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Acronyms and Abbreviations

ANOVA	Analysis of Variance between groups
ASEAN	Association of Southeast Asian Nations
AVRDC	The World Vegetable Center
CLV	Cambodia, Lao PDR and Viet Nam
DAALI	Department of Agronomy and Agricultural Land Improvement
FAO	Food and Agriculture Organization of the United Nations
GAMIC	Government agricultural marketing information center
ha	Hectare
hr	Hour
kg	Kilogram
KHR	Cambodian Riel
km	Kilometer
Lao PDR	Lao People's Democratic Republic
m^2	Square meter
MAFF	Ministry of Agriculture, Forestry and Fisheries
mo	Month
MT	Metric ton
MT/ha	Metric ton per hectare
N	Number of cases
n.a.	Not applicable
NGO	Non-government organization
p	Probability
SD	Standard deviation
TV	Television
US	United States
US$/MT	US dollar per metric ton
yr	Year

1 Vegetables in Cambodia

Supply chains can be defined as "*…a set of interdependent companies that work closely together to manage the flow of goods and services along the value-added chain of agricultural and food products, in order to realize superior customer value at the lowest possible costs* (Folkerts and Koehorst, 1998)."

In this study we assess the supply chain for selected vegetables in Cambodia, and the role different actors play in value addition across the chain, as well as bottlenecks of the chain, in particular postharvest loss. Vegetable production levels and revenues in the CLV region are severely constrained by postharvest losses. Viet Nam alone suffered a $15 million decline in export revenues of vegetables and fruits during the first quarter of 2004 compared to the same quarter in 2003, which was attributed to inadequate postharvest technologies (Socialist Republic of Vietnam, 2004). Improving the postharvest handling and storage of horticulture crops has become a priority in all three countries (Cambodia, Lao PDR and Viet Nam). A stakeholder meeting at AVRDC–The World Vegetable Center in 2001 with representatives from the ASEAN region identified postharvest technologies as one of the most needed areas for research and development especially for the hot-wet ecologies (Kuo, 2002).

During the last 15 years, vegetable production in Cambodia has increased by 50% from 320,000 metric ton (MT) in 1980 to 481,250 MT in 2005 with an annual growth rate of 2% (FAO, 2006). Similar growth has been observed in vegetable area with 77,000 hectare (ha) in 2005, up from 55,000 ha in 1980 amid sluggish growth in yield per hectare over the last decade.

The absence of basic information on vegetables, particularly on individual vegetable production, area and yield makes it difficult to assess the overall vegetable situation in Cambodia. According to Abedullah *et al*. (2002), the top eight vegetables in the five major vegetable-growing provinces are cucumber, cabbage, cauliflower, eggplant, yardlong bean, tomato, Chinese cabbage and mustard. These provinces include Kampong Cham, Kampot, Siem Reap, Kandal and Battambang.

One specific area in vegetable production that can help boost profits of farmers and supply chain actors is the reduction of postharvest spoilage. Traditionally, postharvest research had focused on improving production output through better vegetable quality, harvest and storage. Today, the postharvest sector spans the production-consumption continuum and incorporates a series of activities from the technical, economic to the institutional side. It is in this context that this research was conceptualized.

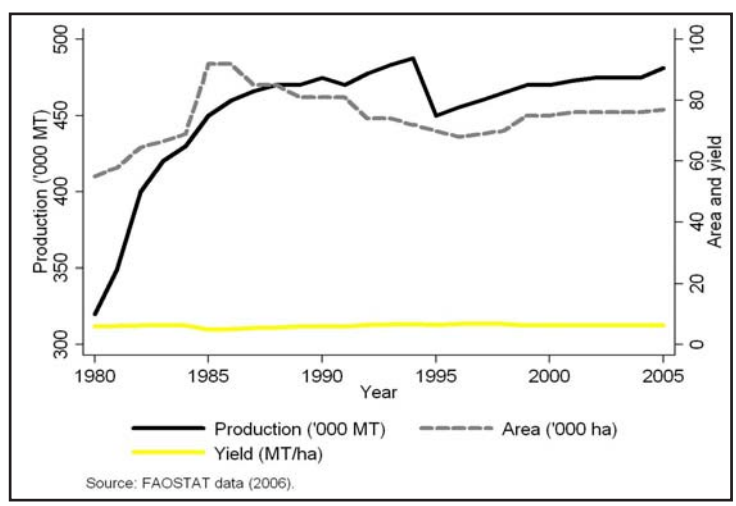

Figure 1-1 Average area, production and yield of vegetables in Cambodia, 1980-2005.

2 Sample selection, methods and respondent profiles

2.1 Sample selection

Crops were predetermined through expert discussions based on high economic value and high incidence of postharvest losses. In these discussions, getting an understanding of the existing supply chains and the different forms of the prevailing retail outlets (supermarkets, small grocery stores, wet markets, street vendors) were also attempted. In analyzing the supply chains for vegetables, an upstream interview approach (retailers to farmers) was applied. This was selected because using a downstream approach (farmers to markets) would run the risk of interviewing a large share of farmers who may not produce vegetables for commercial purposes. With the sample, the objective was to ensure equal representation of retailers, traders (collectors and wholesalers) and farmers, as well as the crops that this study is particularly interested in. Thus, after establishing the different forms of retail outlets for vegetables and their approximate share in total vegetable sales, the sample size of supermarkets, wet market vendors, small grocery stores, and street vendors were also predetermined. These initial respondents were randomly selected from a list of retailers.

After selecting the retailers, the other supply chain actors were randomly culled from the list of names provided by the retailers interviewed since the survey questionnaire requests all actors to provide names of their primary sources of the crop in question. Traders were then selected based on the list of names provided by retailers interviewed. Farmers were selected from the names provided by traders, and in some cases, retailers.

2.2 Sample size

Table 2-1 shows the total sample in the study comprising of 200 respondents. The study sought to include a similar sample size for each crop. The samples included exactly 50 respondents for each crop, and composed of retailers, wholesalers, collectors and farmers.

The selected sites for the study were the provinces of Kandal (including Phnom Penh) and Kampong Cham based on consultations with representatives from the Department of Agronomy and Agricultural Land Improvement (DAALI) under the Ministry of Agriculture, Forestry and Fisheries (MAFF). An upstream interview was applied starting with the selection of retailers from Phnom Penh, Kandal and Kampong Cham. Thirty-six (36) retailers were selected in three major markets in Kampong Cham namely: Song, Bangkok and Tom markets. In Kandal, 34 retailers were targeted and came from major markets of Phnom Penh (18 retailers from Chsa Dumkor and Chbar Ampeou) and Kandal (16 in Takmal, Sa-ang and Koky markets). At the conclusion of the interview, these retailers were asked to identify the wholesalers with whom they most frequently interacted. A total of 40 wholesalers (13 in Kandal, 11 in Phnom Penh and 16 in Kampong Cham) were selected. Names of collectors whom they consider as main trading partners were then solicited from which 26 were selected. These 26 collectors provided the contact details of the randomly selected 64 farmers equally distributed in Kandal and Kampong Cham. The crops that were covered in Kandal and Phnom Penh were tomato and Chinese kale; while in Kampong Cham, cucumber and yardlong bean. Data collection was conducted in September 2005.

Table 2-1 Overview of sample size and distribution

Total	Sample size by crop		Sample size by agent		Sample size by district	
200	Tomato	50	Retailers	70	Phnom Penh	33
	Yardlong bean	50	Wholesalers	40	Kampong Cham	100
	Cucumber	50	Collectors	26	Kandal	67
	Chinese kale	50	Farmers	64		

2.3 Methods

2.3.1 *Data collection*

Four types of questionnaires were developed to gather general and specific information by supply chain actor (retailer, processor, trader and farmer). The generic information sought included: socio-demographic data, postharvest loss estimates, trading information (collaboration with other actors, product trait assessment using Likert-type questions, modes of transport used during purchase from suppliers and delivery to buyers, types of packaging materials for incoming and outgoing products), marketing information (monthly volume of quantities purchased and sold, prices achieved, main trading partners, monthly turnover of entire business), value-adding activities, and attitudes toward postharvest loss. For farmers, production and harvesting practices were also obtained based on the past year's production cycles.

2.3.2 Tests of significance

Most of the analysis relies on descriptive statistics. Significant differences among supply chain actors are estimated based on one-way ANOVA and the Levene test for differences in homogeneity of variances and are identified based on Duncan's multiple rank test.

2.3.3 Mapping of supply chain and main actors

Quantities sold to the primary buyer identified by the respondents were calculated using the estimate provided on the share of produce sold to these trading partners. Aggregation on the total quantity sold and total quantity sold to primary buyers was done by actor and for each main trading partner identified. This became the basis in our derivation of the actual shares of vegetables for which suppliers at different levels sold to the main buyers in relation to total quantity sold. We then mapped out the volume of transactions in the supply chain downstream (from farmers to consumers) using these percentages. Since our analysis generated several missing links between suppliers and their main buyers, especially between traders and other retailers not considered as primary partners, we also incorporated the upstraem linkages (from retailers to farmers) looking into the main sources of vegetable produce. These were added into the flow chart to obtain a complete picture of the demand and supply side of vegetables in the country.

2.3.4 Estimation of postharvest losses and value of postharvest loss

For farmers, postharvest loss was quantified and calculated as a percentage based on total harvested quantity. For collectors, wholesalers and retailers, loss was estimated as the difference between quantity purchased and quantity sold in relation to total quantity purchased. Traders were requested to estimate the total percentage share of postharvest loss by season. However, these estimates were found to exceed the postharvest loss estimated based on the difference in quantities traded by a factor of two. In this paper, loss is considered as the difference between quantities purchased and sold, although this may include small errors due to personal consumption. Since we collected monthly observations for collectors, wholesalers and retailers for an entire year, and information on all production cycles within the past year for farmers, this is the total number of observations used.

To obtain a value of loss experienced, actual loss in kilogram (kg) was multiplied with the average selling price. This value was divided by the total amount of vegetables produced or purchased by each agent in kg to obtain a value of loss based on a uniform denominator, and added across all agents in the supply chain.

2.4 General profile

Most farmers who participated in the survey are male. Women dominate collecting, wholesaling and retailing functions (Table 2-2). Only about 82% of the respondents have secondary education or lower, and the remainder are either uneducated or have reached high school, university or have technical qualifications (Table 2-3).

Table 2-2 Gender profile of vegetable supply chain actors in Cambodia

Supply chain actor	Male		Female		Total	
	N	%	N	%	N	%
Farmer	44	69	20	31	64	32
Collector	10	38	16	62	26	13
Wholesaler	14	35	26	65	40	20
Retailer	5	7	65	93	70	35
Total	73	37	127	64	200	100

Source: Surveys in collaboration between AVRDC and DAALI, 2005. N=200.

Table 2-3 Educational background of vegetable supply chain actors in Cambodia

Education category	Farmer		Collector		Wholesaler		Retailer		Total	
	N	%	N	%	N	%	N	%	N	%
None	5	8	3	12	6	15	7	10	21	11
Primary	23	36	8	31	11	28	32	46	74	37
Secondary	31	48	14	54	19	48	26	37	90	45
High school	5	8	1	4	4	10	3	4	13	7
College/university							1	1	1	1
Technical							1	1	1	1

Source: Surveys in collaboration between AVRDC and DAALI, 2005. N=200.

2.5 Farmer profile

Table 2-4 shows the selected characteristics of farmer-respondents which are quite similar between the two provinces. The average family size is 5.9, as reported also by Abedullah *et al.* (2002), and slightly higher than the national average of 5.1 (National Institute of Statistics, 2004). Household size is higher in Kandal than in Kampong Cham. On the average, the ratio of adults per household is 4.3 and the cultivated area per adult is 2,055 square meters (m^2). The farmers are relatively new in independent farming as shown by the average farming experience of 2.6 years. The average total farm sale is US$ 2,040 per annum, with a large difference between the two provinces. Farm sales in Kandal estimated at US$ 3,010 per annum is twice that in Kampong Cham.

The average owned land is 9,846 m^2 and only a small percentage is rented in or rented out (Table 2-5). Almost three-fourths of owned farmlands are cultivated, 60% of which is devoted to vegetables. The farms are usually near all-weather roads with an approximate distance of 1.8 km but quite far from nearest input markets at 4.7 km. Sizes of lands are larger in Kampong Cham compared to that in Kandal, but the share of vegetable area to total cultivated area is larger in Kandal.

Table 2-6 shows that inputs are generally purchased from markets rather than from traders at farmstead. They are mainly transported in bicycles and motorbikes (Figure 2-1). In few cases, farmers are on foot when they purchase from traders at farmstead or get hold of own inputs.

Table 2-4 Farmer characteristics

Characteristic	Kandal		Kampong Cham		Total	
	Mean	SD	Mean	SD	Mean	SD
Household size	6.2	1.8	5.7	2.3	5.9	2.0
Number of adults	4.3	1.9	4.2	1.9	4.3	1.9
Cultivated area per adult (m^2)	2,048	2,236	2,061	2,530	2,055	2,369
Years in independent farming	2.5	1.2	2.8	1.0	2.6	1.1
Annual sales in business (US$)	3,010	2,863	1,070	648	2,040	2,280

Source: Surveys in collaboration between AVRDC and DAALI, 2005. N=64 . 1US$ = 4,177.50 KHR

Table 2-5 Land details

Farm characteristics	Kandal		Kampong Cham		Total	
	Mean	SD	Mean	SD	Mean	SD
Distance to nearest all-weather road (km)	0.9	0.6	2.6	4.8	1.8	3.5
Nearest distance to place where inputs are obtained (km)	2.6	3.4	6.9	4.7	4.7	4.6
Land owned (m^2)	8,855	7,381	10,838	9,295	9,846	8,385
Land rented in (m^2)	775	1,627	998	2,837	887	2,297
Land rented out (m^2)	119	484	156	884	138	707
Land cultivated (m^2)	7,086	6,911	7,373	7,826	7,229	7,326
Vegetable cultivation area (m^2)	3,970	3,649	2,171	1,159	3,070	2,835
Share of vegetable area to total cultivation area (%)	67	29	53	30	60	30

Source: Surveys in collaboration between AVRDC and DAALI, 2005. N=64.

Table 2-6 Source of farm inputs in Cambodia

Source of input	Kandal		Kampong Cham		Total	
	N	%	N	%	N	%
Market	32	100	32	100	64	100
Trader at farmstead	5	16	7	22	12	19
Own	4	13	5	16	9	14
Other	1	3	2	6	3	5

Source: Surveys in collaboration between AVRDC and DAALI, 2005. N=64. Values are multiple responses.

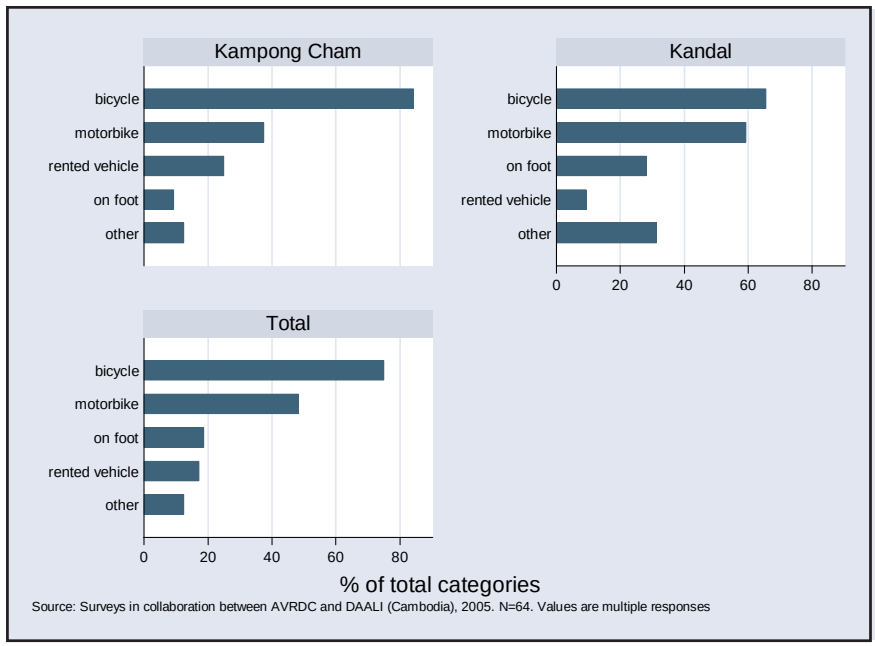

Figure 2-1 Mode of transport of farm inputs in Cambodia

Around half of the farmers hire laborers to assist them in farm-related activities. Except for part-time hired workers, the proportion of male to female is nearly equal. The gap between male-female workers in the farming system has seemingly dwindled over the years with women taking over traditional roles of men partly because of the lack of male labor brought about by the war. For hired labor, full-time men toil the farm 23 days per month, longer than women's labor time by a week. Hired part-time females on the other hand work one and a half months in a year which is 18 days longer than men. It can be observed that more women are hired part-time and with longer working days (Table 2-7).

Table 2-7 Share of female workers to total farm labor, and number of working days of hired farm workers in Cambodia

Characteristic	Mean	SD
% share of female to		
… Full-time family workers	47	24
… Part-time family workers	47	40
… Full-time hired workers	45	43
… Part-time hired workers	62	24
Full-time male workers (person-day/mo)	23	9
Full-time female workers (person-day/mo)	15	10
Casual male workers (person-day/yr)	27	30
Casual female workers (person-day/yr)	45	43

Source: Surveys in collaboration between AVRDC and DAALI, 2005. N=64.

Fellow farmers are the most popular source of information on new product varieties and input supply (Table 2-8). Other sources are traders at the local market and the government's agricultural marketing information center (GAMIC). Aside from these sources, about 25% of the farmers in Kandal also gather information from extension officers and collectors who visit their farms.

Table 2-8 Source of information on new product varieties and inputs of farmers in Cambodia

Characteristic	Kandal		Kampong Cham		Total	
	N	%	N	%	N	%
Seek information on new product varieties and input supply	25	78	20	63	45	70
Source of information[a]						
Radio	1	3			1	2
GAMIC	8	25	7	23	15	24
Any trader at the local market	12	38	7	23	19	30
Collector who comes to the farm	7	22	4	13	11	17
Other farmers	20	63	18	58	38	60
Extension officers	8	25	4	13	12	19
Cooperative/association	1	3	2	6	3	5
NGOs	1	3			1	2
None	7	22	12	39	19	30
Total	32	100	31	100	63	100

Source: Surveys in collaboration between AVRDC and DAALI, 2005. N=200. [a]Values multiple responses.

2.6 Trader profile

Results show that the majority of retail businesses are privately owned. On average, they have been in operation for 10.5 years (Table 2-9). Collectors in Phnom Penh though have by far the longest years in operation of 15.5 years. Wholesalers' operational experience did not vary much with site and ranges from 11.0 (Phnom Penh) to 12.7 years (Kampong Cham).

Among supply chain actors, supermarkets have the highest annual turnover of US$ 1.652 million, followed by wholesalers (US$ 65,128), collectors (US$ 32,446), wet market vendors (US$ 10,553), grocery stores (US$ 9,599) and street vendors (US$ 5,775). All actors from Phnom Penh, except for wholesalers, earn more than their provincial counterparts (Table 2-9).

More women are involved in the marketing of fresh vegetable produce as shown by the ratio of 1:2 full-time family male to female workers engaged in trading (Table 2-10). Men are more preferred than women for part-time jobs especially in collecting; however, women have more workdays (169 days/year) than men (130 days/year). Working days for women (180 days/year) are even more than men (136 days/year) when employed by collectors. Hired full-time workers render their services almost daily working an average of 28 days per month.

Collaboration among supply chain actors is uncommon. In a few cases, collaborative activities, which usually involve four to six other actors include sharing labor, inputs, transport, price or market information and storage facilities; supplying vegetables to one another when stock is insufficient; and bargaining for price.

Table 2-9 Years in operation and annual sales of traders in Cambodia

Parameter	Supply chain actor	Statistic	Phnom Penh	Kandal	Kampong Cham	Total
Years in business	Collector	Mean	15.5	10.3	12.3	12.3
		SD	5.3	3.4	5.3	5.0
	Wholesaler	Mean	11.0	11.8	12.7	12.0
		SD	6.7	5.1	4.4	5.2
	Retailer	Mean	9.2	12.0	10.4	10.5
		SD	3.4	4.9	5.9	5.1
Annual sales of business (US$)	Collector	Mean	55,667	27,686	28,425	32,446
		SD	41,864	13,077	29,965	29,754
	Wholesaler	Mean	54,569	114,788	32,038	65,128
		SD	26,969	85,848	26,399	63,442
	Supermarket	Mean	1,651,646			1,651,646
		SD	1,406,332			1,406,332
	Grocery store	Mean	15,601	6,294	6,901	9,599
		SD	8,129	1,576	4,596	6,647
	Wet market vendor	Mean	13,078	10,056	9,672	10,533
		SD	7,421	9,312	6,387	7,312
	Street vendor	Mean	18,597	3,615	3,110	5,775
		SD	3,593	51	2,550	6,420

Source: Surveys in collaboration between AVRDC and DAALI, 2005. N=136.

Table 2-10 Share of female workers to total labor in trading and retailing, and number of working days of hired workers in Cambodia

Characteristic	Collector		Wholesaler		Retailer	
	Mean	SD	Mean	SD	Mean	SD
% share of female to						
… Full-time family workers	67	36	64	31	91	25
… Part-time family workers	44	43	60	39	50	49
… Full-time hired workers			50	35	61	28
… Part-time hired workers	27	31	30	28		
Full-time male workers (person-day/mo)	28	4	30		30	
Full-time female workers (person-day/mo)			29	1	30	
Casual male workers (person-day/yr)	136	88	126	60	120	
Casual female workers (person-day/yr)	180	107	162	44		

Source: Surveys in collaboration between AVRDC and DAALI, 2005. N=136.

3 The overall supply chain for vegetables

3.1 Overview on chain and actors

The vegetable supply chain was mapped out using the flow of vegetables from the producer to the consumer level. The percentages in the arrows represent the shares of vegetables sold to the main trading partners. Dotted lines represent minimal transaction (< 5%). The main sources of vegetables by each actor were also added to get the overall picture of the demand and supply side of vegetable transactions. These are represented only by lines.

The supply chain for vegetables in Cambodia generally follows the flow presentation (Figure 3-1), although there are slight differences by crop (e.g. yardlong bean supply chain is less complex). The product is collected at the farm by collectors, who are responsible for transport to wholesalers. The wholesale markets in Phnom Penh and Kampong Cham are nightly gathering points for collectors who sell vegetables in bulk to the wholesalers. Wholesalers sell to wet market dealers, grocery stores, supermarkets and street vendors. These retailers deal directly with final consumers except wet market vendors who also cater to restaurants and grocery stores. A certain contingent of vegetables is supplied by importing suppliers and there is evidence that during certain months when local production is low, the share of imports to domestic supply is substantial. However, this study only focuses on local farmers and their production.

The average number of vegetable suppliers of supply chain actors is shown in Table 3-1. The average number of farmers where collectors source their produce from differs with area, being less in Phnom Penh (6) than in Kampong Cham (22) with an average of 18.5. Sometimes, wholesalers also deal directly with farmers, again with large differences across provinces, with those in Phnom Penh dealing with more farmers (17.5) than the other two sites (3 to 5.8). The average number of collectors that wholesalers deal with is between 2.8 in Phnom Penh and 4.8 in Kandal. Retailers source their produce from an average of 4.2 different wholesalers, which is highest in Kandal (4.8) and lowest in Phnom Penh (3.6). They also source their supplies directly from farmers and collectors.

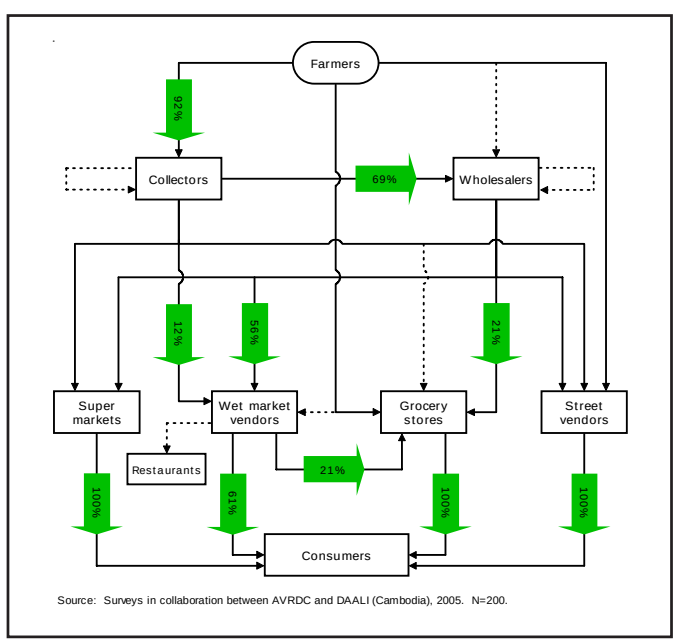

Figure 3-1 Overview of the vegetable supply chain in Cambodia

Table 3-1 Average number of vegetable suppliers of supply chain actors in Cambodia

Supply chain actor	Vegetable supplier	Phnom Penh		Kandal		Kampong Cham		Total	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD
Collector	Farmer	6.3	4.0	14.3	13.0	22.3	26.3	18.5	22.4
	Collector	10.0						10.0	
Wholesaler	Farmer	17.5	17.7	3.0	2.2	5.8	3.8	6.6	7.5
	Middleman			2.6	0.5			2.6	0.5
	Collector	2.8	0.9	4.8	3.2	2.9	1.5	3.4	2.1
Retailer	Farmer	2.5	2.1	2.6	2.4	5.0	2.4	3.7	2.6
	Wholesaler	3.6	1.3	4.8	3.4	4.1	2.9	4.2	2.8
	Collector	1.5	0.7	2.3	0.5	2.8	1.0	2.3	0.8

Source: Surveys in collaboration between AVRDC and DAALI, 2005. N=136.

Transaction on other food types by actor was also explored to identify the relative importance of vegetables. Table 3-2 shows that the farming system is mostly a mixture of vegetables, rice and livestock (mainly cattle and poultry) as can be seen from the percentages of farmers involved in the trade. This is however not the case with traders where very few attempted to diversify traded items to include non-vegetables. For those who did, fruits are a common addition to vegetables for collectors, while rice is for wholesalers. Between the two provinces, collectors from Kandal trade mostly fruits and staples (corn and sweet potato/ cassava), while those from Kampong Cham, a mix of animals (hogs and poultry), fruits and soybean. In the case of wholesalers, sweet potato/ cassava and poultry are popularly traded in Kandal, and cattle and hogs in Kampong Cham.

Table 3-2 Main food items traded in Cambodia

Supply chain actor	Phnom Penh	Kandal	Kampong Cham	Total
Farmer		Rice (47%) Poultry (44%) Cattle (41%)	Rice (81%) Cattle (59%) Poultry (44%)	Rice (64%) Cattle (50%) Poultry (44%)
Collector	Fruits (25%)	Fruits (33%) Corn (17%) Sweet potato/ cassava (17%)	Fruits (6%) Hog (6%) Poultry (6%) Soybean (6%)	Fruits (15%) Corn (4%) Sweet potato/ cassava (4%) Hog (4%) Poultry (4%) Soybean (4%)
Wholesaler	Sweet potato/ cassava (9%)	Sweet potato/ cassava (38%) Rice (8%) Poultry (8%)	Cattle (19%) Rice (6%) Hog (6%)	Sweet potato (15%) Cattle (8%) Rice (5%)

Source: Surveys in collaboration between AVRDC and DAALI, 2005. N=130. Values are multiple responses.

3.2 Packaging and transport along the chain

Vegetables from suppliers are usually packed in plastic bags, bamboo baskets, sacks or crudely tied up using branches or plastic strips (in the case of yardlong bean). Suppliers for collectors and wholesalers commonly use sacks and bamboo baskets while on the retail side, plastic bags are used (Figure 3-2). Among the four crops, collectors of tomato and cucumber generally receive the vegetables in sacks, Chinese kale in bamboo baskets, and yardlong bean tied up. When the vegetables are received by wholesalers, tomatoes are in bamboo baskets, yardlong bean is either tied up or in sacks, while cucumber

and Chinese kale are packaged in the same manner as before. Upon reaching the retailers, all four vegetables are generally packed in plastic bags.

The main means of transportation used in purchasing vegetables from suppliers, regardless of who transports – buyer or seller, are motorbike, rented vehicle, car, public transport and bicycle (Figure 3-3). In the case of farmers, vegetables are mainly brought from the field to the farmhouse using motorbike, hand tractor with cart or carried by foot on the head or shoulder. Except wholesalers, most collectors and retailers are responsible for transporting their purchased vegetables. During purchase from farmers and delivery to wholesale and some retail markets in Phnom Penh, Kandal and Kampong Cham, collectors frequently use motorbike, car, rented vehicle and public transport. Retailers, on the other hand, generally use rented vehicle, motorbike and public transport.

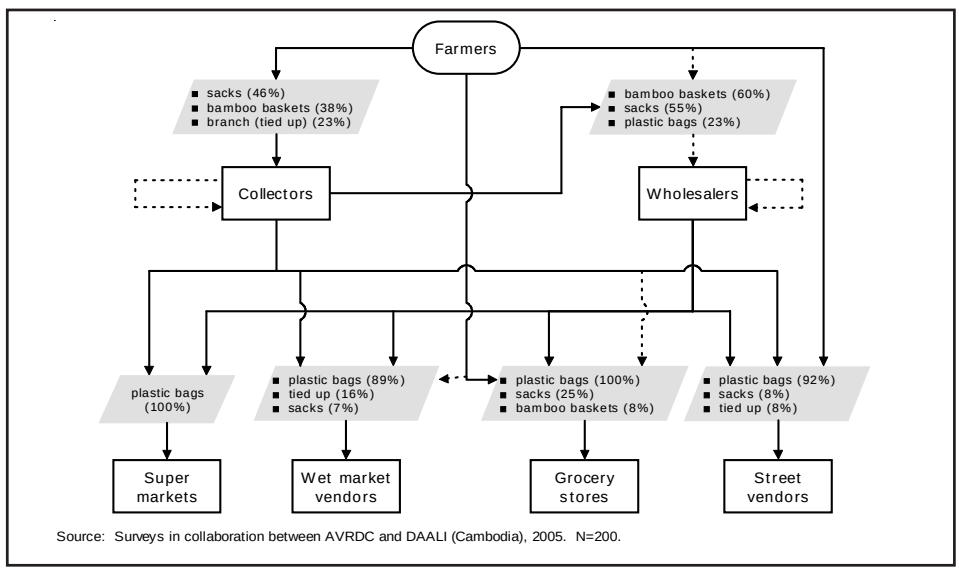

Figure 3-2 Main packaging materials for fresh vegetables in Cambodia

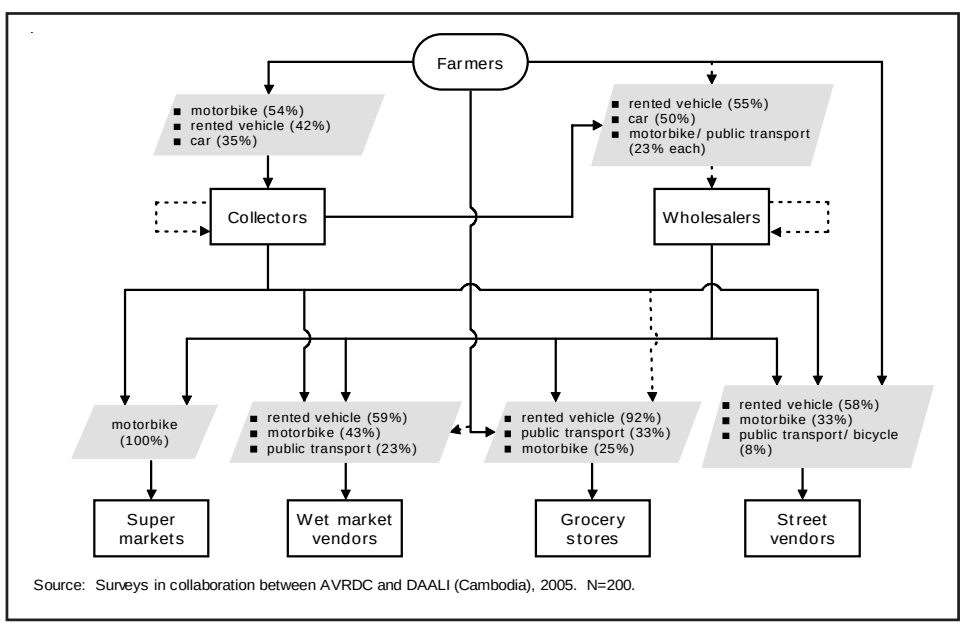

Figure 3-3 Mode of transport of fresh vegetables in Cambodia

3.3 Communication and cooperation

Among the actors, farmers and collectors are more active in seeking information on market prices of their produce before they sell and on the preferred quality traits in vegetables compared with wholesalers and retailers (Table 3-3). However, retailers, especially in Phnom Penh and Kandal, are more after quality than price information. For farmers, the main source of information is other farmers (75%), collectors (56%) and traders in the market (44%). Collectors rely on other traders (62%). Radio, TV and newspapers are only used by 5% of the respondents. Usually, information is sought daily although approximately one-third of the farmers obtain it on a weekly basis. Not all however are satisfied with the quality of information they receive, especially among farmers where 20% complain about the inaccuracy of price information obtained.

Table 3-3 Number of actors who seek information on market price and quality traits of vegetables in Cambodia

Type of information	Supply chain actor	Phnom Penh		Kandal		Kampong Cham		Total	
		N	%	N	%	N	%	N	%
Price	Farmer			28	88	26	81	54	84
	Collector	2	50	6	100	11	69	19	73
	Wholesaler	5	45	3	23	3	19	11	28
	Retailer	11	61	3	19	11	31	25	36
Quality traits	Farmer			26	81	23	72	49	77
	Collector	1	25	4	67	10	63	15	58
	Wholesaler	5	45	2	15	3	19	10	25
	Retailer	10	56	9	56	13	36	32	46

Source: Surveys in collaboration between AVRDC and DAALI, 2005. N=200.

Furthermore, existence of contract arrangements and quality assurance programs was also explored to better understand the degree of communication and cooperation along the supply chain. The survey did not find any respondent involved in any contract arrangement or quality assurance program.

It is interesting to understand farmers' perceptions about quality traits and compare them with other actors' perceptions since a large discrepancy would put farmers at a disadvantage (Concepcion *et al.*, 2004). All respondents were thus asked to rank the significance of 11 quality traits on a Likert scale of 1 (not important at all) to 5 (very important). Table 3-4 shows the average ranks by different respondent type. All respondents consider freshness of the product the most important quality trait and certification the least important. Among farmers, traits relating to appearance (freshness, color and size) are more important than those relating to food safety. Certification is also considered unimportant among farmers. Some interesting differences emerge between actors and their ratings: (a) farmers overrate the size of produce as a quality trait compared to retailers; and (b) farmers underestimate the importance of food safety traits compared to retailers. In the future, more efforts should be made in educating farmers on consumer demands for food free from pesticide and fertilizer residues.

Table 3-4 Assessment of the importance of quality traits of vegetables in Cambodia

Trait	Farmer	Collector	Wholesaler	Retailer	Significance
Freshness	4.9	5.0	5.0	5.0	
Color	4.8	4.8	4.8	4.8	
Size	4.7[a]	4.5[a,b]	4.5[a,b]	4.2[b]	***
Packing	4.5	4.5	4.5	4.2	
Shape	4.5	4.5	4.3	4.2	
Grading	4.4[a,b]	4.6[b]	4.5[b]	4.1[a]	**
Price	4.3	4.5	4.3	4.2	
Free from food-based pathogens	4.2	4.3	4.7	4.5	*
Free from pesticide residues	3.3[a]	3.6[a,b]	4.1[b,c]	4.0[c]	***
Free from fertilizer residues	3.2[a]	3.5[a,b]	3.9[b]	3.8[b]	***
Certification	1.5	2.1	2.0	1.7	

Source: Surveys in collaboration between AVRDC and DAALI, 2005. N=200. Participants ranked importance of traits on a scale from 1 (not important at all) to 5 (very important). ANOVA and Duncan tests were used to test significance of difference between groups based on Levene statistic (***=p<0.001; **=p<0.05; *=p<0.01). A different superscript indicates that figures are statistically different at the 5% level.

3.4 Prices and price margins

Monthly prices that farmers and retailers receive for their product were also analyzed. Figure 3-4 shows that retailer prices fluctuate widely for yardlong bean and Chinese kale. During peak production seasons, yardlong bean and Chinese kale only achieve 44% and 51%, respectively, of the retail price during low production season, while tomato and cucumber 57% and 70%, respectively. Cucumber prices are relatively stable across the year with only small fluctuations.

Among the four crops, tomato has the lowest share to the total sales of wholesalers. With the other three crops, local farmers provide up to 40%, and in the case of Chinese kale, even 50% of all product sold by wholesalers.

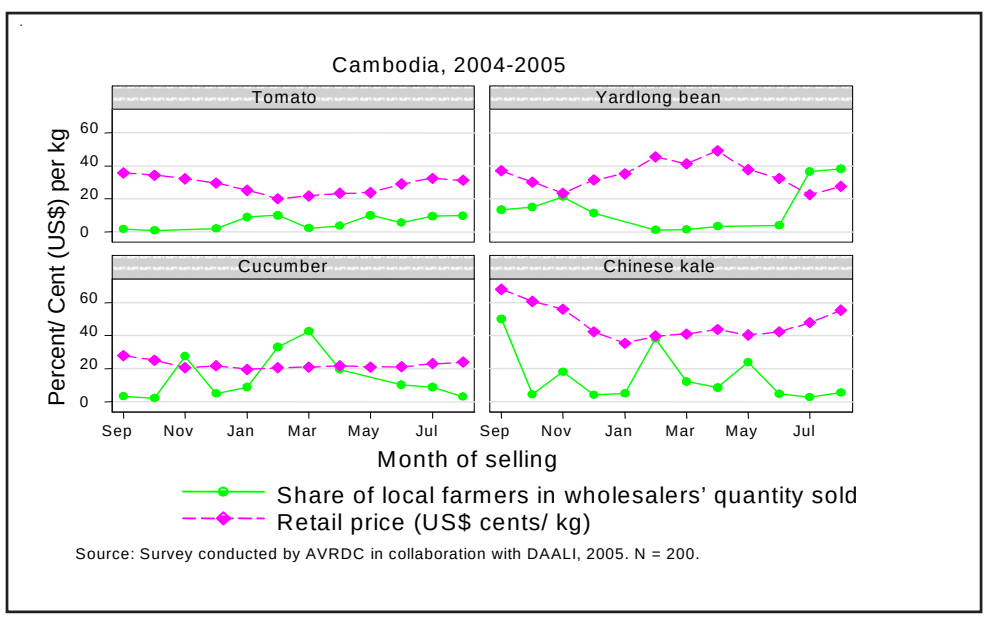

Figure 3-4 Monthly average retail price and share of local production of tomato, yardlong bean, cucumber and Chinese kale in Cambodia

4 Crop supply chains

4.1 Tomato

4.1.1 Economic importance and the supply chain

Preliminary key informant interviews provided a basis in determining the economic importance of tomato and the other three crops (yardlong bean, cucumber and Chinese kale) since individual crop production statistics are not available. Tomato is being identified as a major crop of economic importance in the surveyed locations, although Abedullah *et al.* (2002) reported that tomato is not among Cambodia's five most important crops by area. In the sample, only 17 (27%) of the farmers are engaged in tomato production and about 34% of collectors and 45% of wholesalers are involved in tomato trade.

Figure 4-1 shows that collectors play an important role in the distribution process of tomato. Collectors sell most of their produce to wholesalers and about one-fifth is sold directly to wet market vendors. Collectors operating in Phnom Penh sell directly to retailers, while collectors operating in Kandal sell to wholesalers. Wet market vendors continue to be the most important form of retailing; however, some of them act as intermediate dealers selling produce to grocery stores. In addition to local produce, wholesalers purchased 645 thousand MT from importing suppliers, more than their purchases from domestic collectors (582 thousand MT). Among the four crops, tomato is the only one with purchases from importing suppliers.

Total turnover of tomato (US$ 345 thousand) ranks second to Chinese kale (Table 4-1). Peak harvests are in January and July. Over the year, the wholesalers deal with 1,105 MT of tomato equivalent to a turnover of US$ 276 thousand or 16% of the total turnover (US$ 1.6 million). For farmers and collectors, tomato sales account for about 25% of the total turnover. A much lower contribution of tomato sales to retailers' total turnover was noted. These results indicate that the supply chain actors are not specialized in this crop.

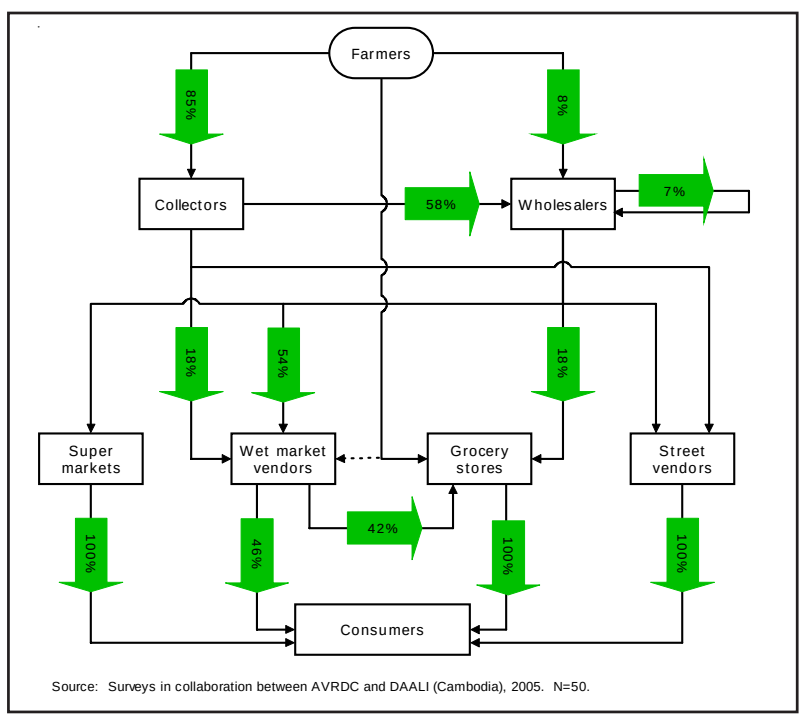

Figure 4-1 Main trading partners in the supply chain of tomato in Cambodia

Table 4-1 Monthly sales of tomato in Cambodia, 2004-2005

Month	Farmer		Collector		Wholesaler		Retailer		Total	
	Quantity (MT)	Sales ('000 US$)	Quantity (MT)	Sales ('000 US$)	Quantity (MT)	Sales ('000 US$)	Quantity (MT)	Sales ('000 US$)	Quantity (MT)	Sales ('000 US$)
Sep-04	1.4	0.2	14.2	4.3	85.3	24.5	5.5	2	106.4	31.0
Oct-04	0.7	0.1	14.6	4.4	85.7	23.8	5.7	2	106.7	30.3
Nov-04			16.1	4.3	91.6	24.2	5.4	1.7	113.1	30.2
Dec-04	1.8	0.2	16.5	3.9	88.1	23.7	5.4	1.6	111.8	29.4
Jan-05	14.2	1.7	15.5	2.5	78.5	17.2	5.3	1.3	113.5	22.7
Feb-05	1.7	0.3	19.5	2.7	79.2	16.9	5	1	105.4	20.9
Mar-05	1.3	0.2	15.5	2	95.4	23.3	4.1	0.9	116.3	26.4
Apr-05	7.9	0.9	19.3	3.9	105	23.2	4	0.9	136.2	28.9
May-05	8.9	1.1	16.2	3.8	101.9	22	4.2	1	131.2	27.9
Jun-05	3.9	0.5	16.7	4.3	93.9	24.1	4.6	1.3	119.1	30.2
Jul-05	15.2	2.1	17.1	4.3	96.4	25.2	5.7	1.8	134.4	33.4
Aug-05	3	0.4	17.4	4.5	103.7	27.5	5.3	1.6	129.4	34.0
Total	59.8	7.6	198.5	44.9	1,104.6	275.6	60.3	17.3	1,423.2	345.4
% share to total sales		25.6		25.1		15.7		1.9		

Source: Surveys in collaboration between AVRDC and DAALI , 2005. N=431 observations.

4.1.2 Postharvest losses

All farmer-respondents, collectors and wholesalers, and 94% of the retailers incur postharvest loss due to spoilage (unmarketable yield) estimated at 105, 16, 67 and 58 kg per MT produce, respectively (Table 4-2). This is equivalent to about 10%, 2%, 7% and 6% of the total volume traded. Wholesalers have high losses during the early dry season (Dry 1) in contrast to farmers where losses are highest in the wet season. For collectors and retailers, losses did not differ much with season. The collectors have the lowest loss among supply chain actors. From farm to retailer, it is estimated that the sum of all losses amounts to 246 kg for every MT of tomato produced on average, or 24.5% of total production.

About half of the farmers (52%) used partially spoiled product on the farm or in the household. All collectors, wholesalers and retailers, and 74% of the farmers sell the partially spoiled produce at lower prices. The average price reduction is highest for farmers (52%) and lowest for retailers (30%). Collectors also reported price reduction for partially spoiled produce of 43% and 34% for dry and wet seasons, respectively; while for wholesalers, 29% for both seasons.

Table 4-2 Postharvest loss estimates of tomato in the supply chain in Cambodia

Parameter	Farmer	Collector	Wholesaler	Retailer
% share with loss	100	100	100	94
Loss values				
- kg per MT	105	16	67	58
- % loss				
Dry 1	6	1	8	5
Dry 2	6	2	4	6
Wet	13	2	7	6
Average	10	2	7	6
Median	6	2	3	5
Damaged/partially spoiled produce				
Sell at reduced price (%)	74	100	100	100
Price reduction in Dry season (%)	52	43	29	30
Price reduction in Wet season (%)	52	34	29	

Source: Surveys in collaboration between AVRDC and DAALI, 2005. N=431 observations. Seasons are based on the months of first harvest or sale. Dry season 1 is from November to January; Dry season 2, February to April; and Wet season, May to October.

Farmers' main reasons for postharvest loss in tomato are disease infection, hot weather during harvest and damage during harvest (Table 4-3). Disease infection is particularly prevalent in tomatoes harvested during the wet season. During focus group discussions, farmers also mentioned how heavy pesticide usage and lack of knowledge in storage technologies contribute to postharvest losses.

Table 4-3. Main reasons for tomato postharvest loss at farm level in Cambodia

Reason	Dry 1		Dry 2		Wet		Total	
	N	%	N	%	N	%	N	%
Hot weather during harvest	3	75	3	75	9	60	15	65
Humid weather during harvest			2	50	7	47	9	39
Diseases	3	75	2	50	13	87	18	78
Damage during harvest	2	50	1	25	9	60	12	52
Damage during transport	2	50	1	25	3	20	6	26
Poor quality of variety	1	25			4	27	5	22
Other reason of spoilage	1	25	2	50	4	27	7	30
Total	4	100	4	100	15	100	23	100

Source: Surveys in collaboration between AVRDC and DAALI, 2005. N=23 observations. Values are multiple responses. See additional notes in Table 4-2.

Trader losses are mainly due to surpluses of produce that could not be sold and high temperature in storage facilities (Table 4-4). During the focus group discussion with collectors and retailers, they also agreed with the farmer groups on how intensive pesticide usage and rainy weather contribute to higher postharvest loss in tomato.

Table 4-4. Main reasons for tomato postharvest loss at trader and retailer levels in Cambodia

Reason	Collector		Wholesaler		Retailer		Total	
	N	%	N	%	N	%	N	%
Poor packaging			5	38	4	24	9	26
High temperature in storage facility	2	50	9	69	10	59	21	62
High humidity in storage facility	1	25	3	23	7	41	11	32
Poor hygiene conditions			3	23	3	18	6	18
Poor infrastructure facilities	2	50	5	38			7	21
Cannot sell all vegetables	3	75	9	69	12	71	24	71
Poor quality of purchased vegetable crop			5	38	6	35	11	32
No loss					1	6	1	3
Total	4	100	13	100	17	100	34	100

Source: Surveys in collaboration between AVRDC and DAALI , 2005. N=34. Values are multiple responses.

Different actors employ different measures to reduce postharvest loss along the supply chain. Farmers harvest during cool weather, are careful during harvest and spray water on the harvested tomatoes. Collectors and wholesalers observe care during transport and collect the produce during cool weather (mainly in the evenings). Retailers focus on the use of proper packaging and cool storage rooms (Table 4-5).

In focus group meetings, farmers requested assistance on how to preserve the quality of tomato and store them for longer periods, and on ways to improve packaging. These were similarly raised by collectors and retailers who requested for technologies related to packaging and enhancing shelf life.

Table 4-5 Measures to prevent loss of tomato along the supply chain in Cambodia

Measure	Farmer		Trader		Retailer		Total	
	N	%	N	%	N	%	N	%
Harvest during cool weather/ demand time of harvest	11	69	4	24			15	30
Careful harvest/ demand careful harvest	9	56	2	12			11	22
Spray water on harvest	10	63					10	20
Observe care during transport	2	13	10	59	1	6	13	26
Harvest after buyer has been identified	1	6					1	2
Collect during cool weather			8	47			8	16
Observe care in packaging			4	24	8	47	12	24
Ensure cool temperature in storage area	8	50	6	35	8	47	22	44
Low humidity in storage area					2	12	2	4
Good hygiene conditions					7	41	7	14
Don't buy more than what is needed					5	29	5	10
Buy high quality vegetable crop					6	35	6	12
Do nothing			3	18	4	24	7	14
Other preventive measures	1	6	2	12			3	6
Total	16	100	17	100	17	100	50	100

Source: Surveys in collaboration between AVRDC and DAALI, 2005. N=50.

4.1.3 From production to value-added activities

4.1.3.1 Production

The average yield for tomato is 21.7 MT per ha, only about half of the yield recorded for Lao PDR and Viet Nam (Table 4-6). The average area under tomato crop is 1,773 m^2, and the average selling price is US$ 132 per MT. Mean sale per cropping cycle is estimated at US$ 330.

As shown in Table 4-1, harvesting is done every month except November, and peaks in January and July. In general, only farmers do the harvesting. Total duration of harvesting recorded is 28 days.

Table 4-6 Average yield, production area, selling price and sales of tomato by season in Kandal, Cambodia

Parameter	Season	Mean	SD
Yield (MT/ha)	Wet	24.7	15.6
	Dry 1	16.4	1.5
	Dry 2	15.9	7.5
	Mean	21.7	13.4
Production area (m^2)	Wet	1,370.4	1,192.3
	Dry 1	2,475.0	1,611.2
	Dry 2	2,580.0	2,319.0
	Mean	1,772.9	1,520.0
Selling price (US$/MT)	Wet	138.1	29.4
	Dry 1	115.2	21.5
	Dry 2	127.2	47.2
	Mean	132.2	31.6
Sales (US$)	Wet	292.4	222.4
	Dry 1	473.1	366.2
	Dry 2	328.7	214.9
	Mean	330.1	246.4

Source: Surveys in collaboration between AVRDC and DAALI (Cambodia), 2005. N=23 observations. See additional notes in Table 4-2.

4.1.3.2 Storage, packaging and transport

Right after harvest, about 80% of farmers store the produce on the ground in the shade, while the rest place the harvest into baskets. In Kandal, harvested fruits stay for about seven hours at the farm before being sold to collectors (Table 4-7). Collectors, in turn, keep the produce for an average 14 hours before selling it. Produce stays with wholesalers for four hours and with retailers for ten hours. In total, approximately 35 hours is the intervening period between harvest and sale to consumers. The number of hours is shorter for produce sold in Phnom Penh markets, but this does not include the time spent at the farm.

Tomato is usually packed in sacks or bamboo baskets when collectors pick them up from their suppliers (Figure 4-2). When they deliver them to wholesalers, the produce is usually in bamboo baskets, sacks or plastic bags. Retailers receive tomatoes pack mainly in plastic bags.

Table 4-7 Number of hours between harvest/purchase and sale of tomato at different levels in the supply chain in Cambodia

Supply chain actor	Phnom Penh		Kandal		Total	
	Mean	SD	Mean	SD	Mean	SD
Farmer			6.7	3.1	6.7	3.1
Collector	6.0		14.3	0.5	12.3	3.7
Wholesaler	8.5	3.2	4.4	3.7	6.3	4.1
Retailer	4.4	4.4	9.9	22.3	7.0	15.8
Total	18.9	7.6	35.3	29.6	32.3	26.7

Source: Surveys in collaboration between AVRDC and DAALI , 2005. N=431 observations.

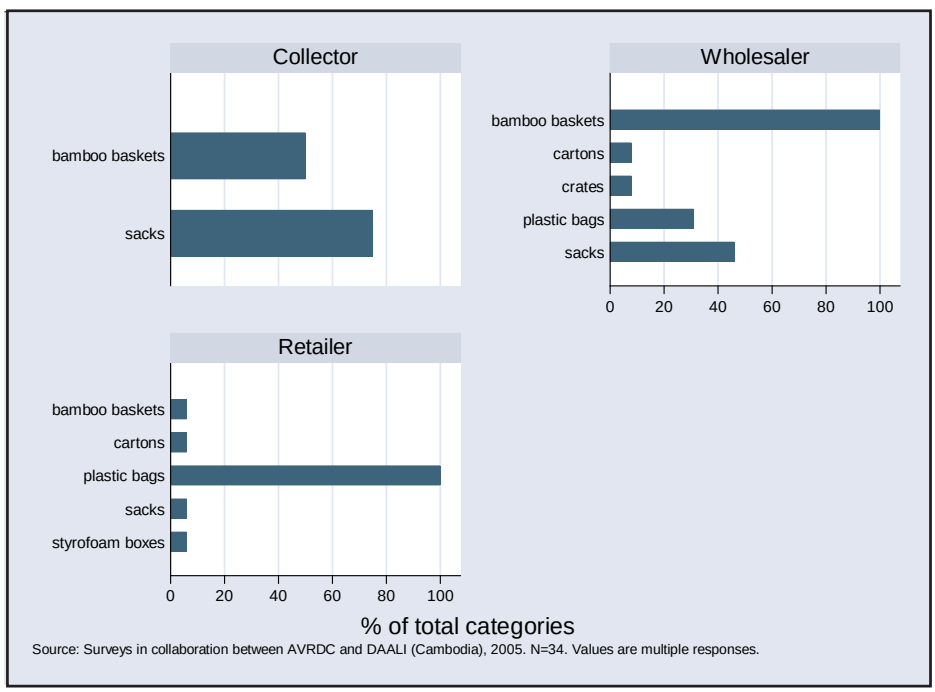

Figure 4-2 Packaging materials for tomato in Cambodia

Most collectors are responsible for collecting the produce from farms, although one collector stated otherwise (Table 4-8). Wholesalers usually wait for the produce to be delivered by collectors, while retailers transport the purchased tomato from wholesale markets to their retail outlets.

Farmers transport the harvested produce from the field to the farmhouse mostly by motorbikes, followed in importance by bicycles or in baskets on foot (Figure 4-3). Collectors rely on public transport, boat and motorbikes, while retailers, rented vehicles. Suppliers of wholesalers usually transport tomato by car.

Table 4-8 Supply chain actors involved in transporting tomato from their suppliers in Cambodia

Supply chain actor	Phnom Penh		Kandal		Total	
	N	%	N	%	N	%
Farmer			2	12	2	12
Collector			3	100	3	75
Wholesaler	1	17			1	8
Retailer	7	78	8	100	15	88

Source: Surveys in collaboration between AVRDC and DAALI, 2005. N=50. In the case of farmers, it is the share of farmers responsible for transporting produce to their buyers.

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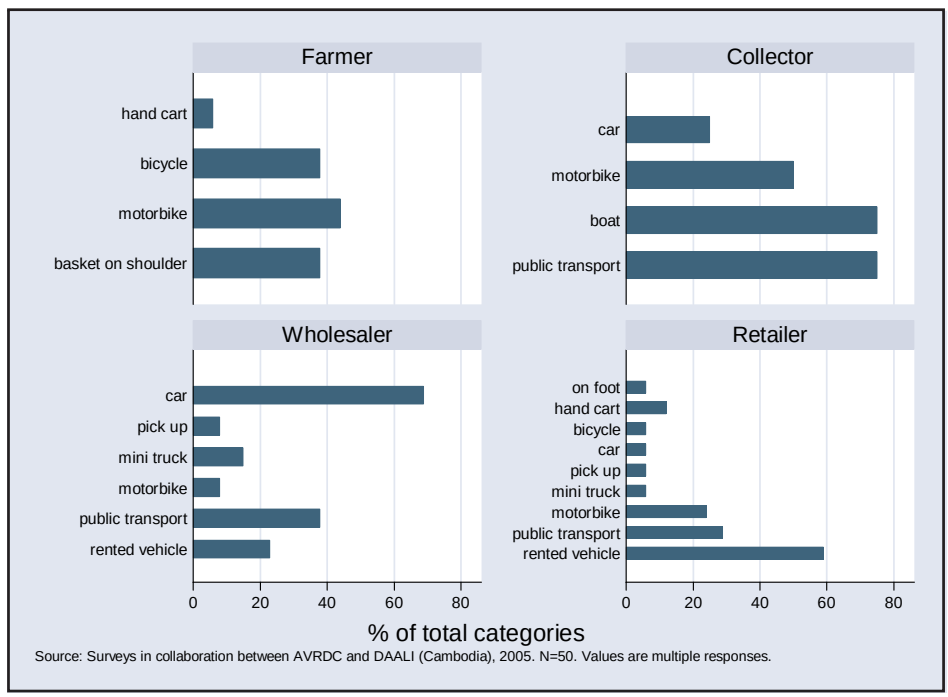

Figure 4-3 Mode of transport of tomato in Cambodia

4.1.3.3 Value-added activities

All actors are involved in value-adding activities except for about 44% of the farmers and 29% of retailers (Table 4-9). Common value-adding activities include sorting, grading, storing, cleaning, repacking and transporting. Repacking is done by approximately 45% of the actors in Cambodia, in contrast to that in Viet Nam where it is less frequently emphasized, as tomato passes from one actor to another.

Table 4-9 Involvement of supply chain actors in value-adding activities for tomato in Cambodia

Supply chain actor	Involved (%)	Not involved (%)
Farmer	56	44
Collector	100	
Wholesaler	100	
Retailer	71	29
Mean	76	24

Source: Surveys in collaboration between AVRDC and DAALI, 2005. N=50.

4.2 Yardlong bean

4.2.1 Economic importance and the supply chain

Yardlong bean is a major crop of economic importance in the surveyed locations. This was reported also by Abedullah *et al.* (2002) as among the five most important crops by area. Of the 64 farmers sampled, 50% are engaged in yardlong bean production. Also, 12 collectors (46%) and 10 wholesalers (25%) deal with yardlong bean in their trading operations.

The supply chain for yardlong bean is relatively straightforward, with less wholesaler involvement as compared to tomato (Figure 4-4). Farmers sell produce to collectors who, in turn, sell only one-fifth of the produce to wholesalers. The remainder is distributed to wet market vendors. A limited amount of produce is also sold between collectors. As with tomato, wet markets are the most important trading point at the retailer level. Aside from consumers, institutional buyers (restaurants) are endpoints in the supply chain.

Among the four vegetable supply chains studied, yardlong bean ranks last both in terms of quantity traded and total turnover (US$ 155 thousand) (Table 4-10). The main harvest time is July, and some harvest also occurs during the early dry season (from November until February). Over the year (September 2004 to August 2005), the wholesalers sampled deal with 318 MT of yardlong bean equivalent to an average turnover of US$ 90 thousand. This is approximately 67% of the total turnover of their enterprise amounting to US$ 135 thousand, indicating a higher degree of specialization. The same is true for farmers and collectors.

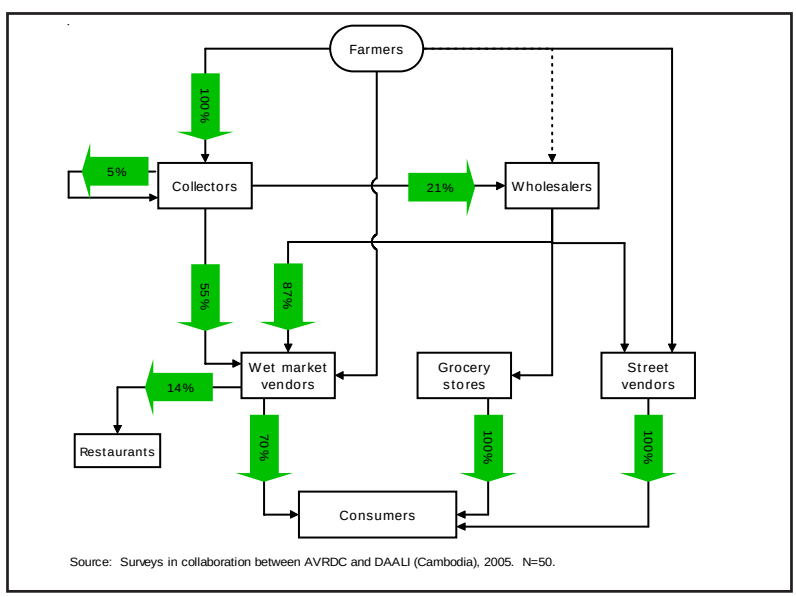

Figure 4-4 Main trading partners in the supply chain of yardlong bean in Cambodia

Table 4-10 Monthly sales of yardlong bean in Cambodia, 2004-2005

Month	Farmer		Collector		Wholesaler		Retailer		Total	
	Quantity (MT)	Sales ('000 US$)	Quantity (MT)	Sales ('000 US$)	Quantity (MT)	Sales ('000 US$)	Quantity (MT)	Sales ('000 US$)	Quantity (MT)	Sales ('000 US$)
Sep-04	4.9	0.8	22.1	6.9	33.1	9.5	4.9	1.8	65.0	19.0
Oct-04	5.8	1.1	13.9	4.1	32.5	9.3	4.4	1.3	56.6	15.8
Nov-04	5.1	0.9	10.2	2.7	25.5	5.0	4.4	1.0	45.2	9.6
Dec-04			8.4	2.4	22.5	7.3	4.4	1.4	35.3	11.1
Jan-05			7.9	2.2	22.3	6.8	4.1	1.4	34.3	10.4
Feb-05	0.6	0.1	7.6	2.0	24.9	9.1	4.6	2.1	37.7	13.3
Mar-05			9.2	2.6	21.8	7.5	3.9	1.6	34.9	11.7
Apr-05	0.9	0.1	10.4	2.9	25.3	9.3	4.5	2.2	41.1	14.5
May-05			7.9	2.2	25.7	6.4	3.8	1.4	37.4	10.0
Jun-05	1.0	0.1	11.7	3.1	25.6	6.5	3.9	1.3	42.2	11.0
Jul-05	20.5	3.9	16.6	4.2	28.0	6.7	3.9	0.9	69.0	15.7
Aug-05	3.2	0.5	18.4	4.3	30.8	6.3	4.2	1.2	56.6	12.3
Total	41.9	7.5	144.4	39.7	317.9	89.8	51.0	17.6	555.2	154.6
% share to total sales		41.0		45.0		66.8		11.6		

Source: Surveys in collaboration between AVRDC and DAALI (Cambodia), 2005. N=432 observations.

4.2.2 Postharvest losses

All farmers, collectors and wholesalers, and 94% of retailers experienced postharvest loss in yardlong bean. Total produce which could not be sold due to spoilage (unmarketable yield) is estimated at 76, 32, 47 and 63 kg per MT produce, for farmers, collectors, wholesalers and retailers, respectively (Table 4-11). Similar with tomato, losses are highest during the wet season and lowest at the end of the dry season. Farmers incur the highest loss while collectors, the lowest. On average, for every MT of yardlong bean that is being produced, 218 kg (or 22%) are lost before the produce reaches the consumer.

Most farmers (92%) used partially spoiled product on the farm or in the household. These blemished produce are also being sold by all collectors, wholesalers and retailers, and 79% of the farmers albeit at lower prices. Farmers experience price reduction of 34% and 42% during wet and dry seasons. Similarly, price reductions for collectors and wholesalers range between 34% and 40% during dry season, and 37% and 41% during wet season, respectively. Retailers lower prices by 21% on average for partially spoiled produce.

Table 4-11 Postharvest loss estimates of yardlong bean in the supply chain in Cambodia

Parameter	Farmer	Collector	Wholesaler	Retailer
% share with loss	100	100	100	94
Loss values				
- kg per MT	76	32	47	63
- % loss				
Dry 1	8	2	3	6
Dry 2	4	3	4	6
Wet	8	4	5	6
Average	8	3	5	6
Median	10	4	3	3
Damaged/partially spoiled produce				
Sell at reduced price (%)	79	100	100	100
Price reduction in Dry season (%)	42	34	40	21
Price reduction in Wet season (%)	34	37	41	

Source: Surveys in collaboration between AVRDC and DAALI, 2005. N=432 observations. Seasons are based on the months of first harvest or sale. Dry season 1 is November to January; Dry season 2, February to April; and Wet season, May to October.

In Table 4-12, main reasons for postharvest losses at the farm level are diseases (92%), hot weather during harvest (83%), and poor quality of variety (54%). Trader and retailer losses are due to failure in selling all vegetables on the same day (91%) and low quality of crops during the time of purchase (79%) (Table 4-13).

Table 4-12 Main reasons for yardlong bean postharvest loss at farm level in Cambodia

Reason	Dry 1		Dry 2		Wet		Total	
	N	%	N	%	N	%	N	%
Hot weather during harvest	3	100	2	100	15	79	20	83
Humid weather during harvest					4	21	4	17
Diseases	3	100	2	100	17	89	22	92
Damage during harvest	3	100			6	32	9	38
Damage during transport	1	33			1	5	2	8
Poor quality of variety	3	100			10	53	13	54
Other reason of spoilage			1	50	2	11	3	13
Total	3	100	2	100	19	100	24	100

Source: Surveys in collaboration between AVRDC and DAALI, 2005. N=24 observations. Values are multiple responses. See additional notes in Table 4-11.

Table 4-13 Main reasons for yardlong bean postharvest loss at trader and retailer levels in Cambodia

Reason	Collector		Wholesaler		Retailer		Total	
	N	%	N	%	N	%	N	%
Poor packaging	2	25	4	50	5	28	11	32
High temperature in storage facility	5	63	2	25	6	33	13	38
High humidity in storage facility			1	12	2	11	3	9
Poor hygiene conditions	3	38			1	6	4	12
Poor infrastructure facilities	1	13	6	75	1	6	8	24
Cannot sell all vegetables	8	100	7	87	16	89	31	91
Poor quality of purchased vegetable crop	6	75	8	100	13	72	27	79
No loss					1	6	1	3
Total	8	100	8	100	18	100	34	100

Source: Surveys in collaboration between AVRDC and DAALI, 2005. N=34. Values are multiple responses.

Supply chain actors employ different measures to reduce postharvest loss. Farmers harvest during cool weather, observe care during harvest, and spray water on harvested produce (Table 4-14). Collectors and wholesalers, on the other hand, demand careful harvest, collect the produce during cool weather (mainly in the evenings), and ensure cool temperature in storage areas. Retailers focus on buying high quality produce, ensuring good hygiene conditions in their area, and good packaging, in addition to using cool storage rooms. Focus groups identified the need for improved packaging methods and for preserving the quality of the crop along the chain.

Table 4-14 Measures to prevent loss of yardlong bean along the supply chain in Cambodia

Measure	Farmer		Trader		Retailer		Total	
	N	%	N	%	N	%	N	%
Harvest during cool weather/ demand time of harvest	14	88	9	56			23	46
Careful harvest/ demand careful harvest	10	63	11	69			21	42
Spray water on harvest	10	63					10	20
Observe care during transport	9	56	9	56	1	6	19	38
Harvest after buyer has been identified	2	13					2	4
Collect during cool weather			11	69			11	22
Observe care in packaging			8	50	7	39	15	30
Ensure cool temperature in storage area	8	50	10	63	10	56	28	56
Low humidity in storage area					2	11	2	4
Good hygiene conditions					7	39	7	14
Don't buy more than what is needed					3	17	3	6
Buy high quality vegetable crop					11	61	11	22
Do nothing			3	19	1	6	4	8
Other preventive measures					1	6	1	2
Total	16	100	16	100	18	100	50	100

Source: Surveys in collaboration between AVRDC and DAALI, 2005. N=50. Values are multiple responses.

4.2.3 From production to value-added activities

4.2.3.1 Production

The average yield recorded for yardlong bean is 12.9 MT per ha, 50% higher than that in Lao PDR. The average area under yardlong bean is 1,887 m^2, and the average selling price is US$ 170 per MT, which is approximately half the selling price in Lao PDR. The average value of yardlong bean sales is US$ 315 per cropping cycle (Table 4-15).

Table 4-15 Average yield, production area, selling price and sales of yardlong bean by season in Kampong Cham, Cambodia

Parameter	Season	Mean	SD
Yield (MT/ha)	Wet	11.9	9.0
	Dry 1	9.6	0.6
	Dry 2	27.3	20.4
	Mean	12.9	10.1
Production area (m^2)	Wet	2,029	1,206
	Dry 1	1,963	726
	Dry 2	425	389
	Mean	1,887	1,181
Selling price (US$/MT)	Wet	173.9	32.9
	Dry 1	183.5	6.9
	Dry 2	113.7	42.3
	Mean	170.1	35.2
Sales (US$)	Wet	339.4	259.8
	Dry 1	311.6	88.6
	Dry 2	86.2	50.8
	Mean	314.8	242.2

Source: Surveys in collaboration between AVRDC and DAALI, 2005. N=24 observations. See additional notes in Table 4-11.

Harvesting is done every month between April and November by the farmers themselves. Around 25% of wholesalers and none from the collectors harvest yardlong bean at the farm. Total duration of harvest is 30.5 days.

4.2.3.2 Storage, packaging and transport

After harvest, most farmers (72%) store the produce on the ground in a shaded area. The rest store the produce either on the ground under the sun, in baskets or by some other means. The produce is held for about two hours at the farm before being sold to collectors. Collectors, in turn, keep the produce for an average of five hours before selling it. Produce stays with wholesalers for five hours and with retailers for four hours. The total elapsed time between harvest and sale to consumers is 16 hours (Table 4-16).

Collectors usually receive yardlong bean tied up without additional form of packaging, although nearly 40% also report receiving yardlong bean in plastic bags (Figure 4-5). When it reaches the wholesalers, the produce is packed in sacks or tied up. Retailers usually receive yardlong bean from their suppliers in plastic sacks.

Table 4-16 Number of hours between harvest/purchase and sale of yardlong bean at different levels in the supply chain in Kampong Cham, Cambodia

Supply chain actor	Mean	SD
Farmer	2.4	0.6
Collector	4.6	7.4
Wholesaler	5.1	2.6
Retailer	4.3	7.0
Total	16.4	17.6

Source: Surveys in collaboration between AVRDC and DAALI, 2005. N=432 observations.

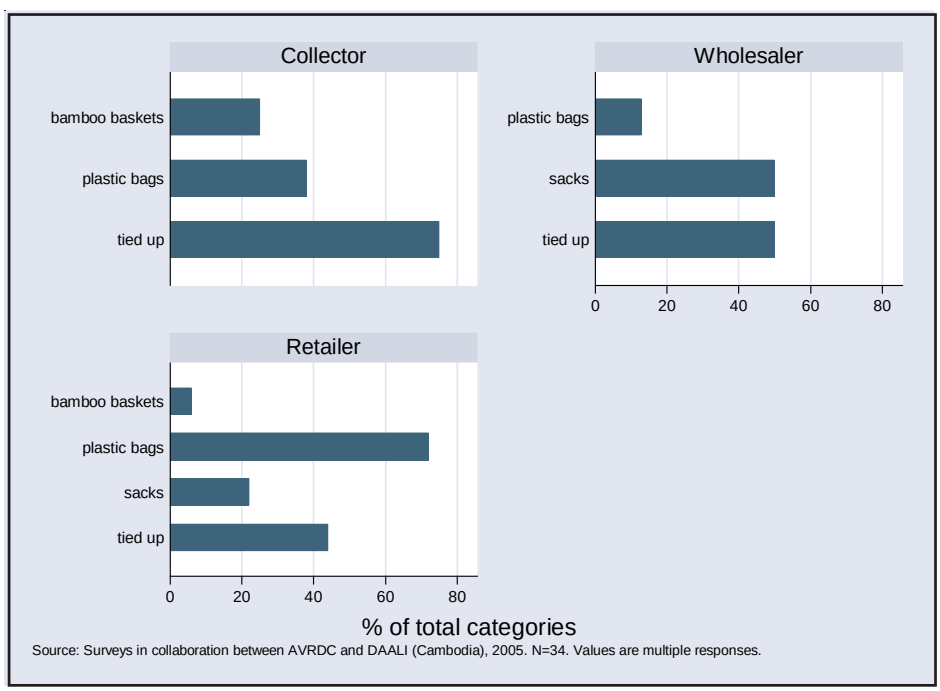

Figure 4-5 Packaging materials for yardlong bean in Cambodia

No farmer is involved in transporting the produce (Table 4-17). In contrast, all collectors have a direct hand in collecting and transporting the produce from farms. Half of the wholesalers pick up the produce by themselves, while 17% of retailers wait for yardlong bean to be delivered to them.

Most farmers transport the produce from the field to the farmhouse on their head, while collectors, wholesalers and retailers rely on motorized vehicles, such as motorbikes or other rented vehicles (Figure 4-6).

Table 4-17 Supply chain actors involved in transporting yardlong bean from their suppliers in Kampong Cham, Cambodia

Supply chain actor	N	%
Collector	8	100
Wholesaler	4	50
Retailer	15	83

Source: Surveys in collaboration between AVRDC and DAALI, 2005. N=50.

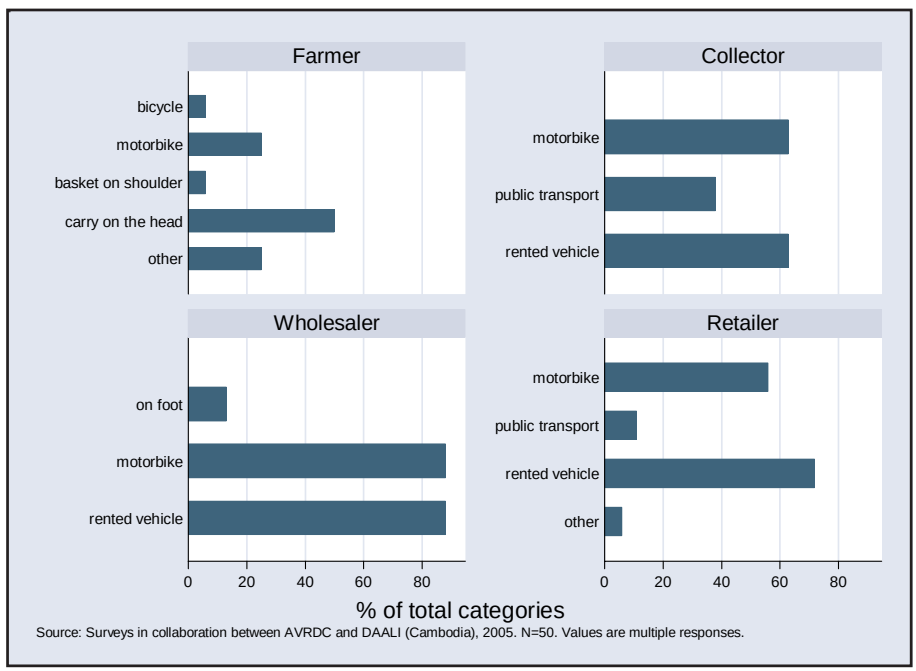

Figure 4-6 Mode of transport of yardlong bean in Cambodia

4.2.3.3 Value-added activities

Almost all supply chain actors (92%) are involved in value-adding activities such as sorting, grading, cleaning, transporting, storage and packing (Table 4-18). While storage is done by all actors, it happens quite often among collectors. All collectors and approximately 80% of the actors clean the produce once it reaches them. Transporting is done by all collectors, consistent with the result in Table 4-17. It is noteworthy to mention that collectors do more value-adding activities compared with the other actors.

Table 4-18 Involvement of supply chain actors in value-adding activities for yardlong bean in Cambodia

Supply chain actor	Involved (%)	Not involved (%)
Farmer	94	6
Collector	100	
Wholesaler	88	13
Retailer	89	11
Mean	92	8

Source: Surveys in collaboration between AVRDC and DAALI , 2005. N=50.

4.3 Cucumber

4.3.1 Economic importance and the supply chain

Cucumber is similarly a major crop of economic importance in the surveyed locations. According to Abedullah *et al.* (2002), cucumber is the most important vegetable crop by area. Of the 64 farmer-respondents, 25 (39%) are engaged in cucumber production, and more than half of all collectors (54%) and 15 wholesalers (38%) are involved in cucumber trade.

Cucumber supply chain is relatively simple. Farmers sell their produce to collectors, who, in turn, sell most of it to wholesalers. From the wholesalers, the produce is mainly sold to wet market vendors, who sell to private households (Figure 4-7).

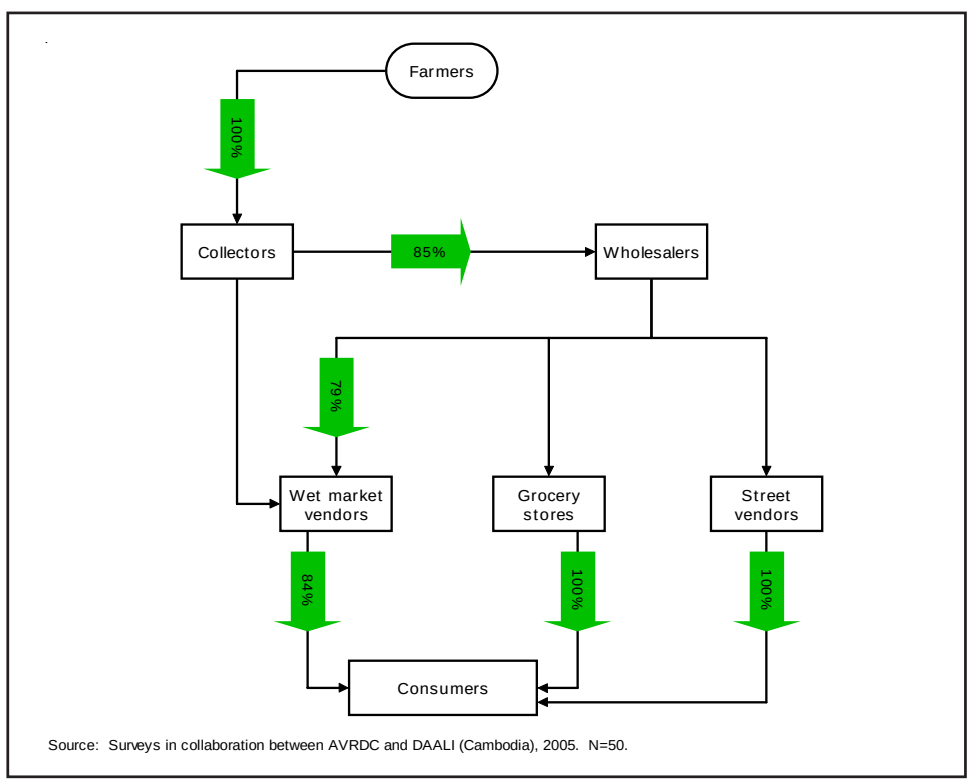

Figure 4-7 Main trading partners in the supply chain of cucumber in Cambodia

In terms of quantities followed through the supply chain, cucumber ranks second to tomato underlining its economic importance. Over the year (September 2004 to August 2005), the respondents traded with 2,146 MT of cucumber equivalent to US$ 308 thousand (Table 4-19). Peak harvesting time is November, February and March. Cucumber accounts for approximately 27% of total sales for farmers, 55% for collectors and 24% for wholesalers. A relatively large share of total annual turnover for collector-respondents is based on cucumber turnover, indicating that there is a relatively large degree of specialization for this crop.

Table 4-19 Monthly sales of cucumber in Cambodia, 2004-2005

Month	Farmer		Collector		Wholesaler		Retailer		Total	
	Quantity (MT)	Sales ('000 US$)	Quantity (MT)	Sales ('000 US$)	Quantity (MT)	Sales ('000 US$)	Quantity (MT)	Sales ('000 US$)	Quantity (MT)	Sales ('000 US$)
Sep-04	0.8	0.1	154.2	20.2	42.2	10.5	5.0	1.4	202.2	32.2
Oct-04			155.0	21.1	41.0	10.0	4.9	1.2	200.9	32.3
Nov-04	14.1	1.1	125.2	16.6	38.9	8.2	4.5	0.9	182.7	26.8
Dec-04			118.5	16.2	31.9	5.1	4.8	1.0	155.2	22.3
Jan-05	2.8	0.2	79.0	10.2	31.8	4.7	4.6	0.9	118.2	16.0
Feb-05	16.0	1.1	190.0	21.8	32.9	5.5	5.3	1.1	244.2	29.5
Mar-05	13.0	1.0	157.9	16.8	33.1	5.7	4.7	1.0	208.7	24.5
Apr-05	4.7	0.3	179.3	20.0	44.9	9.1	5.5	1.2	234.4	30.6
May-05			109.4	13.5	42.9	8.0	4.7	1.0	157.0	22.5
Jun-05	4.5	0.3	100.9	12.7	44.1	8.3	4.5	1.0	154.0	22.3
Jul-05	3.0	0.2	95.0	13.0	34.0	7.0	5.0	1.1	137.0	21.3
Aug-05	0.8	0.1	109.9	18.0	35.7	8.1	5.3	1.3	151.7	27.5
Total	59.7	4.3	1574.5	200.3	453.4	90.1	58.7	13.1	2146.3	307.8
% share to total sales		27.0		55.1		24.0		9.9		

Source: Surveys in collaboration between AVRDC and DAALI, 2005. N=434 observations.

4.3.2 Postharvest losses

About 92% of farmers, all collectors and wholesalers, and 89% of the retailers experienced postharvest loss in cucumber estimated at 63, 42, 48 and 44 kg per MT, respectively (Table 4-20). Similar with the other crops, losses are highest during the wet season compared with the rest of the year due to higher losses at the farm level, although the differences between supply chain actors are not as large as the other crops. On average, for every MT of cucumber produced, 197 kg (or nearly 20%) are lost before the produce finally reaches the consumers.

Approximately half of the farmers (54%) used partially spoiled product on the farm or in the household. All traders and retailers, and about 75% of the farmers sell partially spoiled produce at a lower price. Farmers reduce price by 36% and 40%, and collectors by 43% and 41% during the wet and dry seasons, respectively. Wholesalers and retailers reduce price by 27% and 28%, respectively.

The three main reasons for postharvest loss at the farm are insect (46%) and worm infestation (11%), subsumed under 'others', as well as diseases and extreme weather conditions during harvest (Table 4-21). In focus group discussions, farmers mentioned the poor quality of seeds that they are using. For traders, losses arise when they cannot sell all the produce during the day, in addition to the produce's poor quality during purchase from suppliers (Table 4-22). Wholesalers pointed out during the focus group discussions that packaging cucumber in plastic bags leads to high loss due to moisture build-up.

Table 4-20 Postharvest loss estimates of cucumber in the supply chain in Cambodia

Parameter	Farmer	Collector	Wholesaler	Retailer
% share with loss	92	100	100	89
Loss values				
- kg per MT	63	42	48	44
- % loss				
Dry 1	5	4	4	4
Dry 2	5	5	4	5
Wet	9	4	5	4
Average	6	4	5	4
Median	5	4	3	3
Damaged/partially spoiled produce				
Sell at reduced price (%)	75	100	100	100
Price reduction in Dry season (%)	40	41	27	28
Price reduction in Wet season (%)	36	43	27	

Source: Surveys in collaboration between AVRDC and DAALI, 2005. N=434 observation. Seasons are based on the months of first harvest or sale. Dry season 1 is November to January; Dry season 2, February to April; and Wet season, May to October.

Table 4-21 Main reasons for cucumber postharvest loss at farm level in Cambodia

Reason	Dry 1		Dry 2		Wet		Total	
	N	%	N	%	N	%	N	%
No damage			2	20			2	8
Hot weather during harvest	2	33	4	40	5	50	11	42
Humid weather during harvest					2	20	2	8
Diseases	2	33	3	30	7	70	12	46
Damage during harvest			2	20	1	10	3	12
Poor quality of variety					1	10	1	4
Other reason of spoilage	6	100	5	50	4	40	15	58
Total	6	100	10	100	10	100	26	100

Source: Surveys in collaboration between AVRDC and DAALI, 2005. N=26 observations. Values are multiple responses. See additional notes in Table 4-20.

Table 4-22 Main reasons for cucumber postharvest loss at the trader and retailer levels in Cambodia

Reason	Collector		Wholesaler		Retailer		Total	
	N	%	N	%	N	%	N	%
Poor packaging	1	13	3	38	4	22	8	24
High temperature in storage facility	2	25	1	13	6	33	9	26
High humidity in storage facility	2	25			1	6	3	9
Poor hygiene conditions					1	6	1	3
Poor infrastructure facilities	3	38	1	13	3	17	7	21
Cannot sell all vegetables	4	50	8	100	16	89	28	82
Poor quality of purchased vegetable crop	7	88	5	63	5	28	17	50
No loss					2	11	2	6
Total	8	100	8	100	18	100	34	100

Source: Surveys in collaboration between AVRDC and DAALI, 2005. N=34. Values are multiple responses.

Different actors employ different measures to reduce postharvest loss along the supply chain (Table 4-23). Overall, it can be observed that the ratio of percentages for single answer options is lower for this crop compared with the other crops. Results show that farmers spray water on harvest; however, one focus group pointed out otherwise. Collectors and wholesalers either observe care during transport or simply do nothing, while retailers mainly ensure good hygiene conditions in their area.

Table 4-23 Measures to prevent loss of cucumber along the supply chain in Cambodia

Measure	Farmer		Trader		Retailer		Total	
	N	%	N	%	N	%	N	%
Harvest during cool weather/ demand time of harvest	7	44	3	19			10	20
Careful harvest/ demand careful harvest	6	38	3	19			9	18
Spray water on harvest	9	56					9	18
Observe care during transport	3	19	7	44			10	20
Harvest after buyer has been identified	3	19					3	6
Collect during cool weather			2	13			2	4
Observe care in packaging			4	25	6	33	10	20
Ensure cool temperature in storage area	1	6	5	31	2	11	8	16
Good hygiene conditions					9	50	9	18
Don't buy more than what is needed					2	11	2	4
Buy high quality vegetable crop					6	33	6	12
Do nothing			7	44	5	28	12	24
Other preventive measures	1	6					1	2
Total	16	100	16	100	18	100	50	100

Source: Surveys in collaboration between AVRDC and DAALI, 2005. N=50. Values are multiple responses.

During focus group discussions, farmers identified the need for high quality seed as well as packaging and storage techniques. These were also aired by collectors and wholesalers. In addition, collectors raised the possibility of using chemicals to prolong shelf life and processing technologies.

4.3.3 From production to value-added activities

4.3.3.1 Production

The average yield recorded for cucumber is 14.6 MT per ha, approximately two-thirds of that in Lao PDR (Table 4-24). The average area under cucumber production is 1,712 m^2, and the average selling price is US$ 73 per MT, approximately US$ 20 less than the selling price in Lao PDR. The average value of cucumber sales is US$ 165 per cropping cycle.

Three harvest seasons were noted: between January and April, between June and September, and November. In general, farmers themselves are responsible for harvesting. No collector or wholesaler harvest the produce. Total duration of harvest is 23 days.

4.3.3.2 Storage, packaging and transport

After harvest, 63% of farmers store the harvested cucumber on the ground under the shade, and the rest, mainly on mats. The produce is held for about four hours at the farm before being sold to collectors (Table 4-25). Collectors, wholesalers and retailers keep the produce for an average of five, eight and four hours, respectively. In total, approximately 21 hours is the elapsed time between harvest and sale to consumers .

All collectors receive the produce in sacks from the suppliers. Between collectors and wholesalers, sacks are the most prevalent form of packaging. Retailers receive the produce mostly in plastic bags (Figure 4-8).

Table 4-24 Average yield, production area, selling price and sales of cucumber by season in Kampong Cham, Cambodia

Parameter	Season	Mean	SD
Yield (MT/ha)	Wet	10.7	6.0
	Dry 1	14.4	5.2
	Dry 2	17.9	5.2
	Mean	14.6	6.1
Production area (m^2)	Wet	1,463	1,122
	Dry 1	1,500	501
	Dry 2	2,080	1,054
	Mean	1,712	955
Selling price (US$/MT)	Wet	69.9	9.2
	Dry 1	76.3	14.6
	Dry 2	71.8	6.3
	Mean	72.6	10.2
Sales (US$)	Wet	75.3	24.9
	Dry 1	153.6	80.9
	Dry 2	245.1	129.5
	Mean	164.7	115.0

Source: Surveys in collaboration between AVRDC and DAALI, 2005. N=26 observations. See additional notes in Table 4-20.

Table 4-25 Number of hours between harvest/purchase and sale of cucumber at different levels in the supply chain in Kampong Cham, Cambodia

Supply chain actor	Mean	SD
Farmer	3.7	1.5
Collector	5.2	2.5
Wholesaler	8.0	7.0
Retailer	3.6	7.2
Total	20.5	18.2

Source: Surveys in collaboration between AVRDC and DAALI, 2005. N=434 observations

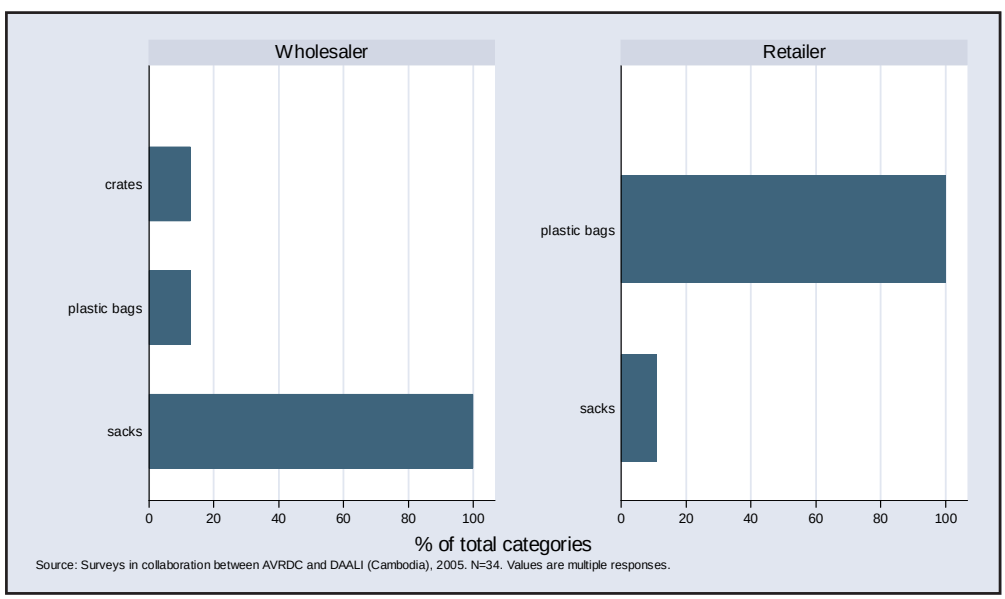

Figure 4-8 Packaging materials for cucumber in Cambodia

Only collectors and retailers are involved in the transport of cucumber (Table 4-26). No farmer or wholesaler respondent reported direct involvement in product transport.

Farmers usually transport cucumber to the farm in baskets by foot (Figure 4-9). In certain cases, cucumber is transported in hand tractors, bicycles and motorbikes. Collectors usually rely on motorbikes, cars and other rented vehicles, while retailers, rented vehicles. Suppliers for wholesalers usually deliver the produce in rented vehicles.

Table 4-26 Supply chain actors involved in transporting cucumber from their suppliers in Kampong Cham, Cambodia

Supply chain actor	N	%
Collector	8	100
Retailer	17	94

Source: Surveys in collaboration between AVRDC and DAALI, 2005. N=50.

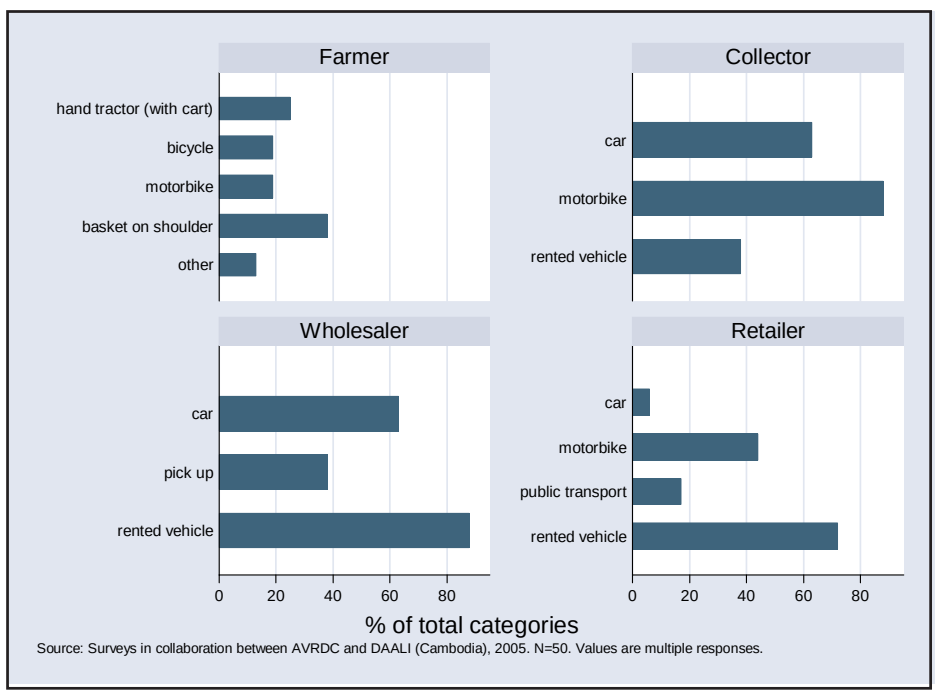

Figure 4-9 Mode of transport of cucumber in Cambodia

4.3.3.3 Value-added activities

Around 34% of supply chain actors are not involved in value-adding activities for cucumber reflecting a higher degree of non-involvement compared with other crops. Again, involvement of collectors is greater than the other actors (Table 4-27). The most common activities are sorting, grading, cleaning, transporting, storage and packing. Pre-cooling is done only at the retailer level. Wholesalers do not repack and deliver cucumber to their buyers.

Table 4-27 Involvement of supply chain actors in value-adding activities for cucumber in Cambodia

Supply chain actor	Involved (%)	Not involved (%)
Farmer	63	38
Collector	100	
Wholesaler	50	50
Retailer	61	39
Mean	66	34

Source: Surveys in collaboration between AVRDC and DAALI, 2005. N=50.

4.4 Chinese kale

4.4.1 Economic importance and the supply chain

Although it is not reported as a major cultivated crop in Cambodia (Abedullah *et al.*, 2002), Chinese kale is being identified with economic importance in the surveyed locations. Of the 64 farmer-respondents, 27 (42%) are engaged in Chinese kale production. Half of the collectors and 43% of wholesalers are involved in Chinese kale marketing and trade.

Compared to the other three crops, Chinese kale has a rather complicated supply chain that involves many possible pathways (Figure 4-10). Farmers usually sell their produce to collectors. Collectors sell to other collectors, to wholesalers or directly to wet market vendors and supermarkets. Unlike the other crops in which the wet market is an important selling point to consumers, Chinese kale is usually sourced by consumers from supermarkets, street vendors or grocery stores.

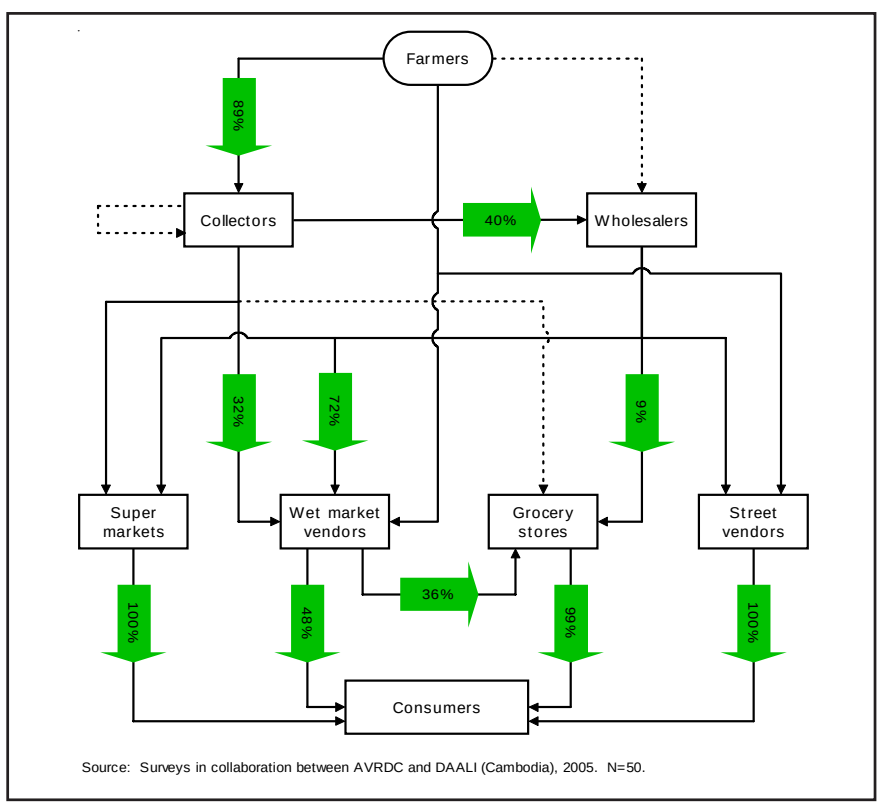

Figure 4-10 Main trading partners in the supply chain of Chinese kale in Cambodia

Survey results highlight the economic importance of Chinese kale based on quantity (1,520 MT) and sales (US$ 476 thousand) which are higher than that for tomato and cucumber (Table 4-28). Harvesting occurs during the entire year with peak levels in September, February and May. A relatively large share of total annual turnover for collectors is based on Chinese kale turnover, indicating that there is a relatively large degree of specialization for this crop.

Table 4-28 Monthly sales of Chinese kale in Cambodia, 2004-2005

Month	Farmer		Collector		Wholesaler		Retailer		Total	
	Quantity (MT)	Sales ('000 US$)	Quantity (MT)	Sales ('000 US$)	Quantity (MT)	Sales ('000 US$)	Quantity (MT)	Sales ('000 US$)	Quantity (MT)	Sales ('000 US$)
Sep-04	24.7	7.9	31.8	17.2	49.1	23.8	7.2	4.9	112.8	53.8
Oct-04	2.3	0.5	34.5	18.2	52.1	21.7	6.9	4.2	95.8	44.6
Nov-04	9.0	1.9	57.4	16.1	50.1	20.8	7.0	3.9	123.5	42.7
Dec-04	1.9	0.4	37.3	9.2	45.4	15.6	6.9	2.9	91.5	28.1
Jan-05	2.9	0.6	41.7	7.7	58.0	12.0	6.9	2.4	109.5	22.7
Feb-05	27.6	7.0	54.6	9.4	72.3	15.1	7.2	2.9	161.7	34.4
Mar-05	8.6	2.1	52.2	10.6	70.7	15.9	6.3	2.6	137.8	31.2
Apr-05	6.8	1.4	42.9	11.4	80.9	30.9	7.6	3.3	138.2	47.0
May-05	18.0	3.9	56.6	15.4	75.1	26.1	6.1	2.5	155.8	47.9
Jun-05	3.4	0.7	55.1	13.6	73.4	23.9	6.1	2.6	138.0	40.8
Jul-05	1.9	0.3	53.3	14.8	72.8	20.1	7.2	3.4	135.2	38.6
Aug-05	3.8	0.8	40.6	14.4	68.4	24.7	7.4	4.1	120.2	44.0
Total	110.9	27.5	557.9	158.0	768.1	250.7	82.8	39.8	1519.7	476.0
% share to total sales		32.4		70.7		52.6		1.4		

Source: Surveys in collaboration between AVRDC and DAALI, 2005. N=440 observations.

4.4.2 Postharvest losses

Ninety percent of farmers, all collectors and wholesalers, and 94% of retailers incur losses due to spoilage (unmarketable yield) estimated at 37, 31, 44 and 52 kg per MT produce, respectively (Table 4-29). Loss for Chinese kale, as opposed to the other crops in the study, increases towards the end of the dry season. For this crop, as with cucumber, losses are relatively equally distributed across the supply chain, although it slightly increases as Chinese kale reaches wholesalers and retailers. In total, the average losses for this crop are lower compared with the other three crops. For every MT of Chinese kale that is being produced, 164 kg (or 16%) are lost before the produce reaches the consumer.

Only 21% of the farmers used partially spoiled product on the farm or in the household, while 65% sell partially spoiled produce at a lower price. For partially spoiled produce, farmers reduce prices by 42% and 50%, collectors by 34% and 37%, wholesalers by 27%, and retailers by 20% during the wet and dry seasons, respectively.

Farmers on average provided two to three reasons for incurring losses. More prominent reasons are hot weather during harvest, disease infection and high humidity during harvest time (Table 4-30). For traders, main reasons for losses are failure to sell in the same day, high temperature in storage facilities and poor quality of produce at the time of purchase (Table 4-31). In the focus group discussion, collectors pointed out that leaving Chinese kale inside the baskets for longer periods contribute to loss.

Table 4-29 Postharvest loss estimates of Chinese kale in the supply chain in Cambodia

Parameter	Farmer	Collector	Wholesaler	Retailer
% share with loss	90	100	100	94
Loss values				
- kg per MT	37	31	44	52
- % loss				
Dry 1	4	3	4	5
Dry 2	4	3	6	5
Wet	3	3	4	5
Average	4	3	4	5
Median	3	3	3	4
Damaged/partially spoiled produce				
Sell at reduced price (%)	65	100	100	100
Price reduction in Dry season (%)	50	37	27	20
Price reduction in Wet season (%)	42	34	27	

Source: Surveys in collaboration between AVRDC and DAALI, 2005. N=440 observation. Seasons are based on the months of first harvest or sale. Dry season 1 is November to January, Dry season 2; February to April; and Wet season, May to October.

Table 4-30 Main reasons for Chinese kale postharvest loss at farm level in Cambodia

Reason	Dry 1		Dry 2		Wet		Total	
	N	%	N	%	N	%	N	%
No damage			1	8	2	13	3	9
Hot weather during harvest	5	100	10	83	11	73	26	81
Humid weather during harvest	1	20	7	58	9	60	17	53
Diseases	4	80	9	75	11	73	24	75
Damage during harvest			2	17	4	27	6	19
Poor quality of variety			1	8	1	7	2	6
Other reason of spoilage	1	20	2	17	1	7	4	13
Total	5	100	12	100	15	100	32	100

Source: Surveys in collaboration between AVRDC and DAALI , 2005. N=32 observations. Values are multiple responses. See additional notes in Table 4-29.

Table 4-31 Main reasons for Chinese kale postharvest loss at trader and retailer levels in Cambodia

Reason	Collector		Wholesaler		Retailer		Total	
	N	%	N	%	N	%	N	%
Poor packaging	3	50	5	45	2	12	10	29
High temperature in storage facility	3	50	7	64	13	76	23	68
High humidity in storage facility	1	17	2	18	5	29	8	24
Low humidity in storage facility			1	9			1	3
Poor hygiene conditions	2	33	2	18	3	18	7	21
Poor infrastructure facilities	2	33	2	18			4	12
Cannot sell all vegetables	3	50	10	91	12	71	25	74
Poor quality of purchased vegetable crop	3	50	3	27	9	53	15	44
No loss					1	6	1	3
Total	6	100	11	100	17	100	34	100

Source: Surveys in collaboration between AVRDC and DAALI, 2005. N=34. Values are multiple responses.

Postharvest loss reduction measures differ with supply chain actors (Table 4-32). More than 50% of farmer-respondents spray water on the produce or observe care during harvesting, while collectors and wholesalers ensure cool temperatures in storage areas or collect the produce during cool weather. Most retailers also ensure cool temperature in storage areas and, at the same time, buy high quality produce and employ hygienic practices.

During focus group meetings, farmers pointed out the need to improve methods to store Chinese kale. Collectors raised the need to improve farmers' production practices to reduce losses. In addition, collectors also believed that if cold storage is fairly available, storage time could be substantially increased. In the current situation, Chinese kale can only be kept for two to three days after harvest before it spoils. Collectors further pointed out the current packaging problem and suggested the need to repackage the produce in smaller units of 10- or 20-kg packs. Retailers suggested that cleaning before packing in baskets could increase storage life.

Table 4-32 Measures to prevent loss of Chinese kale along the supply chain in Cambodia

Measure	Farmer		Trader		Retailer		Total	
	N	%	N	%	N	%	N	%
Harvest during cool weather/ demand time of harvest	7	44	8	47			15	30
Careful harvest/ demand careful harvest	9	56	7	41			16	32
Spray water on harvest	14	88	2	12			16	32
Observe care during transport	3	19	6	35			9	18
Harvest after buyer has been identified	3	19					3	6
Collect during cool weather			9	53			9	18
Observe care in packaging			8	47	5	29	13	26
Ensure cool temperature in storage area	2	13	11	65	13	76	26	52
Low humidity in storage area					4	24	4	8
Good hygiene conditions					9	53	9	18
Don't buy more than what is needed					3	18	3	6
Buy high quality vegetable crop					9	53	9	18
Do nothing			1	6	1	6	2	4
Other preventive measures			1	6			1	2
Total	16	100	17	100	17	100	50	100

Source: Surveys in collaboration between AVRDC and DAALI, 2005. N=50. Values are multiple responses.

4.4.3 From production to value-added activities

4.4.3.1 Production

Mean yield recorded is 16.8 MT per ha, while mean production area is 3,011 m^2. Average selling price is US$ 243 per MT, and the average sale is US$ 862 per cropping cycle (Table 4-33).

Harvesting is done every month of the year. A number of farmers and four out of six collectors manage the harvest operation. One out of eleven wholesalers also do harvesting on the farm. Harvesting duration is only six days, much shorter than the other three crops.

4.4.3.2 Storage, packaging and transport

Among farmer-respondents, 52% store the produce on the ground under the sun, 29% on the ground in shaded area and 19% in baskets after harvest. The produce is held at the farm for about five hours before being sold to collectors (Table 4-34). Collectors keep the produce for an average of four hours in Phnom

Penh and nine hours in Kandal. At the wholesalers' level, the produce stays for an average of nine hours in Phnom Penh and four hours in Kandal. In both areas, the produce stays for about three hours at the retailers' level. The total time elapsed between harvest and sale to consumers is 21 hours in Kandal, and 16 hours between collection and sale to consumers in Phnom Penh.

All farmers and most collectors pack the produce in bamboo baskets (Figure 4-11). Styrofoam boxes are also used regularly rather than sacks and plastic bags. Most wholesalers use bamboo baskets and, in fewer instances sacks and plastic bags. Retailers' main packaging container is a plastic bag.

Farmers transport the harvested produce from the field to the farmhouse on foot, motorbike or hand tractor with cart (Figure 4-12). Collectors use car, mini-truck or rented vehicle. Most wholesalers use the same transport media as with collectors except with greater reliance on public transport. Retailers rely heavily on rented vehicles or motorbikes to transport the produce. These are especially prevalent in Kandal where collectors and retailers do most of the transporting while wholesalers simply wait for deliveries (Table 4-35). In Phnom Penh, some collectors wait for deliveries from their suppliers. One wholesaler transports the produce by himself. Retailers usually pick up the produce by themselves.

Table 4-33 Average yield, production area, selling price and sales of Chinese kale by season in Kandal, Cambodia

Parameter	Season	Mean	SD
Yield (MT/ha)	Wet	16.7	18.4
	Dry 1	14.5	1.9
	Dry 2	17.9	14.0
	Mean	16.8	15.0
Production area (m^2)	Wet	3,285	4,280
	Dry 1	1,960	1,181
	Dry 2	3,106	4,770
	Mean	3,011	4,092
Selling price (US$/MT)	Wet	263.3	108.6
	Dry 1	198.7	45.3
	Dry 2	236.4	53.1
	Mean	243.1	84.4
Sales (US$)	Wet	943.5	893.8
	Dry 1	574.5	366.5
	Dry 2	880.9	714.6
	Mean	862.4	758.9

Source: Surveys in collaboration between AVRDC and DAALI, 2005. N=32 observations.

Table 4-34 Number of hours between harvest/purchase and sale of Chinese kale at different levels in the supply chain in Cambodia

Supply chain actor	Phnom Penh		Kandal		Total	
	Mean	SD	Mean	SD	Mean	SD
Farmer			4.8	2.9	4.8	2.9
Collector	4.0	2.3	9.2	2.6	6.6	3.5
Wholesaler	8.8	2.8	4.0	1.9	6.2	3.4
Retailer	2.9	1.0	2.7	2.9	2.8	2.1
Total	15.7	6.1	20.7	10.3	20.4	11.9

Source: Surveys in collaboration between AVRDC and DAALI, 2005. N=440 observations.

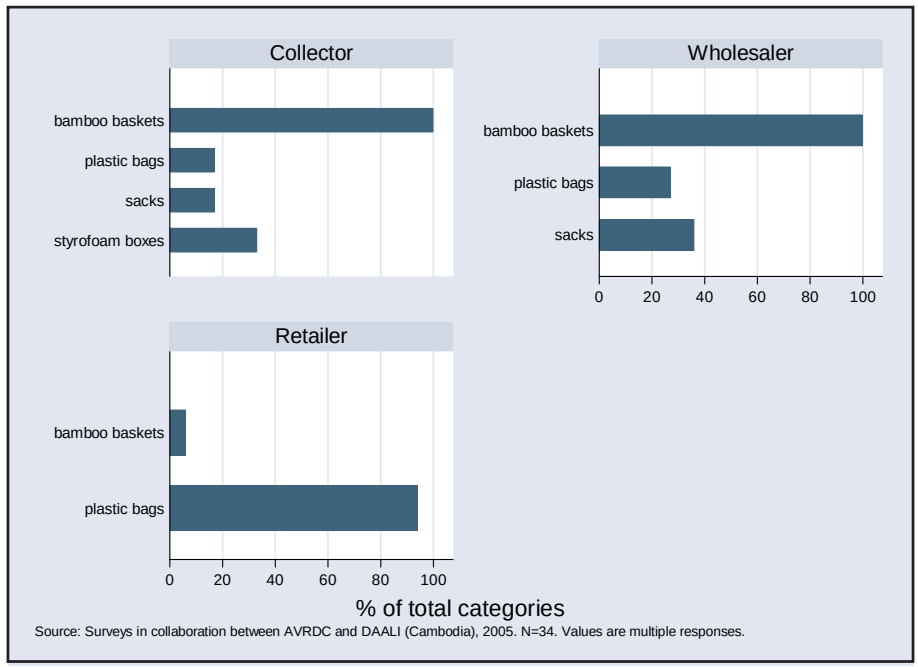

Figure 4-11 Packaging materials for Chinese kale in Cambodia

Table 4-35 Supply chain actors involved in transporting Chinese kale from their suppliers in Cambodia

Supply chain actor	Phnom Penh		Kandal		Total	
	N	%	N	%	N	%
Farmer			7	44	7	44
Collector	1	33	3	100	4	67
Wholesaler	1	20			1	9
Retailer	8	89	8	100	16	94

Source: Surveys in collaboration between AVRDC and DAALI, 2005. N=50.

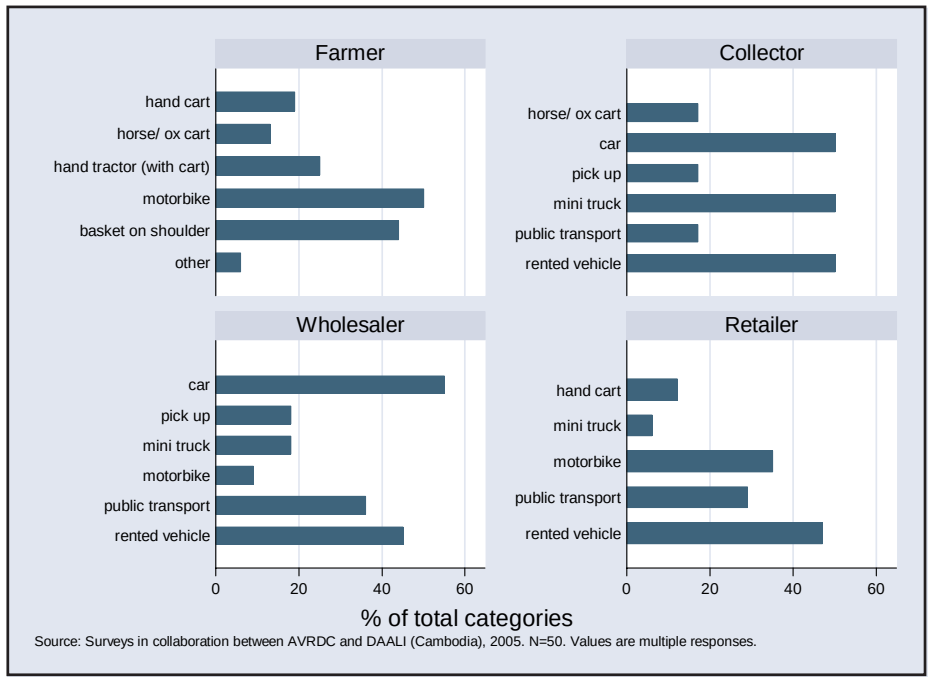

Figure 4-12 Mode of transport of Chinese kale in Cambodia

4.4.3.3 Value-added activities

Almost all supply chain participants (96%) are involved in value-adding activities (Table 4-36). The most common activities are sorting, grading, cleaning, transporting, storage, pre-cooling and packing. While storage is done at all the chain levels, it is less emphasized at the collectors' level. Most chain actors clean the produce. Pre-cooling and packing are also done in all levels of the supply chain, although the former is minimal at the farm level.

Table 4-36 Involvement of supply chain actors in value-adding activities for Chinese kale in Cambodia

Supply chain actor	Involved (%)	Not involved (%)
Farmer	100	
Collector	100	
Wholesaler	91	9
Retailer	94	6
Mean	96	4

Note: Surveys in collaboration between AVRDC and DAALI , 2005. N=50.

5 Discussion

To obtain a value of loss experience, actual loss in kg was multiplied by the average selling price (Table 5-1). This value was divided by the total quantity of vegetables produced or purchased by each actor in kg, to obtain a value of loss based on a uniform denominator, and added across all actors in the supply chain. The loss value for each kg produced or handled is similarly high for Chinese kale, yardlong bean and tomato at around US$ 60 per MT, as compared to that for cucumber (US$ 28 per MT).

Since individual crop production data for Cambodia is not available, values of daily market transactions in Phnom Penh were used and extrapolated for the entire year to obtain total annual value of loss for individual crops (data for Chinese kale was not available). If market transactions in Phnom Penh are a good indicator of total vegetable sales in Cambodia, then total economic value of postharvest loss in cucumber is very high due to the large quantities traded for this crop.

In addition, the average value of loss was used to calculate the value of total postharvest loss for major vegetables in Phnom Penh market only. This is around US$ 1.8 million on an annual basis. Total annual vegetable production in Cambodia is approximately 481,250 MT (FAO, 2006). Based on the average loss value calculated above, total postharvest losses in vegetables have an average value of US$ 24.6 million per annum.

Table 5-1 provides an overview on possible strategies to reduce postharvest loss in vegetables. The table shows that the economic value of loss in cucumber ($28.4) is lower than in the other three crops. Interventions to reduce postharvest loss should thus focus on tomato, yardlong bean, or Chinese kale. While the economic loss is highest at the level of retailers (because they sell the largest quantities of vegetables), farmers bear a high share in the overall loss (Table 4-2, Table 4-11, Table 4-20). Interventions should thus focus on farmers to allow them to reduce their loss. Focus could especially be placed on improving harvesting and packaging practices. Particular emphasis could be placed on quickly removing field heat in harvested crop and on simple structures for evaporative cooling, to reduce quality deterioration at the beginning of the supply chain.

Table 5-1 Average loss in US$ per MT of produce dealt with in Phnom Penh market

Supply chain actor	Tomato	Yardlong bean	Cucumber	Chinese kale	Average
Farmer	13.7	13.7	4.6	8.9	10.1
Collector	3.7	9.1	5.4	9.6	7.2
Wholesaler	17.1	11.5	8.6	16.3	14.1
Retailer	22.1	23.5	9.8	24.4	19.8
Total	56.6	57.8	28.4	59.2	51.2
Annual market transactions, Phnom Penh (2003)[a] in MT	3,089	2,221	9,698		34,540
Annual value of loss (US$)	174,837	128,374	275,423		1,768,448

Source: Surveys in collaboration between AVRDC and DAALI, 2005. N=200. [a] Sokhen, Kanika and Moustier (2004).

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