mixing of samples was based on produce selection and their compatibility. This comparative study of individual and mixed produces shows the CO_2 evolution variations along with O_2 consumption. Through this way, the CO_2 respiration rate was averaged and measured. Subsequently, those values were applied in the mathematical model to estimate the supply, transport loss quantity and CO_2 emission.



3.3 Model description

An SC planning model is used here to optimize the supply between each stage and estimate the loss and CO_2 emission. This planning model considered that the demand D_n of the *n*th produce is equal to the farmer's production. Succeedingly, Q_n is the capacity or supply of any stage of the *n*th produce. Likewise, T_n , W_n , and C_n are the transport, loss quantity and CO_2 emission of the *n*th produce of the concerned stage, respectively. The decision variables are the percentage of supply (PQ_n) and loss (PW_n) quantities, which decide the efficiency of the whole SC in this model. The decision variables are in percentage so that they can estimate the value from the production quantity.

These decision variables are used to calculate the quantity supply and quantity loss at each stage. Equation (1) can estimate the loss at the farmer's end by applying the farmer's loss percentage PW_{nf} , and then the supply capacity of the farmers can be measured by Equation (2). Likewise, the supply capacity of agents, auctioneers, whole sellers and retailers can be measured by Equations (3)-(6), respectively. Equations (7) to (21) measure the supply quantities of each stage to other consequent stages. The total supply quantities were estimated by summing all the supply quantities; likewise, the total loss quantities were estimated by adding all the loss quantities. The loss quantities can be measured by Equations (36) to (53). If the loss is eliminated from the previous supply quantity, then that is nothing but the transported quantity (T_n) .

Equations (22) to (35) calculate transported quantities between each stage. The transported quantities were used to measure the total quantity transported and total transportation losses. The total loss and supply quantities are shown in (54) and (55), respectively. The total CO_2 consumption of loss quantities can be measured by Equation (56). The total supply and loss quantities were large in size; therefore, those large equations were solved algebraically by the MATLAB software package. The supply quantity needs to be optimized to gain higher supply and lower losses. The supply quantity is optimized through GA. Equations (57) to (69) are constraints for the models. In that first five equations are nonlinear constraints. Second five equations are linear constraints and remaining equations are upper and lower bound.

The first five nonlinear equations are the sum of all the supply quantities, which are supplied from the farmer to other stages and should be equal to the total demand or production. In the second five equations, the quantities which are supplied from the farmer to other stages should be greater than supply quantities of each stage to other stages. IMDS The supply quantity which is supplied by the retailer to the customer should be less than 117,9 the sum of supply quantities of the farmer to the retailer and other stages to the customer. In linear equations, first is the sum of all the percentages of supply quantities supplied from the farmer to other stages which should be equal to 100; likewise, the remaining percentage of supply quantities, supplied from each stage to other stages, should be less than or equal to 100. Finally, the bound constraints should be defined for all the objectives while solving an objective using GA.

> There are three bound constraints: loss, supply and CO₂ emission. These three constraints should be greater than 0; likewise, the loss should be less than demand, the supply should be less than or equal to demand, and CO₂ emission should be less than the overall emission. Based on the above constraints, the supply structure of Indian TASCM is optimized. These optimized supply structures are shown in Table I. The loss, supply and CO₂ emission quantities are estimated by Equations (54)-(56), respectively, based on the optimized supply structure:

$$W_{\rm nf} = D_n \,\times {\rm PW}_{\rm nf} \tag{1}$$

$$Q_{\rm nf} = D_n - W_{\rm nf} \tag{2}$$

$$Q_{\rm ng} = T_{\rm nfg} - W_{\rm ng} \tag{3}$$

$$Q_{\rm na} = \left[T_{\rm nfa} + T_{\rm nga} \right] - W_{\rm na} \tag{4}$$

$$Q_{\rm nl} = \left[T_{\rm nfl} + T_{\rm ngl} + T_{\rm nal} \right] - W_{\rm nl} \tag{5}$$

$$Q_{\rm nr} = \left[T_{\rm nfr} + T_{\rm ngr} + T_{\rm nar} + T_{\rm nlr}\right] - W_{\rm nr} \tag{6}$$

$$Q_{\rm nfg} = Q_{\rm nf} \times PQ_{\rm nfg} \tag{7}$$

$$Q_{\rm nfa} = Q_{\rm nf} \times PQ_{\rm nfa} \tag{8}$$

		Type-1 in %	Supply structures Type-2 in %	Type-3 in %
	DO			
	PQ_{nfg}	20	20	0
	PQ_{nfa}	20	20	0
	PQ_{nfl}	20	20	0
	PQ_{nfr}	20	20	0
	PQnfe	20	20	100
	PQ _{nga}	25	0	0
	PQ _{ngl}	25	0	0
	PQ_{ngr}	25	0	0
	PQnge	25	100	0
	PQ _{nal}	30	0	0
	PQ _{nar}	30	0	0
	PQnae	40	100	0
	PQ_{nlr}	50	0	0
Table I.	PQ _{nle}	50	0	0
Supply structures	PQnre	100	100	0

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$Q_{ m nfl} = Q_{ m nf} imes { m PQ}_{ m nfl}$ $Q_{ m nfr} = Q_{ m nf} imes { m PQ}_{ m nfr}$	(9) (10)	Indian traditional agriculture supply chain
$Q_{ m nfe} = Q_{ m nf} imes { m PQ}_{ m nfe}$	(11)	
$Q_{\rm nga} = Q_{\rm ng} \times {\rm PQ}_{\rm nga}$	(12)	1827
$Q_{ m ngl} = Q_{ m ng} imes { m PQ}_{ m ngl}$	(13)	
$Q_{ m ngr} = Q_{ m ng} imes { m PQ}_{ m ngr}$	(14)	
$Q_{ m nge} = Q_{ m ng} imes { m PQ}_{ m nge}$	(15)	
$Q_{\rm nal} = Q_{\rm na} imes { m PQ}_{\rm nal}$	(16)	
$Q_{\rm nar} = Q_{\rm na} \times { m PQ}_{\rm nar}$	(17)	
$Q_{\rm nae} = Q_{\rm na} \times {\rm PQ}_{\rm nae}$	(18)	
$Q_{ m nlr} = Q_{ m nl} imes { m PQ}_{ m nlr}$	(19)	
$Q_{ m nle} = Q_{ m nl} imes { m PQ}_{ m nle}$	(20)	
$Q_{\rm nre} = Q_{\rm nr} \times {\rm PQ}_{\rm nre}$	(21)	
$T_{\rm nfg} = Q_{\rm nfg} - W_{\rm nfg}$	(22)	
$T_{\mathrm{nfa}} = Q_{\mathrm{nfa}} - W_{\mathrm{nfa}}$	(23)	
$T_{\rm nfl} = Q_{\rm nfl} - W_{\rm nfl}$	(24)	
$T_{\rm nfr} = Q_{\rm nfr} - W_{\rm nfr}$	(25)	
$T_{\rm nfe} = Q_{\rm nfe} - W_{\rm nfe}$	(26)	
$T_{\rm nga} = Q_{\rm nga} - W_{\rm nga}$	(27)	
$T_{\rm ngl} = Q_{\rm ngl} - W_{\rm ngl}$	(28)	
$T_{\rm ngr} = Q_{\rm ngr} - W_{\rm ngr}$	(29)	
$T_{\rm nge} = Q_{\rm nge} - W_{\rm nge}$	(30)	

$$T_{\rm nal} = Q_{\rm nal} - W_{\rm nal} \tag{31}$$

$$T_{\rm nar} = Q_{\rm nar} - W_{\rm nar} \tag{32}$$

$$T_{\text{nae}} = Q_{\text{nae}} - W_{\text{nae}} \tag{33}$$

$$T_{\rm nlr} = Q_{\rm nlr} - W_{\rm nlr} \tag{34}$$

$$T_{\rm nle} = Q_{\rm nle} - W_{\rm nle} \tag{35}$$

$$W_{\rm ng} = T_{\rm nfg} \times \rm PW_{\rm ng} \tag{36}$$

$$W_{\rm na} = \left[T_{\rm nfa} + T_{\rm nga} \right] \times {\rm PW}_{\rm na} \tag{37}$$

$$W_{\rm nl} = \left[T_{\rm nfl} + T_{\rm ngl} + T_{\rm nal}\right] \times PW_{\rm nl}$$
(38)

$$W_{\rm nr} = \left[T_{\rm nfr} + T_{\rm ngr} + T_{\rm nar} + T_{\rm nlr}\right] \times PW_{\rm nr}$$
(39)

$$W_{\rm nfg} = Q_{\rm nfg} \times {\rm PW}_{\rm nfg} \tag{40}$$

$$W_{\rm nfa} = Q_{\rm nfa} \times {\rm PW}_{\rm nfa} \tag{41}$$

$$W_{\rm nfl} = Q_{\rm nfl} \times \rm PW_{\rm nfl} \tag{42}$$

$$W_{\rm nfr} = Q_{\rm nfr} \times PW_{\rm nfr} \tag{43}$$

$$W_{\rm nfe} = Q_{\rm nfe} \times \rm PW_{\rm nfe} \tag{44}$$

$$W_{\rm nga} = Q_{\rm nga} \times PW_{\rm nga} \tag{45}$$

$$W_{\rm ngl} = Q_{\rm ngl} \times PW_{\rm ngl} \tag{46}$$

$$W_{\rm ngr} = Q_{\rm ngr} \times PW_{\rm ngr} \tag{47}$$

$$W_{\rm nge} = Q_{\rm nge} \times PW_{\rm nge} \tag{48}$$

$$W_{\rm nal} = Q_{\rm nal} \times PW_{\rm nal} \tag{49}$$

$$W_{\rm nar} = Q_{\rm nar} \times {\rm PW}_{\rm nar} \tag{50}$$

$$W_{\rm nae} = Q_{\rm nae} \times {\rm PW}_{\rm nae} \tag{51}$$

$$W_{\rm nlr} = Q_{\rm nlr} \times PW_{\rm nlr}$$
 (52) Indian traditional

$$W_{\rm nle} = Q_{\rm nle} \times PW_{\rm nle}$$
 (53) agriculture
supply chain

Objective 1 – total loss:

$$\min f(W) = \sum_{n} \sum_{f} W_{nf} + \sum_{n} \sum_{g} W_{ng} + \sum_{n} \sum_{a} W_{na} + \sum_{n} \sum_{l} W_{nl} + \sum_{n} \sum_{r} W_{nr}$$

$$+ \sum_{n} \sum_{f} \sum_{g} W_{nfg} + \sum_{n} \sum_{f} \sum_{a} W_{nfa} + \sum_{n} \sum_{f} \sum_{l} W_{nfl}$$

$$+ \sum_{n} \sum_{f} \sum_{r} W_{nfr} + \sum_{n} \sum_{f} \sum_{e} W_{nfe} + \sum_{n} \sum_{g} \sum_{a} W_{nga}$$

$$+ \sum_{n} \sum_{g} \sum_{l} W_{ngl} + \sum_{n} \sum_{g} \sum_{r} W_{ngr} + \sum_{n} \sum_{g} \sum_{e} W_{nge}$$

$$+ \sum_{n} \sum_{a} \sum_{l} W_{nal} + \sum_{n} \sum_{a} \sum_{r} W_{nar} + \sum_{n} \sum_{g} \sum_{e} W_{nae}$$

$$+ \sum_{n} \sum_{l} \sum_{r} W_{nlr} + \sum_{n} \sum_{l} \sum_{e} W_{nle} + \sum_{n} \sum_{r} \sum_{e} W_{nre}$$
(54)

Objective 2 – total supply:

$$\max f(Q) = \sum_{n} \sum_{f} Q_{nf} + \sum_{n} \sum_{g} Q_{ng} + \sum_{n} \sum_{a} Q_{na} + \sum_{n} \sum_{l} Q_{nl} + \sum_{n} \sum_{r} Q_{nr}$$

$$+ \sum_{n} \sum_{f} \sum_{g} Q_{nfg} + \sum_{n} \sum_{f} \sum_{a} Q_{nfa} + \sum_{n} \sum_{f} \sum_{l} Q_{nfl} + \sum_{n} \sum_{f} \sum_{r} Q_{nfr}$$

$$+ \sum_{n} \sum_{f} \sum_{e} Q_{nfe} + \sum_{n} \sum_{g} \sum_{a} Q_{nga} + \sum_{n} \sum_{g} \sum_{l} Q_{ngl} + \sum_{n} \sum_{g} \sum_{r} Q_{ngr}$$

$$+ \sum_{n} \sum_{g} \sum_{e} Q_{nge} + \sum_{n} \sum_{a} \sum_{l} Q_{nal} + \sum_{n} \sum_{a} \sum_{r} Q_{nar} + \sum_{n} \sum_{a} \sum_{e} Q_{nae}$$

$$+ \sum_{n} \sum_{l} \sum_{r} Q_{nlr} + \sum_{n} \sum_{l} \sum_{e} Q_{nle} + \sum_{n} \sum_{r} \sum_{e} Q_{nre}$$
(55)

Objective 3 – total carbon dioxide produced by loss:

$$\min f(CW) = \sum_{n} \sum_{f} CW_{nf} + \sum_{n} \sum_{g} CW_{ng} + \sum_{n} \sum_{a} CW_{na} + \sum_{n} \sum_{l} CW_{nl}$$
$$+ \sum_{n} \sum_{r} CW_{nr} + \sum_{n} \sum_{f} \sum_{g} CW_{nfg} + \sum_{n} \sum_{f} \sum_{a} CW_{nfa}$$
$$+ \sum_{n} \sum_{f} \sum_{l} CW_{nfl} + \sum_{n} \sum_{f} \sum_{r} CW_{nfr} + \sum_{n} \sum_{f} \sum_{e} CW_{nfe}$$
$$+ \sum_{n} \sum_{g} \sum_{a} CW_{nga} + \sum_{n} \sum_{g} \sum_{l} CW_{ngl} + \sum_{n} \sum_{g} \sum_{r} CW_{ngr}$$
$$+ \sum_{n} \sum_{g} \sum_{e} CW_{nge} + \sum_{n} \sum_{a} \sum_{l} CW_{nal} + \sum_{n} \sum_{a} \sum_{r} CW_{nar}$$

$$+\sum_{n}\sum_{a}\sum_{e}CW_{nae} + \sum_{n}\sum_{l}\sum_{r}CW_{nlr} + \sum_{n}\sum_{l}\sum_{e}CW_{nle}$$
$$+\sum_{n}\sum_{r}\sum_{e}CW_{nre}$$
(56)

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Nonlinear constraints:

$$Q_{\rm nfg} + Q_{\rm nfa} + Q_{\rm nfl} + Q_{\rm nfr} + Q_{\rm nfe} = D_n \tag{57}$$

$$Q_{\rm nga} + Q_{\rm ngl} + Q_{\rm ngr} + Q_{\rm nge} \leqslant Q_{\rm nfg} \tag{58}$$

$$Q_{\rm nal} + Q_{\rm nar} + Q_{\rm nae} \leqslant Q_{\rm nfa} + Q_{\rm nga} \tag{59}$$

$$Q_{\rm nlr} + Q_{\rm nle} \leqslant Q_{\rm nfl} + Q_{\rm ngl} + Q_{\rm nal} \tag{60}$$

$$Q_{\rm nre} \leqslant Q_{\rm nfr} + Q_{\rm nge} + Q_{\rm nae} + Q_{\rm nle} \tag{61}$$

Linear constraints:

$$PQ_{nfg} + PQ_{nfa} + PQ_{nfl} + PQ_{nfr} + PQ_{nfe} = 100$$
(62)

$$PQ_{nga} + PQ_{ngl} + PQ_{ngr} + PQ_{nge} \leqslant 100$$
(63)

$$PQ_{nal} + PQ_{nar} + PQ_{nae} \le 100 \tag{64}$$

$$PQ_{nlr} + PQ_{nle} \leqslant 100 \tag{65}$$

$$PQ_{nre} \leq 100$$
 (66)

Bound:

$$0 \leqslant W < D_n \tag{67}$$

$$0 \leqslant Q \leqslant D_n \tag{68}$$

$$0 \leqslant \mathrm{CW} < D_n \times C_n \tag{69}$$

3.4 Proposed GA

Type 3 supply structure is optimized by GA. The GA solves the mathematical model using the MATLAB R2014a optimization tool box. The traditional optimization and search algorithms are not good enough to solve large SC problems (Kannan *et al.*, 2010). So this research paper chooses the GA because this is inspired by biological evolution and works based on survival of the fittest. GA is the stochastic search algorithm that works iteratively on a population, carrying out a search directed by the fitness of each solution (Xie and Dong, 2002). This GA is more flexible with objective function and not depends on any priori hypotheses (Naso *et al.*, 2007). In this paper, the optimization toolbox is used to run the GA solver.

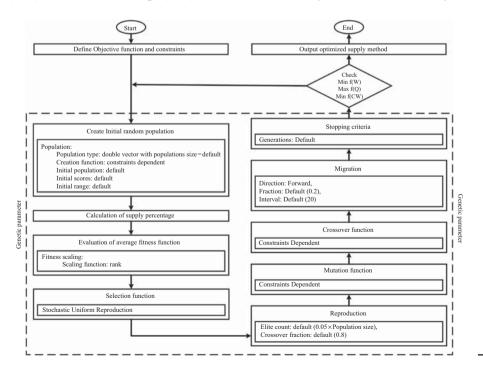
There are 13 decision variables in this modeling; the GA uses the binary decoding to proceed with the problem.

There are different terms that are specified for the purpose of optimization. Before specifying certain values for each of these terms, all of them were tested with regard to the accuracy of the results. The selected and used MATLAB prescribed terms in the GA toolbox for optimization are shown in the flow chart. The GA starts with defining objective function and constraints as described in Section 3.3. Then double vector population and constraint-dependent creation function were applied for constraints. The initial population, scores and ranges are not required to change from default values, because the feasible solution is obtained from default values. Rank scaling is applied, because ranking automatically introduces a uniform scaling across the population and also rank fitness scaling removes the effect of the spread of the raw scores.

Stochastic uniform reproduction is applied as a selection function, and then the default elite count and crossover fraction is applied in reproduction. The constraint-dependent crossover and mutation is applied, in addition to the optimization toolbox, which applies adaptive feasible mutation, when constraints were present; likewise. if linear constraints are present, then the optimization toolbox chooses intermediate crossover function. In terms of migration, the forward direction was applied with default fraction and interval. This optimization toolbox ends when the optimized supply structure is obtained; it is described in Section 4.1 (Figure 4).

4. Results and discussions

The mathematical model is used to plan an optimized supply structure to estimate loss and CO_2 emission of Indian traditional ASCM. The previous researchers such as Gangwar *et al.* (2007) and Sharma and Singh (2011) calculated PHL for every level of ASCM, but they did



Indian traditional agriculture supply chain

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Figure 4.

flow chart

Genetic algorithm

not consider the environmental impacts. Therefore, the CO_2 emissions of supply and loss were estimated through the respiration rate, which is measured for open and closed transportation of the selected produces such as potato, tomato and its combination.

4.1 Optimization of supply

This model is specifically used to plan the supply, estimate loss and CO_2 emission by demand or production of produces. The 13 nomenclature and 36 decision variables are described in the topic of nomenclature. The decision variables are nothing but supply quantity percentage and loss quantity percentage at each of the stages. These percentages are the input for mathematical modeling to estimate the loss and CO_2 emissions. The percentage of supply quantities of each stage like farmers to an agent is described in nomenclature and the values are shown in first column of Table I. The type 1, type 2 and type 3 columns are three different supply structures which are optimized.

The supply quantities are optimized through GA using the MATLAB R2014a optimization toolbox. Table I displays three optimized values which are called optimized supply structures. These supply structures are optimized to supply the agriculture produces to the customer through various stages. Among various supply structures, type 3 is the most optimized supply structure because this eliminates all the intermediaries. According to Neven *et al.* (2009) cooperative market is most efficient than other direct market or chain store market. Therefore, the supply structure type 1 is the most feasible option, because this method includes all the stages of ASCM. Succeeding, the supply structure type 2 supplies produces from the farmer to customer through other intermediaries directly, therefore this eliminates the supply between intermediaries.

These supply structures are applied in the mathematical model to calculate PHL and CO_2 emission. The PHL was measured by assuming loss percentage and CO_2 emissions were measured by measuring the respiration rate of produces and their group. The quantities of selected agriculture produces were identified and are shown in Table II. The agriculture produces have to be supplied to the customers to satisfy their demand without affecting the environment.

4.2 Calculation of overall CO_2 emission

The respiration rates of CO_2 of open and closed transportation were measured and shown in Table II. It comprises a year, production quantity of produces, as well as CO_2 emission produced by respiration of agriculture produces during open and closed transportation. Succeeding that, the respiration rate of CO_2 was applied to quantity of production to

	Produces	Year	Production In Kg	Clo Respiration rate ml CO ₂ /hr.	sed CO ₂ ml CO ₂ /hr.	O Respiration rate ml CO ₂ /hr.	pen CO ₂ ml CO ₂ /hr.	Difference ml CO ₂ /hr.
Table II. CO_2 respiration rate and CO_2 produced by respiration	Potato Tomato Potato and Tomato	2010-2011 2011-2012 2012-2013 2010-2011 2011-2012 2012-2013 2010-2011 2011-2012 2012-2013	$\begin{array}{c} 42,339,000\\ 41,483,000\\ 45,344,000\\ 16,826,000\\ 18,653,000\\ 18,227,000\\ 59,165,000\\ 60,136,000\\ 63,571,000\end{array}$	2.33 5.24 4.13	98,527,927 96,535,912 105,520,922 88,188,945 97,764,673 95,531,909 244,107,434 248,113,660 262,286,043	6.02 18.21 12.21	2,981,617,987 3,030,551,496	$\begin{array}{c} 494,202,295\\ 484,210,629\\ 529,278,180\\ 1,517,759,854\\ 1,682,561,189\\ 1,644,134,605\\ 2,737,510,553\\ 2,782,437,837\\ 2,941,372,152\end{array}$

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estimate the overall CO_2 emission. Both potato and tomato and their combination of respiration vary in open and closed transportation. The respiration rate is highly reduced, when potato and tomato are combined together in a closed transportation.

As referred to in Table II, potato has a rate of $6.02 \text{ ml CO}_2/\text{hr}$, tomato and its combination have respiration rates of $18.21 \text{ ml CO}_2/\text{hr}$ and $12.21 \text{ ml CO}_2/\text{hr}$, respectively, in open transportation. If the produces are transported in a closed container, then potato has a rate of $2.33 \text{ ml CO}_2/\text{hr}$, and tomato and its combination have respiration rates of $5.24 \text{ ml CO}_2/\text{hr}$ and $4.13 \text{ ml CO}_2/\text{hr}$, respectively. The potato has the lowest respiration rate, and the transportation method of potato, tomato and their combination is shown in Table II.

However, the respiration rate changes in the closed transportation according to the headspace; if the headspace decreases, then the respiration rate also decreases. In comparison, the potato has a less respiration rate than tomato. However, both have reduced respiration in the closed transportation. Complete production of CO_2 emission is shown in Table II, which is estimated by applying the respiration rates to the overall production of agriculture production during past three years of 2014, because this work is conducted during the year of 2014. Thus, the overall CO_2 emission of Indian traditional ASCM will increase.

4.3 Calculation of loss and CO_2 emission

The CO_2 emission is not only produced by the transported agricultural produces but also emitted during PHL. Therefore, supply and loss are major sources of CO_2 emissions, which will increase the environmental impacts of Indian traditional ASCM. Table III comprises the loss of all three combinations such as potato, tomato and mixture of both, with total PHL in terms of kg for an assumed percentage of PHL for each stage, as well as supply structures and exact production of each year. If the traditional ASCM adopts type 1 supply structure, it will have 50 percent of PHL, leaving highest quantity of loss; otherwise if it adopts a most optimized supply structure type 3 with 10 percent of PHL, it will be the lowest loss. The comparison of type 1 and type 3 reveals that the total loss reduced to 15 percent in all percentage of PHL.

The PHL percentages of each stage and supply structure are interlinked with each other. The optimized supply structure reduces the loss and CO_2 emission, but the transportation method reduces CO_2 emission only. Tables IV and V comprise the CO_2 emission of loss produces during closed and open transportation, respectively. Table IV shows the significance of closed transportation by comparing CO_2 emission produced by selected produce respiration along with an assumed percentage of PHL and optimized supply structures.

Table IV clarifies that the PHL of tomato in supply structure type 3 has lowest CO_2 emission, which is 5, 10, 15, 18, and 22 percent with respect to each percentage of PHL. The supply structure type 3 of potato has CO_2 emission of 7, 14, 20 25, and 29 percent with respect to each percentage of PHL, which is slightly higher than tomato. The supply structure type 3 of mixed produces has CO_2 emission of 6, 12, 17, 22, and 25 percent with respect to each percentage of PHL. Therefore, the tomato has lowest CO_2 than both, but the potato CO_2 emission can be reduced by mixing both. The open transportation CO_2 emission is estimated and shown in Table V to compare with closed transportation.

Table V clarifies the differentiation of CO_2 emission of open transportations of selected produces compared with the PHL percentage and optimized supply structures, because this open transportation is more traditional than the existing transportation method. Table V clarifies that the CO_2 emission of open transportation is much higher. The potato has 90 percent of CO_2 emission in supply structure type 1 with highest loss percentage. This table is used here to estimate the current CO_2 emission of selected produces for five different loss and three different supply structures. In Table V, it is estimated to compare the closed transportation with traditional open transportation. The difference between closed and traditional open transportation is shown in Table VI. Indian traditional agriculture supply chain

IMDS 117,9	Average %	67 64 64 49	49 49 67 67 67 67 67 67 67 67	49 49 64 64 49 49 49
	%	$\begin{array}{c} 200 \\$	72 88 88 6 0 0 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	75 75 88 88 88 88 88 75 75
1834	50% kg	38,213,015 37,440,433 40,925,174 37,311,244 36,556,894 39,59,400 31,754,250	31,112,250 34,008,000 15,186,287 16,835,243 16,450,757 14,827,913 16,457,913 16,62,544 16,062,544 16,062,544	13,989,750 13,670,250 54,275,676 57,375,932 52,139,156 52,934,850 52,934,850 55,021,944 44,373,750 45,102,000 45,102,000
	%	$\begin{array}{c} 6.8\\ 6.8\\ 8.3\\ 8.3\\ 8.3\\ 8.3\\ 8.3\\ 8.3\\ 8.3\\ 8$	$\begin{array}{c} 67\\ 67\\ 67\\ 68\\ 83\\ 83\\ 83\\ 83\\ 83\\ 83\\ 83\\ 83\\ 83\\ 8$	$\begin{array}{c} 64\\ 64\\ 64\\ 64\\ 64\\ 64\\ 64\\ 64\\ 64\\ 64\\$
	40% kg	of loss 35,291,443 34,577,928 37,796,244 33,876,619 33,191,710 36,281,004 27,096,960	26,549,120 29,020,160 14,025,221 15,548,106 15,193,016 13,462,954 14,583,933 14,583,933 14,583,933	$\begin{array}{c} 11.937,920\\ 11.665,280\\ 12.665,280\\ 50,126,035\\ 50,126,035\\ 50,289,260\\ 47,339,573\\ 48,116,497\\ 50,864,937\\ 37,865,600\\ 38,487,040\\ 40,685,440\\ 40,685,440\\ \end{array}$
	tage %	ntage 73 73 68 68 68 68 51 51	1 21 21 21 21 22 23 23 23 23 23 23 23 23 23 23 23 23	$\begin{array}{c} 51\\ 51\\ 51\\ 51\\ 51\\ 51\\ 51\\ 51\\ 51\\ 51\\$
	Loss percentage 30% kg %	Total loss and percentage 57 30,844,849 73 57 30,844,849 73 57 30,3221,235 73 57 30,34,055 73 52 28,924,565 68 52 28,339,775 68 52 30,977,479 68 52 30,977,479 68 52 30,977,479 68	21,156,330 23,125,440 12,258,094 13,589,102 13,78,752 13,278,752 13,278,752 11,494,951 11,494,951 11,494,951 12,452,067 11,454,067 11,2558,095 11,454,067 11,454,067 11,454,067 11,454,067 11,454,067 12,454,067 11,2558,095 11,2558,095 11,2558,095 11,2558,095 11,2558,095 11,2558,095 11,2558,095 11,2558,095 11,2558,095 11,2558,095 11,2558,095 11,2558,095 11,2558,095 11,2558,095 11,2558,095 11,2558,095 11,2558,055 11,2558,055 11,2558,055 11,2558,055 11,2558,055 12,2558,055 11,2558,055 12,2558,055 12,2558,055 11,2558,055 12,2558,0558,0558,0558,0558,0558,0558,055	9,513,030 9,295,770 43,102,943 44,3102,943 46,312,807 40,419,516 40,419,516 41,082,871 43,429,546 30,174,150 30,669,360 33,669,360 32,421,210
	%	<i>Total l</i> 57 57 57 52 52 52 36 36	36222222222222222222222222222222222222	36 37 57 57 52 36 36 36 36 36 36
	20% kg		14,933,880 16,323,840 9,613,397 10,657,239 10,413,847 8,745,213 9,694,785 9,473,374 9,473,374 9,473,374	6,715,080 6,561,720 33,3803,438 33,3203,438 33,320,770 33,750,554 33,750,554 33,740,646 33,040,646 33,040,646 21,259,400 21,648,960 21,648,960 221,888,560
	%	$\begin{array}{c} 33\\ 33\\ 33\\ 33\\ 33\\ 33\\ 33\\ 33\\ 33\\ 33$	$\begin{array}{c} 19\\ 20\\ 30\\ 30\\ 32\\ 32\\ 32\\ 32\\ 32\\ 32\\ 32\\ 32\\ 32\\ 32$	$\begin{array}{c} 19 \\ 19 \\ 33 \\ 30 \\ 30 \\ 30 \\ 30 \\ 30 \\ 30 \\ 3$
	10% kg	14,360,127 14,069,798 15,379,334 12,578,155 12,578,155 12,323,853 13,470,886 8,044,410	7,881,770 8,615,360 5,706,878 6,326,542 6,182,055 4,998,702 5,541,471 5,414,914 5,414,914	3,544,070 3,463,130 20,067,005 20,396,340 21,561,389 17,576,857 17,576,857 17,576,857 17,576,857 17,576,857 18,885,800 11,241,350 11,241,350 11,242,840 12,078,490
	Production In Kg	42,339,000 41,483,000 45,344,000 42,339,000 41,483,000 41,483,000 45,344,000 45,344,000	41,483,000 45,344,000 16,826,000 18,653,000 18,653,000 16,826,000 18,653,000 18,653,000 18,653,000 18,827,000 18,277,000	18,653,000 59,165,000 60,136,000 63,571,000 59,165,000 60,136,000 60,136,000 63,571,000 63,571,000 63,571,000 63,571,000 63,571,000 63,571,000 63,571,000
	Year	2010-2011 2011-2012 2012-2013 2010-2013 2011-2013 2011-2012 2012-2013 2010-2011	2011-2012 2012-2013 2010-2011 2011-2012 2011-2012 2011-2013 2011-2013 2012-2013 2012-2013	2011-2012 2012-2013 2010-2011 2012-2013 2010-2011 2010-2011 2010-2011 2012-2013 2010-2011 2011-2012 2011-2013
	Supply	Type-1 Type-2 Type-3	Type-1 Type-2 Type-3	Type-1 Type-2 Type-3
Table III. Total loss of each supply stage	Produces	Potato	Tomato	Potato and Tomato

$ \begin{array}{llllllllllllllllllllllllllllllllllll$	$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	Produces	Supply Method	Year	Production In Kg	Res Rate ml	Respiration te Closed ml CO ₂ /hr.	10% kg	%	20% kg	%	Loss percentage 30% kg %	ntage %	40% kg	%	50% kg	7 %	Average %
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	$ \begin{array}{c} 2010\ 2011\ 4.2339,000\ 2 & 98.649.870\ 33.459,067\ 13 & 55.327.95\ 22 & 71.88.499\ 28 & 82.229,061\ 32 & 80.065.73\ 33 & 72.362.665\ 55 \\ 2010\ 2011\ 2013\ 45.344,000\ 2 & 96.655.300\ 32.782,659\ 13 & 55.232,655\ 27 & 6969.348\ 28 & 95.566.57\ 33 & 87.255.566\ 55 \\ 15.2010\ 2011\ 42.339,000\ 2 & 96.655.300\ 23.782,165\ 11 & 51.275.67\ 23 & 75.366.84\ 31 & 85.177.562\ 24 \\ 15.275.260\ 25 & 45.347,100\ 11 & 51.275.67\ 26 & 84.534,77\ 31\ 35.115.951\ 144\ 20\ 2015\ 4012\ 402\ 2015\ 402\ 2012\ 2011\ 4021\ 402\ 402\ 402\ 29 \\ 10.5661.520\ 31.387,106\ 11 & 535.513.953\ 11\ 50.2177.562\ 26 & 84.534,77\ 31\ 30.106\ 402\ 31.379,17\ 412\ 20\ 64.534,730\ 31\ 95.177.562\ 28 & 84.54,730\ 31\ 95.177.562\ 28 & 84.54,730\ 31\ 95.177.562\ 28 & 84.54,730\ 31\ 95.166,61.520\ 31.387,174\ 42\ 20\ 65.01.590\ 25\ 73.987\ 4102\ 29 \\ 2010\ 2011\ 2011\ 4122\ 30\ 31.51,079\ 10\ 55.84.539\ 11\ 402\ 24.82.216.51\ 22\ 23.956\ 4103\ 29 \\ 2010\ 2011\ 16\ 85.500\ 5 \ 97.44,120\ 31.51,079\ 10\ 55.84.539\ 11\ 402\ 24.82.216.51\ 22\ 23.956\ 410\ 20\ 25\ 24.91.54\ 25\ 20.5664.450\ 25\ 26.1664.55\ 25\ 20.5664.50\ 25\ 26.1664.50\ $	$\begin{array}{llllllllllllllllllllllllllllllllllll$	$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	2010-2011 42:33:000 2 98:669:870 33:45:007 13 65:32:355 27 71:86:499 28 80:05:33 27 59:0061 28 80:05:33 27 27:30:32:355 35:35:33 27:30:35:37 25 73:39:16:33 23:35:16:33 27:30:16:33 27									Ø	0, bv	i loss ml CO		closed)				
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	00112012 41,483,00 6665,30 32,723,629 15 52,232,55 27,41,479 28 80,565,73 28 72,756,263 55,356,565 55 55,356,565 55 55,356,565 55 55,356,565 55 55,356,565 55 55,356,565 55 55,356,565 55 55,356,565 55 55,356,565 55 55,356,565 55 55,356,565 55 55,356,565 55 55,356,565 55 55,356,565 55 55,356,565 55 55,356,565 55 55,356,561 53,316,557 56 57,356,545 55 73,957,412 55 74,122 55,313,557 16 64,322,412 57 73,451,667 55 73,451,667 56 77,41,220 56 73,451,667 56 77,41,202 56 77,41,202 56 73,451,667 56 73,451,667 56 77,34,501 56 75,342,150 56 76,364,771 56 57,341,612 56 77,342,502 56 77,342,502 56 77,41,502	00112012 41,483,000 6665.300 32,723,629 15 52,3256 25 7,41,57 11 5,344,000 5,344,000 16,344,100 86,649,870 26,935,130 25 55,356,653 35 55,356,653 35 55,356,653 35 55,344,000 16,552,300 35,344,000 16,561,320 35,344,000 16,561,320 35,344,000 36,665,330 38,71,557 11 51,275,265 84,517,573 31 85,94,602 56,663,330 38,17,557 35,115,473 31 85,177,562 38,115,473 31 85,177,562 38,115,473 31 85,177,562 38,115,473 31 85,177,523 38,115,473 35,34,103 96,665,330 38,117,413 90,911,414 90,311,414 90,311,414 90,311,414 90,311,412 96,911,416 38,176,112 96,7356 96,915,610 96,665,330 38,117,412 96,911,416 96,911,410 96,911,410 96,911,410 96,911,410 96,911,410 96,911,410 96,911,410 96,911,410 96,911,410 96,911,410 96,911,410 96,911,410	Potato	Type-1		42,339,000	2	98,649,870	33,459,097	13	56,362,795	52	71,868,499	8	82,229,061	32	89,036,325	35	26
$ \begin{array}{llllllllllllllllllllllllllllllllllll$	$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	$\begin{array}{llllllllllllllllllllllllllllllllllll$	$\begin{array}{llllllllllllllllllllllllllllllllllll$	20122013 45,34,000 106,661,550 58,888 13 0,036,130 2 56,96,52,88 26,355,566 55 20112012 14,3520 2 56,66,570 23,771,571 15,127,575 5 78,956,433 35,857,403 34,514,77 7 35,34,000 2 96,665,500 33,871,557 11 5,117,420 5 38,4153 15 31,755,26 36 81,534,53 3 89,555,123 35,341,000 38,4154 7 37,359,14 36,553,123 36,513,453 16,615,32 32,950,101 31,755,165 16,834,50 5 74,911,52 37,341,60 14,92,944,90 35,345,01 46,32,34,12 26,323,60 29,306,60 25 74,911,65 20,315,01 45,324,12 26,333,51 26,323,51 20,323,51 26,323,52 26,324,60 29 26,324,32 26,325,31 26,323,51 26,323,51 26,323,51 26,323,51 26,323,51 26,323,51 26,323,51 26,323,51 26,323,51 26,323,51 26,323,51 26,323,51 26,323,51 26,323,5		•		41,483,000		96,655,390	32,782,629	13	55,223,265	22	70,415,479		80,566,573	32	87,236,209	В	26
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	2010-2011 42.339,000 2 98,69,870 29,377,101 11 51,277,575 26 73,396,693 20 63,31,534 20 73,396,693 26,553,500 27,177,555 56 77,396,693 26,553,500 27,177,555 56 73,396,693 20 65,317,517 21 30,326,693 36,311,744 20 72,177,555 56 73,396,693 26 66,353,300 25,306,932 66,315,300 27,417,553 56 73,396,403 29 30,11,744 20 72,177,555 56 73,396,403 29 30,10,2011 42,339,400 5 86,493,773 15,491,744 20 72,177,555 56 73,987,403 20 71,120 23,966,655 20 66,575,301 35,74,301 16 42,324,112 17,306,89 27,41,223 27,491,566 27,491,566 27,491,566 27,491,566 27,491,566 27,491,566 27,491,566 27,491,566 27,491,566 27,491,566 26,564,596 16,667,738 26,567,516 66,773,820 26,564,403 26,564,103 26,774,2			2012-2013	45,344,000		105,651,520	35,833,848	13	60,363,130	22	76,969,348		88,065,248	32	95,355,656	35	26
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	$\begin{array}{llllllllllllllllllllllllllllllllllll$	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	2011-2012 41,453,000 96,655,300 28,714,577 11 60,256,65 20 65,07,356,684 31 85,177,562 34 2012-2013 45,344,000 96,655,300 33,347,457 11 50,216,473 35 33,055 56 84,534,773 31 35,166,403 29 36,166,675 35 33,056 41,432 50 34,166 20 20,153 35 34,002 36,665,300 18,564,504 7 36,04,471 14 49,294,219 20 61,1547 25 73,561,597 26 73,561,597 26 73,561,597 26 73,561,592 36,566,402 26,665,300 36,560,400 16,661,530 30,075,716 16 73,241,203 16 71,268,311,203 16 71,268,311,203 16 71,268,321,312 17,41,203 18,77,016 56,773,280 56,665,300 56,666,300 58,761,412 58,716,412 58,716,412 58,716,412 58,716,412 58,716,412 58,716,412 58,716,412 58,716,412 58,716,412 58,716,412 58,		Type-2		42,339,000	2	98,649,870	29,307,101	11	51,272,678	20	67,394,237		78,932,523	31	86,935,198	34	24
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	$ \begin{array}{llllllllllllllllllllllllllllllllllll$	$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	2012/2013 45,344,00 16,651,520 31,387,165 11 54,911,744 20 72,177,526 56 84,534,73 31 30,105,402 31 31,051 25 72,911,53 32 2011/2012 11,483,000 5 86,655,50 0,377,539 7 35,151,57 7 35,151,57 25 73,551,12 73,556,11 54,91,74 26 74,417 26 74,417 26 74,417 26 74,417 26 74,417 26 74,417 26 74,417 26 74,417 26 74,417 26 74,417 26 74,417 26 74,417 26 74,417 26 74,417 26 74,417 26 74,417 26 74,417 26 74,417 76 74,358 27 74,358 27 74,358 26 74,341 26 74,417 76 74,358 76 85,764 26 74,417 76 76 76 76 76 76 76		•		41,483,000		96,655,390	28,714,577	Π	50,236,059	20	66,031,676		77,336,684	31	85,177,562	35	24
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	$ \begin{array}{c} 2010-2011 \ 4.2339,000 \ 2 \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ $	$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$			2012-2013	45,344,000		105,651,520	31,387,165	Π	54,911,744	20	72,177,526		84,534,739	31	93,105,402	34	24
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	$\begin{array}{llllllllllllllllllllllllllllllllllll$	$\begin{array}{llllllllllllllllllllllllllllllllllll$	$\begin{array}{llllllllllllllllllllllllllllllllllll$	$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$		Type-3		42,339,000	2	98,649,870	18,743,475	5	35,513,953	14	50,311,434		63,135,917	25	73,987,403	29	19
$ \begin{array}{rcrcrcccccccccccccccccccccccccccccccc$	$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	$\begin{array}{llllllllllllllllllllllllllllllllllll$	$\begin{array}{llllllllllllllllllllllllllllllllllll$	2012-2013 45,344,000 105,651,520 20,073,789 7 38,034,547 14 53,882,275 20 67,616,973 25 79,238,640 29 2010-2011 16,826,000 5 88,168,240 25,694,010 105,551,142 26 2011-2012 18,653,000 5 88,168,240 25,694,00 15,584,599 16 64,232,412 21 73,461,162 36,504,90 25 82,168,570 28 85,103,490 10 55,843,90 51 73,461,162 36,504,90 25 86,103,491 10 64,713,605 21 76,611,960 28 85,103,490 27 76,611,960 28 76,68,262 25 76,68,262 25 27,714,720 26,773,205 27 76,68,262 25 27,714,720 21,741,720 26,773,206 9 66,773,282 66,173,366 16 41,965,802 15 61,257,729 28 26 27,682,262 20 20,255,4170 18 73,306,290 27 26,254,701 18 76,306,325			2011-2012	41,483,000		96,655,390	18,364,524	2	34,795,940	14	49,294,249		61,859,450	25		ର	19
$ \begin{array}{rrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrr$	$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	$\begin{array}{llllllllllllllllllllllllllllllllllll$	$ \begin{array}{rrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrr$			2012-2013	45,344,000		105,651,520	20,073,789	2	38,034,547	14	53,882,275			25	-	29	19
$ \begin{array}{rrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrr$	$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	$\begin{array}{llllllllllllllllllllllllllllllllllll$	$ \begin{array}{rrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrr$	Fomato	Type-1		16,826,000	വ	88,168,240	29,904,040	10	50,374,201	16	64,232,412			24		26	19
$ \begin{array}{rrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrr$	$ \begin{array}{llllllllllllllllllllllllllllllllllll$	$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	$ \begin{array}{rrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrr$		1		18,653,000		97,741,720	33,151,079	10	55,843,931	16	71,206,893			24		26	19
$ \begin{array}{llllllllllllllllllllllllllllllllllll$	$ \begin{array}{llllllllllllllllllllllllllllllllllll$	$ \begin{array}{llllllllllllllllllllllllllllllllllll$	$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$			2012-2013	18,227,000		95,509,480	32,393,970	10	54,568,559	16	69,580,659			24		26	19
$ \begin{array}{rrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrr$	$ \begin{array}{rcrcrcccccccccccccccccccccccccccccccc$	$ \begin{array}{rcrcrcccccccccccccccccccccccccccccccc$	$ \begin{array}{rcrcrcccccccccccccccccccccccccccccccc$	$ \begin{array}{rrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrr$		Type-2		16,826,000	2	88,168,240	26,193,197	6	45,824,914	15	60,233,544	20		23		25	18
$ \begin{array}{rrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrr$	$ \begin{array}{rcrcrcccccccccccccccccccccccccccccccc$	$ \begin{array}{rcrcrcccccccccccccccccccccccccccccccc$	$ \begin{array}{rcrcrcccccccccccccccccccccccccccccccc$	$ \begin{array}{rrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrr$				18,653,000		97,741,720	29,037,306	6	50,800,673	15	66,773,820	20		23		32	18
$ \begin{array}{rrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrr$	$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	$ \begin{array}{llllllllllllllllllllllllllllllllllll$	$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	$ \begin{array}{rrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrr$			2012-2013	18,227,000		95,509,480	28,374,147	6	49,640,479	15	65,248,829	20		53	_	Я	18
2011-2012 18,653,000 97,741,720 18,570,927 5 35,187,019 10 49,848,277 15 62,554,701 18 73,306,290 2012-2013 18,227,000 95,509,480 18,146,801 5 34,383,413 10 48,709,835 15 61,126,067 18 71,632,110 2010-2011 59,165,000 4 244,351,450 82,876,722 11 139,608,198 19 178,015,156 25 203,677,819 28 220,539,115 2010-2011 59,165,000 4 244,351,450 82,876,732 11 139,608,198 19 178,015,156 25 203,677,819 28 286,5545 2011-2012 60,136,000 4 244,351,450 82,876,732 11 150,004,779 19 191,271,891 25 282,564,532 285,545 28 285,545 28 286,554 77 158,544 28 286,554 77 158,544 28 286,565 27 71,585,543 71,586 28 286,565 57	$ \begin{array}{rcrcrcccccccccccccccccccccccccccccccc$	$ \begin{array}{rcrcrcrcrcrcrcrcrcrcrcrcrcrcrcrcrcrcrc$	$ \begin{array}{rcrcrcrcrcrcrcrcl} 2011.2012 & 18,653,000 & 97,741,720 & 18,570,927 & 5 & 55,187,019 & 10 & 49,848,277 & 15 & 62,554,701 & 18 & 73,306,290 & 22 & 2010-2011 & 59,165,000 & 4 & 244,351,450 & 82,366,820 & 13 & 10 & 48,709,835 & 15 & 61,126,067 & 18 & 71,632,110 & 22 & 2010-2011 & 59,165,000 & 4 & 244,351,450 & 82,236,820 & 11 & 141,899,410 & 19 & 180,936,692 & 25 & 203,677,819 & 28 & 259,655,597 & 31 & 2010-2011 & 59,165,000 & 4 & 244,351,450 & 82,236,882 & 11 & 141,899,410 & 19 & 180,936,692 & 25 & 203,677,819 & 28 & 259,665,597 & 31 & 2010-2011 & 59,165,000 & 4 & 244,351,450 & 72,582,417 & 10 & 177,000,200 & 18 & 166,932,600 & 22 & 234,755 & 50 & 30 & 228,5567 & 31 & 2010-2011 & 59,165,000 & 4 & 244,351,450 & 77,998,353 & 10 & 136,457,867 & 18 & 179,364,024 & 23 & 130,721,194 & 77 & 218,887,713 & 30 & 2012-2013 & 63,571,000 & 262,548,230 & 77,998,353 & 10 & 136,457,867 & 18 & 179,364,024 & 23 & 100,721,190 & 27 & 231,370,628 & 30 & 2012-2013 & 63,571,000 & 262,548,230 & 77,998,353 & 10 & 136,457,867 & 18 & 179,364,024 & 23 & 100,772,190 & 27 & 231,370,628 & 30 & 2012-2013 & 63,571,000 & 262,548,230 & 77,998,353 & 10 & 136,457,867 & 18 & 179,364,024 & 23 & 100,772,190 & 27 & 231,370,628 & 30 & 2012-2013 & 63,571,000 & 262,548,230 & 77,998,353 & 10 & 136,457,867 & 18 & 179,364,024 & 23 & 100,772,190 & 27 & 231,370,628 & 30 & 2012-2013 & 63,571,000 & 262,548,230 & 49,426,776 & 6 & 87,966,522 & 12 & 124,619,240 & 17 & 156,384,928 & 27 & 183,236,558 & 25 & 2010-2011 & 50,136,000 & 222,548,230 & 49,884,164 & 6 & 94,517,363 & 12 & 123,899,597 & 17 & 168,030,867 & 22 & 196,911,173 & 25 & 2012-2013 & 63,571,000 & 22,548,230 & 49,884,164 & 6 & 94,517,363 & 12 & 133,899,597 & 17 & 168,030,867 & 22 & 196,911,173 & 25 & 2012-2013 & 63,571,000 & 22,548,230 & 49,884,164 & 6 & 94,517,363 & 12 & 133,899,597 & 17 & 168,030,867 & 22 & 196,911,173 & 25 & 2012-2013 & 63,571,000 & 22,548,230 & 49,884,164 & 6 & 94,517,363 & 12 & 133,899,597 & 17 & 168,030,867 & 22 & 196,911,177 & 25 & 2012,2013 & 63,571,000 & 22,548,230 & 49,884,$	2011-2012 18,653,000 97,741,720 18,570,927 5 35,187,019 10 49,848,277 15 62,554,701 18 73,306,290 22 2012-2013 18,227,000 55,509,480 18,146,801 5 34,383,413 10 48,709,835 15 61,126,067 18 71,632,110 22 2010-2011 59,165,000 4 224,351,450 82,236,829 11 141,899,410 19 19,271,891 25 203,677,819 28 229,5597 31 2012-2013 63,577,000 4 224,351,450 82,236,882 11 141,899,410 19 19,1271,891 25 128,845,646 28 236,5597 31 2012-2013 63,577,000 4 224,351,450 72,529,417 10 127,000,200 18 166,932,603 23 195,512,437 27 213,334,715 30 2012-2013 63,577,000 282,548,230 77,998,353 10 127,000,200 18 166,932,603 23 155,12,437 27 213,347 15 30 2012-2013 63,577,000 282,548,230 77,998,353 10 127,000,200 18 166,932,603 22 13,34715 30 22012-2013 63,571,000 262,548,230 77,998,353 10 136,457,867 18 179,364,024 23 210,072,190 27 231,370,628 30 2012-2013 63,571,000 262,548,230 77,998,353 10 136,457,867 18 179,364,024 23 210,072,190 27 231,370,628 30 2012-2013 63,571,000 262,548,230 77,998,353 10 136,457,867 18 179,364,024 23 210,072,190 27 231,370,628 30 2012-2013 63,571,000 262,548,230 77,998,353 10 136,457,867 18 179,364,024 23 210,072,190 27 231,370,628 30 2012-2013 63,571,000 262,548,230 77,998,353 10 136,457,867 11 156,384,928 22 183,266,355 23 103,570 25 2011-2012 60,136,000 222,548,230 49,884,164 6 94,517,363 12 133,899,597 17 168,030,867 22 196,911,173 25 2011-2012 60,136,000 222,548,230 49,884,164 6 94,517,363 12 133,899,597 17 168,030,867 22 196,911,173 25 2011-2012 60,136,000 222,548,230 49,884,164 6 94,517,363 12 133,899,597 17 168,030,867 22 196,911,177 25 2011-2012 2012-2013 63,577,100 222,548,230 49,884,164 6 94,517,363 12 133,899,597 17 168,030,867 22 196,911,177 25 2011-2012 2012-2013 63,577,100 222,548,230 49,884,164 6 94,517,363 12 133,899,597 17 168,030,867 22 196,911,177 25 2012-2013 63,577,120 25 2012-2013 63,577,120 25 2013,712,60 25 2012-2013 63,577,100 222,548,230 49,884,164 6 94,517,363 12 133,899,597 17 168,030,867 22 196,911,177 25 2012-2013 63,577,100 222,548,230 49,884,164 6 94,517,363 12 133,899,597 17 168,030,86		Type-3		16,826,000	ß	88,168,240	16,751,966	വ	31,740,566	10	44,965,802		56,427,674	18		22	14
2012-2013 18,227,000 95,509,480 18,146,801 5 34,383,413 10 48,709,835 15 61,126,067 18 71,632,110 2010-2011 59,165,000 4 244,351,450 82,876,722 11 139,608,198 19 178,015,156 25 203,677,819 28 220,539,115 2010-2011 59,165,000 4 244,351,450 82,876,722 11 139,608,198 19 178,015,156 25 203,677,819 28 220,539,115 2011-2012 60,136,000 4 244,351,450 82,876,732 11 150,004,779 19 191,271,891 25 205,6545,53 205,5545 23 256,655,547 215,334,715 215,334,715 215,334,715 216,336,562 27 215,334,715 216,336,562 27 215,334,715 27 215,334,715 215,334,715 216,336,553 201,36,002 248,366,5547 27 218,3662,557 27 218,3564,554 28 256,665,5547 216,334,715 212,334,715 213,336,652 201,36,602 </td <td>2012-2013 18,227,000 95,509,480 18,146,801 5 34,383,413 10 48,709,835 15 61,126,067 18 71,632,110 22 2010-2011 59,165,000 4 244,351,450 82,876,732 11 139,608,198 19 178,015,156 25 203,677,819 28 220,539,115 31 2010-2011 59,165,000 4 244,351,450 82,876,732 11 139,608,198 19 178,015,156 25 203,677,819 28 220,539,115 31 2011-2012 60,136,000 285,544,351 11 150,004,779 19 191,271,891 28 28,543 31 2010-2011 59,165,000 4 244,351,450 72,582,411 10 127,000,200 18 166,672,255 23 198,771,134 27 213,34,715 30 2011-2012 60,136,000 4 244,557,766 18 179,364,024 28 236,533,4715 30 2011-2012 60,136,000 4 244,357,766 17 156,64,222 213,70,628 30 201,02,014 24,557,146</td> <td>2012-2013 18,227,000 95,509,480 18,146,801 5 34,383,413 10 48,709,835 15 61,126,067 18 71,632,110 22 2010-2011 59,165,000 4 244,351,450 82,865,732 11 139,608,198 19 178,015,156 25 203,677,819 28 28 31 2011-2012 60,136,000 284,351,450 82,866,732 11 150,004,779 19 191,271,891 25 207,020524 28 236,592,597 31 2011-2012 60,136,000 285,548,230 80,048,537 10 127,000200 18 166,932,603 23 195,512,437 77 215,334,715 30 2011-2012 60,136,000 285,548,230 77,598,433 18 179,304,433 18 179,364,124 213,334,715 30 2011-2013 63,577,000 282,548,230 77,588,433 13 295,512,437 27 215,334,715 30 2011-2013 63,577,000 28,366,680 77,589,4433 18 169,672,255 23 130,772,199 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265,577 00 265,577 00 260,577 12 12,328,00 567 17 156,964,457 17 156,964,457 12 156,951,475 22 186,271,260 20,1177 068 10,1178 000 857 100 850 166 877 16,000 11,177 068 10,1177 008 10,1177 008 10,1177 008 10,1177 008 10,1177 008 10,1177 008 10,1177 008 10,1177 008 10,1177 008 10,1177 008 10,1177 008 10,1177 008 10,1177 008 10,	2011-2012 60,136,000 248,361,680 84,236,882 11 141,899,410 19 180,936,692 25 207,020,524 28 224,158,543 31 2012-2013 63,571,000 282,548,230 89,048,537 11 150,004,779 19 191,271,891 25 218,845,646 28 236,902,597 31 2012-2011 59,165,000 4 244,351,450 72,582,417 10 127,000,200 18 166,922,603 23 195,512,437 72 215,334,715 30 2011-2012 60,136,000 248,361,680 77,988,353 10 129,084,493 18 166,957,2255 23 196,721,134 27 213,376,528 30 2011-2012 60,136,000 285,548,230 77,988,553 10 136,66522 12 124,619,240 17 156,344,93 30 2010-2013 63,577,000 282,548,230 77,988,571 6 87,966,552 12 124,619,240 17 156,344,932 210,072,190 27 231,370,528 25 201,075,130 283,556,823 25 201,020,313 63,571,303 <td>2011-2012 60,136,000 248,361,680 84,236,882 11 141,899,410 19 180,936,692 25 207,020,524 28 224,158,543 31 2012-2013 63,571,000 222,548,230 89,048,537 11 150,004,779 19 191,271,891 25 218,845,646 28 236,992,597 31 2012-2011 59,165,000 4 244,351,450 72,582,417 10 127,000,200 18 166,932,603 23 195,512,437 27 215,334,715 30 2011-2012 60,136,000 248,361,680 73,783,785 10 129,084,493 18 166,9572,255 23 199,721,134 27 213,36,628 30 2011-2012 60,136,000 248,361,680 73,983,531 10 36,566,5527 12 124,619,240 17 156,364,457 17 156,364,356 30 2011-2012 60,136,000 244,357,867 18 179,364,457 17 156,324,328 23,326,528 30 2010-2011 59,165,000 4 244,357,867 18 179,364,457 17 156,</td> <td>$\begin{array}{rcrcrcrc} 2011-2012 & 60,136,000 & 248,361,680 & 84,236,882 & 11 & 141,899,410 & 19 & 180,936,692 & 25 & 207,020,524 & 28 & 236,962,597 & 31 \\ 2012-2013 & 63,571,000 & 262,548,230 & 89,048,537 & 11 & 150,004,779 & 19 & 191,271,891 & 25 & 218,845,646 & 28 & 236,962,597 & 31 \\ 2010-2011 & 59,165,000 & 4 & 244,351,450 & 73,585 & 10 & 127,000,200 & 18 & 166,932,603 & 23 & 195,512,437 & 7 & 215,334,715 & 30 \\ 2011-2012 & 60,136,000 & 228,546,80 & 73,785,785 & 10 & 129,084,493 & 18 & 169,672,255 & 23 & 198,721,134 & 27 & 218,888,731 & 30 \\ 2011-2012 & 60,136,000 & 222,548,230 & 77,998,353 & 10 & 136,6524 & 28 & 210,072,190 & 27 & 231,370,628 & 30 \\ 2010-2011 & 59,165,000 & 4 & 244,351,450 & 46,426,776 & 6 & 87,966,522 & 12 & 124,619,240 & 17 & 156,384,928 & 25 \\ 2010-2011 & 59,165,000 & 4 & 244,351,450 & 46,426,776 & 6 & 87,966,522 & 12 & 1226,664,457 & 17 & 158,951,475 & 22 & 183,270,628 & 30 \\ 2010-2011 & 59,165,000 & 4 & 244,351,450 & 46,426,776 & 6 & 87,966,522 & 12 & 1226,664,457 & 17 & 158,951,475 & 22 & 183,270,628 & 30 \\ 2010-2011 & 59,165,000 & 4 & 244,351,719 & 6 & 89,410,205 & 12 & 123,899,597 & 17 & 168,030,867 & 22 & 196,911,173 & 25 \\ 2011-2012 & 60,136,000 & 262,548,230 & 49,884,164 & 6 & 94,517,363 & 12 & 133,899,597 & 17 & 168,030,867 & 22 & 196,911,173 & 25 \\ 2012-2013 & 63,571,000 & 262,548,230 & 49,884,164 & 6 & 94,517,363 & 12 & 133,899,597 & 17 & 168,030,867 & 22 & 196,911,173 & 25 \\ 2012-2013 & 63,571,000 & 262,548,230 & 49,884,164 & 6 & 94,517,363 & 12 & 133,899,597 & 17 & 168,030,867 & 22 & 196,911,173 & 25 \\ 2012-2013 & 63,571,000 & 262,548,230 & 49,884,164 & 6 & 94,517,363 & 12 & 133,899,597 & 17 & 168,030,867 & 22 & 196,911,173 & 25 \\ 2012-2013 & 63,577,000 & 262,548,230 & 49,884,164 & 6 & 94,517,363 & 12 & 133,899,597 & 17 & 168,030,867 & 22 & 196,911,173 & 25 \\ 2012-2013 & 63,577,000 & 262,548,230 & 49,884,164 & 6 & 94,517,363 & 12 & 133,899,597 & 17 & 168,030,867 & 22 & 196,911,173 & 25 \\ 2012-2013 & 63,577,000 & 262,548,230 & 49,884,164 & 6 & 94,517,363 & 12 & 133,899,597 & 17 & 1$</td> <td>2011-2012 60,136,000 248,361,680 84,236,882 11 141,899,410 19 180,936,692 25 207,020,524 28 224,158,543 31 2012-2013 63,571,000 262,548,230 89,048,537 11 150,004,779 19 191,271,891 25 218,845,646 28 236,962,597 31 2010-2011 59,165,000 4 244,351,450 72,552,417 10 127,000,200 18 166,932,603 23 195,512,437 27 215,334,715 30 2011-2012 60,136,000 228,566,680 73,785 10 129,0084,493 18 169,672,255 23 198,721,134 27 218,888,731 30 2011-2012 60,136,000 222,548,230 77,998,353 10 136,407 18 179,364,024 17 156,384,928 25 2010-2011 59,165,000 4 244,357,166 6 87,966,522 12 124,619,240 17 156,384,928 25 2011-2012 60,136,000 222,548,230 49,884,164 6 94,517,363 12 133,899,597 17 168,030,867 22 196,911,173 25 2011-2012 60,136,000 262,548,230 49,884,164 6 94,517,363 12 133,899,597 17 168,030,867 22 196,911,173 25 2011-2012 60,136,000 262,548,230 49,884,164 6 94,517,363 12 133,899,597 17 168,030,867 22 196,911,173 25 2011-2012 60,136,000 262,548,230 49,884,164 6 94,517,363 12 133,899,597 17 168,030,867 22 196,911,173 25 2011-2012 60,136,000 262,548,230 49,884,164 6 94,517,363 12 133,899,597 17 168,030,867 22 196,911,173 25 2011-2012 60,136,000 262,548,230 49,884,164 6 94,517,363 12 133,899,597 17 168,030,867 22 196,911,173 25 2011-2012 60,136,000 262,548,230 49,884,164 6 94,517,363 12 133,899,597 17 168,030,867 22 196,911,173 25 2011-2012 60,136,000 262,548,230 49,884,164 6 94,517,363 12 133,899,597 17 168,030,867 22 196,911,173 25 20112-2013 63,577,000 262,548,230 49,884,164 6 94,517,363 12 133,899,597 17 168,030,867 22 196,911,173 25 20112-2013 63,577,000 262,548,230 49,884,164 6 94,517,363 12 133,899,597 17 168,030,867 22 196,911,173 25 20112-2013 63,577,000 262,548,230 49,884,164 6 94,517,363 12 133,899,597 17 168,030,867 22 196,911,173 25 20112-2013 63,577,000 262,548,230 49,884,164 6 94,517,363 12 133,899,597 17 168,030,867 22 196,911,173 25 2012-2013 600,577,000 262,548,230 49,884,164 6 94,517,363 12 133,899,597 17 168,030,867 22 196,911,173 25 20,567,577,500 25 20,575,577,500 25 20,575,577,500 25 20,575,575,575 20 25 20,57</td> <td>otato and Tomato</td> <td>Type-1</td> <td>2010-2011</td> <td>59,165,000</td> <td>4</td> <td>244,351,450</td> <td>82,876,732</td> <td>₽</td> <td>139,608,198</td> <td>19</td> <td>178,015,156</td> <td>32</td> <td></td> <td>- 1</td> <td></td> <td>31</td> <td>23</td>	2011-2012 60,136,000 248,361,680 84,236,882 11 141,899,410 19 180,936,692 25 207,020,524 28 224,158,543 31 2012-2013 63,571,000 222,548,230 89,048,537 11 150,004,779 19 191,271,891 25 218,845,646 28 236,992,597 31 2012-2011 59,165,000 4 244,351,450 72,582,417 10 127,000,200 18 166,932,603 23 195,512,437 27 215,334,715 30 2011-2012 60,136,000 248,361,680 73,783,785 10 129,084,493 18 166,9572,255 23 199,721,134 27 213,36,628 30 2011-2012 60,136,000 248,361,680 73,983,531 10 36,566,5527 12 124,619,240 17 156,364,457 17 156,364,356 30 2011-2012 60,136,000 244,357,867 18 179,364,457 17 156,324,328 23,326,528 30 2010-2011 59,165,000 4 244,357,867 18 179,364,457 17 156,	$ \begin{array}{rcrcrcrc} 2011-2012 & 60,136,000 & 248,361,680 & 84,236,882 & 11 & 141,899,410 & 19 & 180,936,692 & 25 & 207,020,524 & 28 & 236,962,597 & 31 \\ 2012-2013 & 63,571,000 & 262,548,230 & 89,048,537 & 11 & 150,004,779 & 19 & 191,271,891 & 25 & 218,845,646 & 28 & 236,962,597 & 31 \\ 2010-2011 & 59,165,000 & 4 & 244,351,450 & 73,585 & 10 & 127,000,200 & 18 & 166,932,603 & 23 & 195,512,437 & 7 & 215,334,715 & 30 \\ 2011-2012 & 60,136,000 & 228,546,80 & 73,785,785 & 10 & 129,084,493 & 18 & 169,672,255 & 23 & 198,721,134 & 27 & 218,888,731 & 30 \\ 2011-2012 & 60,136,000 & 222,548,230 & 77,998,353 & 10 & 136,6524 & 28 & 210,072,190 & 27 & 231,370,628 & 30 \\ 2010-2011 & 59,165,000 & 4 & 244,351,450 & 46,426,776 & 6 & 87,966,522 & 12 & 124,619,240 & 17 & 156,384,928 & 25 \\ 2010-2011 & 59,165,000 & 4 & 244,351,450 & 46,426,776 & 6 & 87,966,522 & 12 & 1226,664,457 & 17 & 158,951,475 & 22 & 183,270,628 & 30 \\ 2010-2011 & 59,165,000 & 4 & 244,351,450 & 46,426,776 & 6 & 87,966,522 & 12 & 1226,664,457 & 17 & 158,951,475 & 22 & 183,270,628 & 30 \\ 2010-2011 & 59,165,000 & 4 & 244,351,719 & 6 & 89,410,205 & 12 & 123,899,597 & 17 & 168,030,867 & 22 & 196,911,173 & 25 \\ 2011-2012 & 60,136,000 & 262,548,230 & 49,884,164 & 6 & 94,517,363 & 12 & 133,899,597 & 17 & 168,030,867 & 22 & 196,911,173 & 25 \\ 2012-2013 & 63,571,000 & 262,548,230 & 49,884,164 & 6 & 94,517,363 & 12 & 133,899,597 & 17 & 168,030,867 & 22 & 196,911,173 & 25 \\ 2012-2013 & 63,571,000 & 262,548,230 & 49,884,164 & 6 & 94,517,363 & 12 & 133,899,597 & 17 & 168,030,867 & 22 & 196,911,173 & 25 \\ 2012-2013 & 63,571,000 & 262,548,230 & 49,884,164 & 6 & 94,517,363 & 12 & 133,899,597 & 17 & 168,030,867 & 22 & 196,911,173 & 25 \\ 2012-2013 & 63,577,000 & 262,548,230 & 49,884,164 & 6 & 94,517,363 & 12 & 133,899,597 & 17 & 168,030,867 & 22 & 196,911,173 & 25 \\ 2012-2013 & 63,577,000 & 262,548,230 & 49,884,164 & 6 & 94,517,363 & 12 & 133,899,597 & 17 & 168,030,867 & 22 & 196,911,173 & 25 \\ 2012-2013 & 63,577,000 & 262,548,230 & 49,884,164 & 6 & 94,517,363 & 12 & 133,899,597 & 17 & 1$	2011-2012 60,136,000 248,361,680 84,236,882 11 141,899,410 19 180,936,692 25 207,020,524 28 224,158,543 31 2012-2013 63,571,000 262,548,230 89,048,537 11 150,004,779 19 191,271,891 25 218,845,646 28 236,962,597 31 2010-2011 59,165,000 4 244,351,450 72,552,417 10 127,000,200 18 166,932,603 23 195,512,437 27 215,334,715 30 2011-2012 60,136,000 228,566,680 73,785 10 129,0084,493 18 169,672,255 23 198,721,134 27 218,888,731 30 2011-2012 60,136,000 222,548,230 77,998,353 10 136,407 18 179,364,024 17 156,384,928 25 2010-2011 59,165,000 4 244,357,166 6 87,966,522 12 124,619,240 17 156,384,928 25 2011-2012 60,136,000 222,548,230 49,884,164 6 94,517,363 12 133,899,597 17 168,030,867 22 196,911,173 25 2011-2012 60,136,000 262,548,230 49,884,164 6 94,517,363 12 133,899,597 17 168,030,867 22 196,911,173 25 2011-2012 60,136,000 262,548,230 49,884,164 6 94,517,363 12 133,899,597 17 168,030,867 22 196,911,173 25 2011-2012 60,136,000 262,548,230 49,884,164 6 94,517,363 12 133,899,597 17 168,030,867 22 196,911,173 25 2011-2012 60,136,000 262,548,230 49,884,164 6 94,517,363 12 133,899,597 17 168,030,867 22 196,911,173 25 2011-2012 60,136,000 262,548,230 49,884,164 6 94,517,363 12 133,899,597 17 168,030,867 22 196,911,173 25 2011-2012 60,136,000 262,548,230 49,884,164 6 94,517,363 12 133,899,597 17 168,030,867 22 196,911,173 25 2011-2012 60,136,000 262,548,230 49,884,164 6 94,517,363 12 133,899,597 17 168,030,867 22 196,911,173 25 20112-2013 63,577,000 262,548,230 49,884,164 6 94,517,363 12 133,899,597 17 168,030,867 22 196,911,173 25 20112-2013 63,577,000 262,548,230 49,884,164 6 94,517,363 12 133,899,597 17 168,030,867 22 196,911,173 25 20112-2013 63,577,000 262,548,230 49,884,164 6 94,517,363 12 133,899,597 17 168,030,867 22 196,911,173 25 20112-2013 63,577,000 262,548,230 49,884,164 6 94,517,363 12 133,899,597 17 168,030,867 22 196,911,173 25 2012-2013 600,577,000 262,548,230 49,884,164 6 94,517,363 12 133,899,597 17 168,030,867 22 196,911,173 25 20,567,577,500 25 20,575,577,500 25 20,575,577,500 25 20,575,575,575 20 25 20,57	otato and Tomato	Type-1	2010-2011	59,165,000	4	244,351,450	82,876,732	₽	139,608,198	19	178,015,156	32		- 1		31	23
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200 200,000 246,000 266,000		Type-2		59,165,000	4	244,351,450	72,592,417	10	127,000,200	18	166,932,603	R	~			30	22
2012-2013 63571,000 262,548,230 77,998,353 10 136,457,867 18 179,364,024 23 210,072,190 27 231,370,628 2010-2011 59,165,000 4 244,351,450 46,426,776 6 87,966,522 12 124,619,240 17 156,384,928 22 183,263,588 2011-2012 60,136,000 248,361,680 47,188,719 6 89,410,205 12 126,664,457 17 158,951,475 22 186,271,260 2012-2013 63,571 000 265,589 20 08,841 6 6 6,157 333 17 138,000 877 19 106,011 172	2012-2013 63,571,000 262,548,230 77,998,353 10 136,457,867 18 179,364,024 23 210,072,190 27 231,370,628 30 2010-2011 59,165,000 4 244,351,450 46,426,776 6 87,966,522 12 124,619,240 17 156,384,928 22 183,263,588 25 2011-2012 60,136,000 248,361,680 47,188,719 6 89,410,205 12 126,664,457 17 158,951,475 22 186,271,260 25 2011-2012 60,136,000 248,361,680 47,188,719 6 89,410,205 12 126,664,457 17 158,951,475 22 186,271,260 25 2012-2013 63,571,000 262,548,230 49,884,164 6 94,517,363 12 133,899,597 17 168,030,867 22 196,911,173 25 2012-2013 63,571,000 262,548,230 49,884,164 6 94,517,363 12 133,899,597 17 168,030,867 22 196,911,173 25 2012-2013 63,571,000 262,548,230 49,8	2012-2013 63,571,000 262,548,230 77,998,353 10 136,457,867 18 179,364,024 23 210,072,190 27 231,370,628 30 2010-2011 59,165,000 4 244,351,450 46,426,776 6 87,966,522 12 124,619,240 17 156,384,928 22 183,263,588 25 2011-2012 60,136,000 248,361,680 47,188,719 6 89,410,205 12 126,664,457 17 158,951,475 22 186,271,260 25 2012-2013 63,571,000 262,548,230 49,884,164 6 94,517,363 12 133,899,597 17 168,030,867 22 196,911,173 25 2012-2013 63,571,000 262,548,230 49,884,164 6 94,517,363 12 133,899,597 17 168,030,867 22 196,911,173 25 2012-2013 63,571,000 262,548,230 49,884,164 6 94,517,363 12 133,899,597 17 168,030,867 22 196,911,173 25 2012-2013 63,571,000 262,548,230 49,884,164 6 94,517,363 12 133,899,597 17 168,030,867 22 196,911,173 25 2012-2013 63,571,000 262,548,230 49,884,164 6 94,517,363 12 133,899,597 17 168,030,867 22 196,911,173 25 2012-2013 63,571,000 262,548,230 49,884,164 6 94,517,363 12 133,899,597 17 168,030,867 22 196,911,173 25 2012-2013 63,571,000 262,548,230 49,884,164 6 94,517,363 12 133,899,597 17 168,030,867 22 196,911,173 25 2012-2013 63,571,000 262,548,230 49,884,164 6 94,517,363 12 133,899,597 17 168,030,867 22 196,911,173 25 2012-2013 63,571,000 262,548,230 49,884,164 6 94,517,363 12 133,899,597 17 168,030,867 22 196,911,173 25 2012-2013 63,571,000 262,548,230 49,884,164 6 94,517,363 12 133,899,597 17 168,030,867 22 196,911,173 25 2012-2013 63,571,000 262,548,230 49,884,164 6 94,517,363 12 133,899,597 17 168,030,867 22 196,911,173 25 2012-2013 63,571,000 262,548,230 49,884,164 6 94,517,363 12 133,899,597 17 168,030,867 22 196,911,173 25 2012-2013 63,571,000 262,548,520 49,884,164 6 94,517,363 12 133,899,597 17 168,030,867 22 196,911,173 25 2012-2013 63,571,000 262,548,520 49,884,164 6 94,517,363 12 133,899,597 17 168,030,867 22 196,911,173 25 2012-2014 2000 262,548,520 49,884,164 6 94,517,363 12 133,899,597 17 168,030,867 22 196,911,173 25 2012-2014 2000 262,548,520 49,580,597 20 200,587 20 20,598,597 20 200,597 20 200,597 20 200,597 20 200,597 20 200,597 20 200,597 20 200,597 20 200,597 20 200,	2012-2013 63,571,000 262,548,230 77,998,353 10 136,457,867 18 179,364,024 23 210,072,190 27 231,370,628 30 Type-3 2010-2011 59,165,000 4 244,351,450 46,426,776 6 87,966,522 12 124,619,240 17 156,384,928 22 183,263,588 25 2011-2012 60,136,000 248,361,680 47,188,719 6 89,410,205 12 126,664,457 17 158,951,475 22 186,271,260 25 2012-2013 63,571,000 262,548,230 49,884,164 6 94,517,363 12 133,899,597 17 168,030,867 22 196,911,173 25	2012-2013 63,577,000 26,57,867 18 179,364,024 23 210,072,190 27 231,370,628 30 Type-3 2010-2011 59,165,000 4 244,351,450 46,426,776 6 87,966,522 12 124,619,240 17 156,384,928 22 183,263,588 25 2011-2012 60,136,000 248,361,680 47,188,719 6 89,410,205 12 126,664,457 17 156,384,928 25 2011-2012 60,136,000 248,361,680 47,188,719 6 89,410,205 12 126,664,457 17 168,030,867 22 196,911,173 25 2012-2013 63,571,000 262,548,230 49,884,164 6 94,517,363 12 133,899,597 17 168,030,867 22 196,911,173 25 2012-2013 63,577,000 282,548,230 49,884,164 6 94,517,363 12 133,899,597 17 168,031,177 25 196,911,177 25 2012-2013 63,577,000 282,548,230 49,884,164 6 94,517,363 12 133,899,597 </td <td></td> <td></td> <td></td> <td>60,136,000</td> <td></td> <td>248,361,680</td> <td>73,783,785</td> <td>10</td> <td>129,084,493</td> <td>18</td> <td>169,672,255</td> <td>33</td> <td>198,721,134</td> <td></td> <td>218,868,731</td> <td>30</td> <td>22</td>				60,136,000		248,361,680	73,783,785	10	129,084,493	18	169,672,255	33	198,721,134		218,868,731	30	22
2010-2011 59,165,000 4 244,351,450 46,426,776 6 87,966,522 12 124,619,240 17 156,384,928 22 183,263,588 2011-2012 60,136,000 248,361,680 47,188,719 6 89,410,205 12 126,664,457 17 158,951,475 22 186,271,260 2019-2013 63,571 000 969,548 20 40,884 164 6 04,517 333 19 133,806,507 17 158,030 857 29 106,011 173	2010-2011 59,165,000 4 244,351,450 46,426,776 6 87,966,522 12 124,619,240 17 156,384,928 22 183,263,588 25 2011-2012 60,136,000 248,361,680 47,188,719 6 89,410,205 12 126,664,457 17 158,951,475 22 186,271,260 25 2012-2013 63,571,000 262,548,230 49,884,164 6 94,517,363 12 133,899,597 17 168,030,867 22 196,911,173 25 2012-2013 63,571,000	2010-2011 59,165,000 4 244,351,450 46,426,776 6 87,966,522 12 124,619,240 17 156,384,928 22 183,263,588 25 2011-2012 60,136,000 248,361,680 47,188,719 6 89,410,205 12 126,664,457 17 158,951,475 22 186,271,260 25 2012-2013 63,571,000 262,548,230 49,884,164 6 94,517,363 12 133,899,597 17 168,030,867 22 196,911,173 25	Type-3 2010-2011 59,165,000 4 244,351,450 46,426,776 6 87,966,522 12 124,619,240 17 156,384,928 22 183,265,588 25 2011-2012 60,136,000 248,361,680 47,188,719 6 89,410,205 12 126,664,457 17 158,951,475 22 186,271,260 25 2012-2013 63,571,000 262,548,230 49,884,164 6 94,517,363 12 133,899,597 17 168,030,867 22 196,911,173 25 2012-2012 63,571,000 262,548,230 49,884,164 6 94,517,363 12 133,899,597 17 168,030,867 22 196,911,173 25 2012-2012 63,571,000 262,548,230 49,884,164 6 94,517,363 12 133,899,597 17 168,030,867 22 196,911,173 25 2012-2012 63,571,000 262,548,230 49,884,164 6 94,517,363 12 133,899,597 17 168,030,867 22 196,911,173 25 2012-2012 63,571,000 262,548,230 49,884,164 6 94,517,363 12 133,899,597 17 168,030,867 22 196,911,173 25 2012-2012 63,571,000 262,548,230 49,884,164 6 94,517,363 12 133,899,597 17 168,030,867 22 196,911,173 25 2012-2012 63,571,000 262,548,230 49,884,164 6 94,517,363 12 133,899,597 17 168,030,867 22 196,911,173 25 2012-2012 63,571,000 262,548,230 49,884,164 6 94,517,363 12 133,899,597 17 168,030,867 22 196,911,173 25 2012-2012 63,571,000 262,548,230 49,884,164 6 94,517,363 12 133,899,597 17 168,030,867 22 196,911,173 25 2012 64,571 2012 6	Type-3 2010-2011 59,165,000 4 244,351,450 46,426,776 6 87,966,522 12 124,619,240 17 156,384,928 22 183,265,588 25 2011-2012 60,136,000 248,361,680 47,188,719 6 89,410,205 12 126,664,457 17 158,951,475 22 186,271,260 25 2012-2013 63,571,000 262,548,230 49,884,164 6 94,517,363 12 133,899,597 17 168,030,867 22 196,911,173 25 2012-2013 63,571,000 262,548,230 49,884,164 6 94,517,363 12 133,899,597 17 168,030,867 22 196,911,173 25 2012-2012 2012-2013 63,571,000 262,548,230 49,884,164 6 94,517,363 12 133,899,597 17 168,030,867 22 196,911,173 25 2012-2012 2012-2013 63,571,000 262,548,230 49,884,164 6 94,517,363 12 133,899,597 17 168,030,867 22 196,911,173 25 20 200 262,548,230 49,884,164 6 94,517,363 12 133,899,597 17 168,030,867 22 196,911,173 25 2012-2012 60,150 200 262,548,230 49,884,164 6 94,517,363 12 133,899,597 17 168,030,867 22 196,911,173 25 2012-2012 60,150 200 262,548,230 49,884,164 6 94,517,363 12 133,899,597 17 168,030,867 22 196,911,173 25 2012-2012 60,150 200 262,548,230 49,884,164 6 94,517,363 12 133,899,597 17 168,030,867 22 196,911,173 25 2012-2012 60,150 200 262,548,230 49,884,164 6 94,517,363 12 133,899,597 17 168,030,867 22 196,911,173 25 2012 60,150 200 200 200 200 200 200 200 200 200 2			2012-2013	63,571,000		262,548,230	77,998,353	10	136,457,867	18	179,364,024	23	-	- 1		30	22
2011-2012 60,136,000 248,361,680 47,188,719 6 89,410,205 12 126,664,457 17 158,951,475 22 186,271,260 2019-2013 63-577 000 269,548 290 49,884 164 6 04,517 363 19 133,800,507 17 168,030,877 29 196,6011173	2011-2012 60,136,000 248,361,680 47,188,719 6 89,410,205 12 126,664,457 17 158,951,475 22 186,271,260 25 2012-2013 63,571,000 262,548,230 49,884,164 6 94,517,363 12 133,899,597 17 168,030,867 22 196,911,173 25	2011-2012 60,136,000 248,361,680 47,188,719 6 89,410,205 12 126,664,457 17 158,951,475 22 186,271,260 25 2012-2013 63,571,000 262,548,230 49,884,164 6 94,517,363 12 133,899,597 17 168,030,867 22 196,911,173 25	2011-2012 60,136,000 248,361,680 47,188,719 6 89,410,205 12 126,664,457 17 158,951,475 22 186,271,260 25 2012-2013 63,571,000 262,548,230 49,884,164 6 94,517,363 12 133,899,597 17 168,030,867 22 196,911,173 25	2011-2012 60,136,000 248,361,680 47,188,719 6 89,410,205 12 126,664,457 17 158,951,475 22 186,271,260 25 2012-2013 63,571,000 262,548,230 49,884,164 6 94,517,363 12 133,899,597 17 168,030,867 22 196,911,173 25 2012-2012-2013 63,571,000 262,548,230 49,884,164 6 94,517,363 12 133,899,597 17 168,030,867 22 196,911,173 25 2012-2012-2013 63,571,000 262,548,230 49,884,164 6 94,517,363 12 133,899,597 17 168,030,867 22 196,911,173 25 2012-2012-2013 63,571,000 262,548,230 49,884,164 6 94,517,363 12 133,899,597 17 168,030,867 22 196,911,173 25 2012-2012-2013 63,571,000 262,548,230 49,884,164 6 94,517,363 12 133,899,597 17 168,030,867 22 196,911,173 25 2012-2012-2013 63,571,000 262,548,230 49,884,164 6 94,517,363 12 133,899,597 17 168,030,867 22 196,911,173 25 2012-2012-2012-2013 63,571,000 262,548,230 49,884,164 6 94,517,363 12 133,899,597 17 168,030,867 22 196,911,173 25 2012-2012-2012-2012-2012-2012-2012-2012		Type-3		59,165,000	4	244,351,450	46,426,776	9	87,966,522	12	124,619,240	17				25	16
63 571 000 969 548 930 40 884 164 6 94 517 363 19 133 800 507 17 168 030 867 99 196 011 173	63,571,000 262,548,230 49,884,164 6 94,517,363 12 133,899,597 17 168,030,867 22 196,911,173 25	63,571,000 262,548,230 49,884,164 6 94,517,363 12 133,899,597 17 168,030,867 22 196,911,173 25	2012-2013 63,571,000 262,548,230 49,884,164 6 94,517,363 12 133,899,597 17 168,030,867 22 196,911,173 25	2012-2013 63,571,000 262,548,230 49,884,164 6 94,517,363 12 133,899,597 17 168,030,867 22 196,911,173 25				60,136,000		248,361,680	47,188,719	9	89,410,205	12	126,664,457	17		-		25	16
00,011,000 202,046,200 43,004,104 0 34,011,000 12 100,0303,031 11 100,000,021 120,311,110							2012-2013	63,571,000		262,548,230	49,884,164	9	94,517,363	12	133,899,597	17		-		25	16

Indian traditional agriculture supply chain

1835

Table IV.CO2 emission duringclosed transportation

IMDS 117,9	Average	$\begin{array}{c} 67\\ 67\\ 67\\ 66\\ 66$
	%	7 2 2 8 8 8 8 6 2 2 2 8 8 8 8 8 6 2 2 2 2
1836	50% kg	230,042,349 225,391,407 225,391,407 224,613,687 224,613,687 229,565,588 191,166,585 187,295,745 229,566,780 306,569,780 306,569,780 306,569,780 306,569,780 306,569,780 306,569,780 305,553,348 229,801,095 229,801,095 229,801,095 229,801,095 251,653,348 664,007,119 664,007,933 551,695,420 684,027,933 551,695,420 684,027,933 551,695,420 550,695,420 551,695,420 5520,595,420 5520,595,420 5520,595,420 5520,595,420 5520,595,500 5520,595,500 5520,500 5520,500 5520,500 5520,500 5520,500 5520,500 5520,500 5500,500 5000,500 5000,500 5000,500 5000,500 5000,500 5000,500 5000,500 5000,500 5000,500 5000,500 5000,500 5000,500 5000,500 5000,5000,500 5000,
	%	$\mathop{\otimes}\limits_{\otimes} \mathop{\otimes}\limits_{\otimes} \mathop{\otimes}_{\otimes} $
	40% kg	(<i>open</i>) 212,484,485 212,484,485 203,937,249 1199,814,093 203,937,249 1163,123,669 1163,123,669 1163,123,669 1163,123,669 1159,567,392 256,569,483 2245,160,387 2245,160,382 2245,160,382 226,1966,934 1196,066,934 1196,066,934 217,389,523 212,424,749 217,389,523 212,424,749 217,389,523 212,424,749 217,389,523 212,424,749 217,389,523 212,424,749 217,389,523 212,424,749 217,389,523 217,399,523 217,399,523 217,399,523 217,399,523 217,490,523 217,490,523 217,490,523 217,490,523 217,490,523 217,490,523 217,490,523 217,490,523 217,490,523 217,490,523 217,490,523 217,490,523 217,490,523 217,490,5
	age %	
	Loss percentage 30% kg %	y loss mil CO_{2}/hr 185,685,993 73 181,931,837 73 181,931,837 73 174,125,883 68 174,125,883 68 170,605,447 68 186,484,424 68 129,989,198 51 129,989,198 73 247,457,541 73 247,457,541 73 247,457,541 73 2247,457,541 73 226,752,140 68 2329,323,060 68 73 247,457,541 73 2547,457 51 169,275,972 51 169,275,972 51 169,275,972 51 169,275,972 51 169,275,972 51 169,275,972 51 169,275,972 51 169,275,972 51 173,232,276 68 501,621,856 51,621,856 53,426,372 51 374,472,886 51 374,774 51 374,77
	%	$ \begin{array}{c} CO_{2} \ by \\ CO_{2} \ by \ by \\ CO_{2} \ by \ b$
	20% kg	CX 145,624,045 155,959,675 132,472,756 132,472,756 132,472,756 132,472,756 132,472,756 132,472,756 111,874,977 1175,059,963 112,963,315 119,488,921 1175,059,976 112,739,976 112,7566
	%	$\begin{array}{c} 333 \\ 344 \\ 345 \\$
	10% kg	86,447,967 84,700,182 92,583,590 75,720,492 74,189,593 81,094,735 44,427,348 47,448,255 51,864,467 103,922,246 112,575,228 100,910,179 98,605,577 64,537,515 63,063,597 64,537,515 63,063,597 64,537,515 64,537,515 63,063,597 64,537,515 63,063,597 64,537,515 63,063,597 64,537,515 63,063,597 64,537,515 63,063,597 64,537,515 63,063,597 64,537,515 64,547,515 64,547,5
	Respiration te Open ml CO ₂ /hr.	254,880,780 249,727,660 272,970,880,780 254,880,780 272,970,880 272,970,880 249,727,660 272,970,880 3331,913,670 776,201,910
	Re Rate m	6 6 6 6 6 6 11 12 12 12 12 12
	Production] In Kg	42,339,000 41,483,000 45,344,000 42,339,000 42,339,000 41,483,000 41,483,000 16,826,000 18,853,000 18,553,0000
	Year	2010-2011 2011-2012 2012-2013 2010-2011 2011-2012 2010-2011 2011-2012 2011-2012 2011-2012 2011-2012 2011-2012 2011-2012 2011-2012 2011-2012 2011-2012 2011-2012 2012-2013 2012-2
	Supply Method	Type-1 Type-2 Type-3 Type-3 Type-3 Type-3 Type-3 Type-3
Table V.	0	Potato Type-1 Type-2 Type-3 Type-3 Potato and Tomato Type-3 Type-3 Type-3
CO ₂ emission by open transportation	Produces	Potato Tomato Potato a

Indian traditional agriculture		8 8 8 8																		41 41	Ę	Average %
supply chain	20	2 2 2	20 28 20 28	58	88	88	38	13 E	23	23 G	63	64	5 2	46	46	46	5 7 0	54	55	3 13		%
1837	385,240,260	358,539,900 364,424,160 385,240,260	452,657,305 358.539.900	428,198,388	421,284,383	438,547,465	431,466,355	181,447,058	163,674,915	213,200,292	192,318,025	213,366,325	218.353.105	125,489,520	114,804,202	117,173,182	124,894,938 147 450 186	137,678,489	151,013,892	138,155,198	100 200 11 1	50% kg
	45	$^{42}_{42}$	42 53	53	88	5	8	46	46	57	57	59	26	68 0	99 93	36	49 49	65	51	5 6	Ū	%
	328,738,355	303,934,048 310,975,283 328,738,355	410,988,692 305,954,048	388,781,299	382,503,751	405,018,362	398,478,638	154,834,822	139,669,260	193,574,495 180153 619	174,614,509	197,053,424	201,500,110	107,084,390	97,966,252	99,987,782	1.22,477,409	125,004,726	139,468,141	127,592,556	(difference)	40% kg
	34	34 85 87 83	345 34	45	42 42	8 4 x	84	98 90	36	49 10	49	52	22 22	5 G	31	31	$^{4}_{2}$	42	45	5 f		age %
	261,963,377	243,807,132 247,808,429 261,963,377	350,910,730 243,807.132	331,949,595	326,589,692	353,987,524 374 207 478	348,271,781	123,383,999	111,298,943	165,277,947	149,089,516	172,225,410	176.250.648	85,332,874	78,066,858	79,677,764	114,3/3/7/11	106,731,646	121,895,662	111.516.358		Loss percentage 30% kg %
	24	5 2 2	24	34	3 25	x x	38	26	26	27 27	37	41	41	22	22	52	38	33	35	3 8	2	%
	184,915,325	172,099,152 174,923,597 184,915,325	266,968,419 172.099.152	252,543,027	248,465,282	277,614,343 203 471 820	273,131,778	87,094,588 97 107 709	78,563,960	125,741,359 122 860,660	113,425,406	135,067,596	124,000,702	60,234,970	55,106,018	56,243,128	79,000,094 86,963,233	81,200,078	95,596,545	87,456,587	00 961 950 00	20% kg
	133	13 I3	13 20	20	38	22	52	14	14	7 7	21	54	57	5 13	12	12	<u>0</u> 2	18	21	35	5	%
	97,594,199	90,830,108 92,320,787 97,594,199	152,597,263 90.830.108	144,351,811	142,021,001	164,802,424	162,141,402	45,966,588	41,464,311	70.921.430	64,833,162	80,181,258	82.055.248	31,790,678	29,083,731	29,683,873	49,707,570	46,413,391	56,749,742	51.917.553	E9 080 970	10% kg
	63,571,000	59,165,000 60,136,000 63,571,000	63,571,000 59.165.000	60,136,000	59,165,000	60,136,000 63 571 000	59,165,000	18,653,000	16,826,000	18,653,000	16,826,000	18,227,000	10,020,000	45,344,000	41,483,000	42,339,000	41,483,000 45,344,000	42,339,000	45,344,000	42,333,000 41,483,000	000 000 01	Production In Kg
	2012-2013	2010-2011 2011-2012 2012-2013	2012-2013 2010-2011	2011-2012	2010-2011	2011-2012	2010-2011	2011-2012	2010-2011	2011-2012	2010-2011	2012-2013	2011-2012	2012-2013	2011-2012	2010-2011	2012-2013	2010-2011	2012-2013	2011-2012		Year
		1 ype-3	Tvpe-3	4	Type-2		Type-1		Type-3		Type-2		1 ype-1	L.	1	Type-3		Type-2		1 ypc-1	Ę	Supply Method
Table VI. CO ₂ emission difference between closed and open transportation							Potato and Tomato						1 UILIAU	Tomato						I UIDIU	D	Produces

Table VI depicts the differentiation of CO₂ emission of open and closed transportation compared with PHL percentage and optimized supply structure. The open transportation has high CO₂ emission than the closed transportation. It clearly clarifies that in supply structure type 3, the potato has lowest differentiation of 12, 22, 31, 39, and 46 percent with respect to all PHL percentage, because the potato has moderate respiration in closed transportation. By comparing Tables IV-VI, the lowest and highest CO₂ emissions of individual produces are identified. However, if the produces are mixed together, then the produces emit moderately. If tomato and potato are combined together and transported, then overall emission is reduced.

5. Conclusion

In this paper, Indian traditional ASCM was modeled as a planning model by considering intermediaries to reduce the PHL and CO_2 emission, through optimizing the supply structures and modified transportation method, respectively. This model is optimized through GA with constraints. Three alternative supply structures were considered, undergoing an optimization amongst three. One of the methods was found to have a reduced PHL. The overall losses are reduced through the optimized supply structures like type 1, type 2 and type 3. The PHLs are compared with each other to identify the optimized supply structure. The supply structure type-1 approximately replicates the existing SC, because type-1 supply structure transports produces from farmer to customer through intermediaries.

Succeeding, supply structure type-1 has average PHL of 67 percent for potato, tomato and their combination. Consequently, supply structure type-3 has lowest average PHL of 49 percent. Likewise, the supply structure type-1 and type-3 emits 67 and 49 percent of CO_2 , respectively, during open transportation. Therefore, type-3 supply structure is found as well-optimized supply structure for each produce and their combinations. Even though supply structures are optimized to reduce loss, CO_2 emission is high due to open transportation. Therefore, the closed transportation is identified as alternative transportation method for potato, tomato and their combination, because the CO_2 emission is highly reduced as compared to open transportation, and in this closed transportation, tomato has lowest emission of 14 percent.

The combination of potato and tomato has CO_2 emission of 16 percent, which is higher than tomato but lower than potato. However, this mixed closed transportation reduces CO_2 emission of potato. Therefore, this research paper identified that the mixed closed transportation is the best transportation method for the short-duration domestic purpose. These supply structures and the mixed closed transportation method can only be implemented when shortest distance markets are grouped together. This grouping reduces the traveling distance and time.

6. Future work

Further this model can be extended to other produces, which is most commonly available produces to estimate the CO_2 emission and losses. Because each produces has its own respiration rate, so measuring the respiration rate of other produces to estimate the emission becomes crucial.

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