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LOGISTIC VALUE CHAIN ANALYSIS AS AN APPROACH TO MODELLING TOMATO SUPPLY CHAIN NETWORK: STRUCTURAL MARKET EVIDENCE FROM BHARATPUR METROPOLITAN CITY, NEPAL

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ABSTRACT
This research established a complete framework for tomato value chain (TVC) analysis, thereby facilitating the modeling of the supply chain. Tomato supply chain in Chitwan district of Nepal, due to disorganized marketing channel is facing enormous barriers and obstacles. The central aim of this paper is to investigate the market structure and analyze the value chain so as to prioritize the most effective approach to modify the supply chain. Bharatpur metropolitan city of Chitwan district of Nepal was selected as our study area due to high involvement of potential farmers in tomato sector. A total of 180 respondents were interviewed, including farmers, traders, processors, distributors, and consumers and the data were analyzed using both descriptive and analytical statistics. The study was based on redesigning Porter's value chain for tomato production, processing, and marketing, which can be applied in strengthening the supply chain network. As an economic approach, profitability analysis (B:C ratio, breakeven point), degree of value addition, margin distribution, and price spread were analyzed. Likert-scaling technique was applied for determining the problems in tomato sector. Value addition was found to substantially contribute to effective supply chain management in agricultural sector. The results revealed that the B/C ratio and break-even price were 2.07 and NRs. 58235 (1 NRs. =0.0085 US$) respectively, indicating that tomato is a profitable enterprise. The evidence further revealed that wholesalers were the most benefited actors along the chain. Farmers were observed to add the maximum value to the product. Several constraints were reported to weaken the marketing channel; price fluctuation, lack of marketing information, wholesaler's dominancy over retailers, and faulty marketing system being the major problems. It is recommended that the government and concerned stakeholders need to focus on formulating the policies regarding marketing channel, determining floor and ceiling price for tomato, and encourage the actors to perform value-addition activities so that consumers can get the maximum utility.

KEY WORDS
Break-even point, margin, marketing, supply chain management, value addition.

The concept of Value chain analysis (VCA) has been globally used as a diagnostic approach to determine and address complex issues across value chains in an agricultural development background (Muflikh et al., 2021). The product is assumed to gain value as it moves from one actor to others in the chain (Hellin and Meijer, 2006). VCA has, over the years, been useful and applicable object of literature in agri-economics and farm management (Abecassis-Moedas, 2006). Value chain (VC) and Supply chain are the interrelated terms. A good VC model systematizes the supply chain of the product. The absolute success of tomato supply chain is believed to be achieved when the functions and actors across the value chain are well coordinated to add value to the final form of tomato for consumers, increasing the profit margin of every actor over the chain. Tomato supply chain is an intricate network, thus needs a more integrative and structural understanding of value

chain models to solve various issues. Nepal, the land of Himalayan, is an agrarian country with approximately 2/3rd (66%) of the population directly engaged in farming (Khanal et al., 2021). Tomato (*Solanum lycopersicum* L.) is the third largest vegetable of Nepal in terms of production, with production of 0.4 million tonnes and productivity of 18.01 tonnes/ha in 2019 (MoALD, 2019). It is mainly grown for consumption as vegetable. Besides, it has health and industrial importance too. It is processed in the industries to manufacture different products. Tomato production involves multiple actors and different factors of production. From production to consumption, the products are supplied through different chain. In case of Nepal, most of the chain components are usually disjoint and there is weak coordination among the supply chain members. This has created chaos in the marketing of the product.

In Nepal, tomato has been consumed for meeting domestic and nutritional food requirement, creation of income for producers, and generation of employment. Despite its critical role in market development, the tomato industry is confronted with a myriad of constraints in view of value addition and supply chain management. The tomato value chain in Nepal is disintegrated into tiered systems and have poor linkages. A plausible explanation for this disintegration is that the farmers are not strongly connected with the end market which limits them to acquire a large producer's share. Moreover, unscrupulous traders and brokers absorb the large share of profit. A good supply and value chain will invariably provide a competitive advantage for an enterprise (Rushton et al., 2010), so will be the case in managed tomato marketing. Competitive advantage is achieved through the creation of value-added product as a result of cooperation between farming communities involved in the distribution activities of the company's products (Walters and Rainbird, 2004). A number of constraints has hindered the effective marketing management of the tomato. These constraints include: land fragmentation, tremendous post-harvest losses, instable and unpredictable income for tomato, market price fluctuation, lack of supporting services such as R&D, lack of marketing information, wholesaler's dominancy over retailers, high influence of middlemen, etc. The farmer cannot move up the value chain due to a lack of supporting services that augment weak horizontal and vertical association in the chain. Lack of intervention from the government, Nepali farmers are prone to unscrupulous trades. Since farmers are the critical actor and central point for tomato supply chain's success, problems faced in value chain and possible ways to modelling the efficient chain system need to be discussed. The trend analysis of the area, production, and yield of tomato for a few years in Chitwan was analyzed (Figure 1) that showed a fluctuation. The yield of tomato increased from 14.34 tonnes/ha in 2012 to 15.57 tonnes/ha in 2019 indicating positive prospects of production.

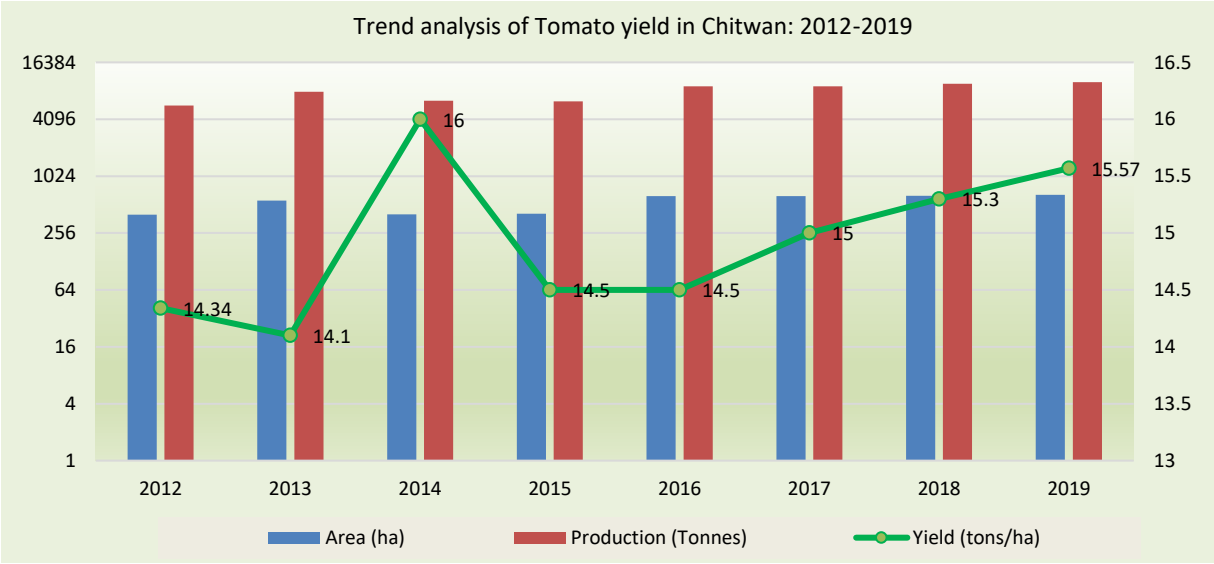

Figure 1 – Trend of tomato production in Chitwan district. Source: MoALD (2012-2020)

Even though tomato is well cultivated in Chitwan district where this study was conducted, the promising potential for tomato value addition and marketing, as well as comparative advantages and existing barriers across the value chain, have not been well documented in order to assess effective value chain development strategies for upgrading tomato value chain. Yet, there is an imbalance between supply and demand of tomato product. Effective strategies will be required to balance the supply and demand gap in the sector. Several researches were already undertaken about value chain analysis of tomato in Nepal, but none of them addressed the use of VCA in modelling the supply chain. Therefore, this study aimed to clarify how the value-added tomato contribute to supply performances of the product to the market and therefore in modelling supply chain. Moreover, the study helps to determine profit margin, degree of value addition, marketing channel, chain's actor relationship, and profitability analysis of tomato in the study area.

THEORETICAL FRAMEWORK

Substantial problems arise in the tomato supply chain (TSC) because of complex connectivity between actors involved in tomato value chain (TVC) and how the value is created and delivered. In a consequence, such problem has nothing to do with a value component that is added, however it has to do with degree of connectivity and value addition that is interrupted. Stronger the mutual relationship among value components, more complex of the problem a supply chain has (Kaplinsky and Morris, 2001). VCA has been widely used by tomato farmers to create high value products that have high market and export potential (Trienekens, 2011).

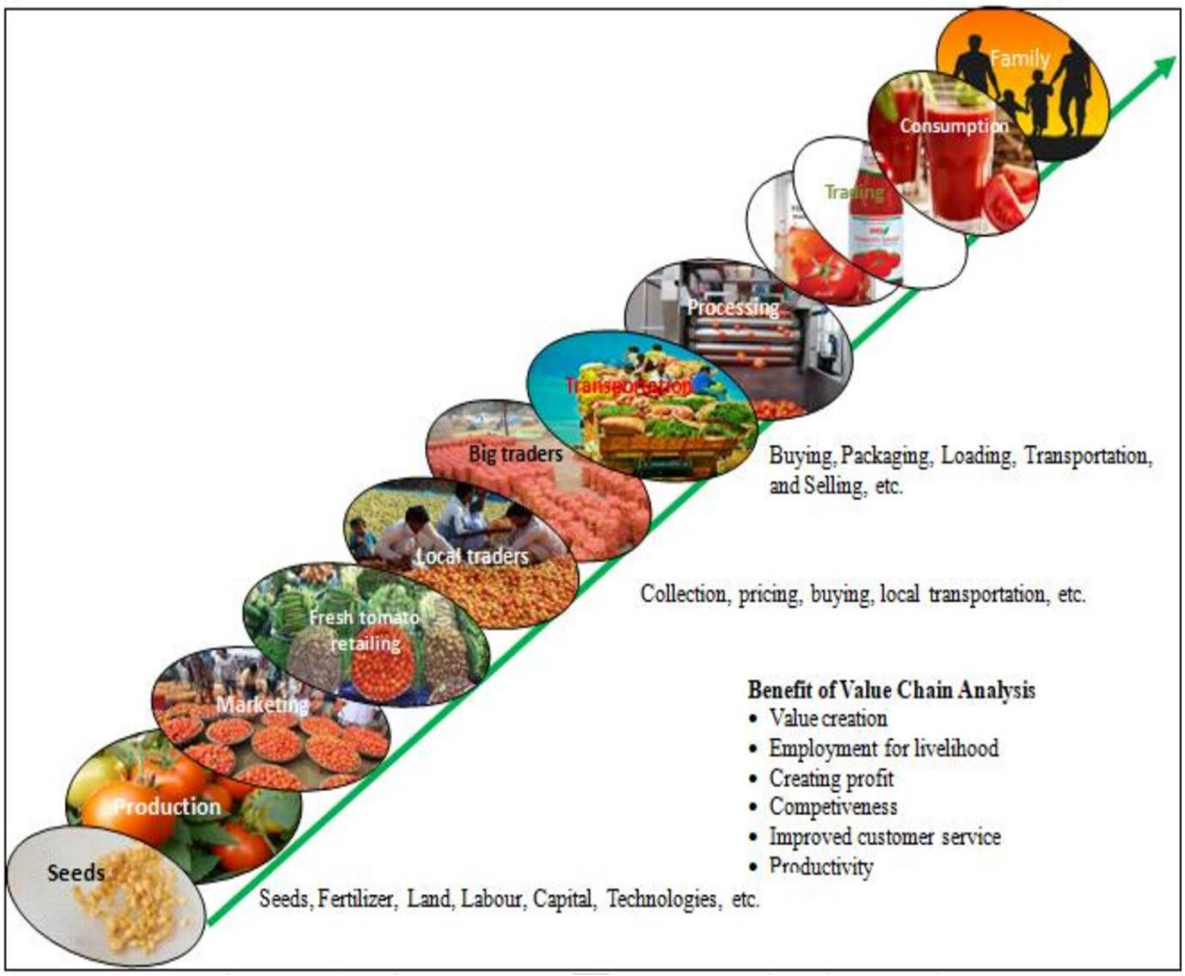

Figure 2 – Sequential activities of tomato value chain Source: Sharma and Ali (2019)

The impact of growth in the tomato business on the farmer depends on how they participate in markets and different stakeholders, either participating just a producer or being active in a large market (Food and Agriculture Organization, 2007). The study of value chain in this study helps to assess the degree of income disparity for different members. Figure 2 delineates the product flows, value adding stages, shows key actors and their relationship in the chain. It signifies the activities from sowing of seeds by the farmers to how it reached to the consumers (family). The major tomato value chain actors identified in the study area were input suppliers, producers, collectors, wholesalers, processors, retailers, consumers and also other value chain supporters. The theoretical framework shows passing of product through different stages of input supply, production, transportation, processing, marketing, distribution, and delivery to the consumers. The value chain phase initiates at the input supply and passes through production up to the final phase. Furthermore, market participation is one of the important components, which is defined as actor's participation in any market associated with activity that supports the sales of tomato product (Adeoti et al., 2014; Otekunrin et al., 2019), which boost income level of farmers resulting in poverty reduction (Ouma et al., 2010).

The objective of the present study is to employ a value chain mapping approach as a model to strengthen the tomato supply chain. Our research aims to explain about importance of value addition in supply chain management, primary and secondary activities during tomato production, processing and marketing, and logistics outsourcing. However, the secondary objectives were to calculate pthe rice spread of the supply chain, identify bottlenecks faced by different actors in the chain, and policy implications for the improvement in the existing marketing system. With the complex nature of this scope in mind and the literature discussion above, the following research questions were formulated:

RQ 1: What is the structure (actors–material–channels–product) and the key issues (interrelations and interactions) in the tomato supply chain?

RQ 2: How can the term value chain be defined and applied to supply chain modeling?

RQ 3: Is there a relationship between the value addition activities and the supply chain management, and long-term economic success?

RQ 4: What is the margin distribution, upgrading required in the product to add value, and market opportunities and constraints?

MATERIALS AND METHODS OF RESEARCH

The paper was designed to study the modeling of the supply chain of tomato products through value addition at different stages of production. In keeping with the objectives of the research, the rationale for selecting Bharatpur metropolitan city as a study site is mainly attributed to the high involvement of small households in the tomato sector, presence of a clear supply chain and value addition activities, adequacy of input resources in the market, the high scope for both export and expanding the local market for tomato enterprises, and ample scope for improvement in the sector. In this section, we include the methodological approach employed, data, and research design. The diagram provides a complete view of the research methodology used to conduct this study. The complete flow of research methodology has been organized in figure 3. The paper ends with the main conclusions, insights, and recommendations.

The study was conducted in several villages of Bharatpur metropolitan city of Chitwan district, which is located in central southern part of Bagmati province of Nepal. Bharatpur is the headquarter of Chitwan district, and is the 5th largest city of Nepal, covering the area of 433 km^2, with latitude 27° 40' 59.99" N and longitude 84° 25' 59.99" E. The economy of the study area is traditionally based on agriculture. It holds several small-scale processing industries that mostly process the food surpluses of the Chitwan district. The study district shares its border with India in the south (Figure 4). The presence of Chitwan National Park, which is listed in UNESCO world heritages list, has increased the popularity of the district, globally. This area was purposively selected for this study because of its highest tomato production potential in the country.

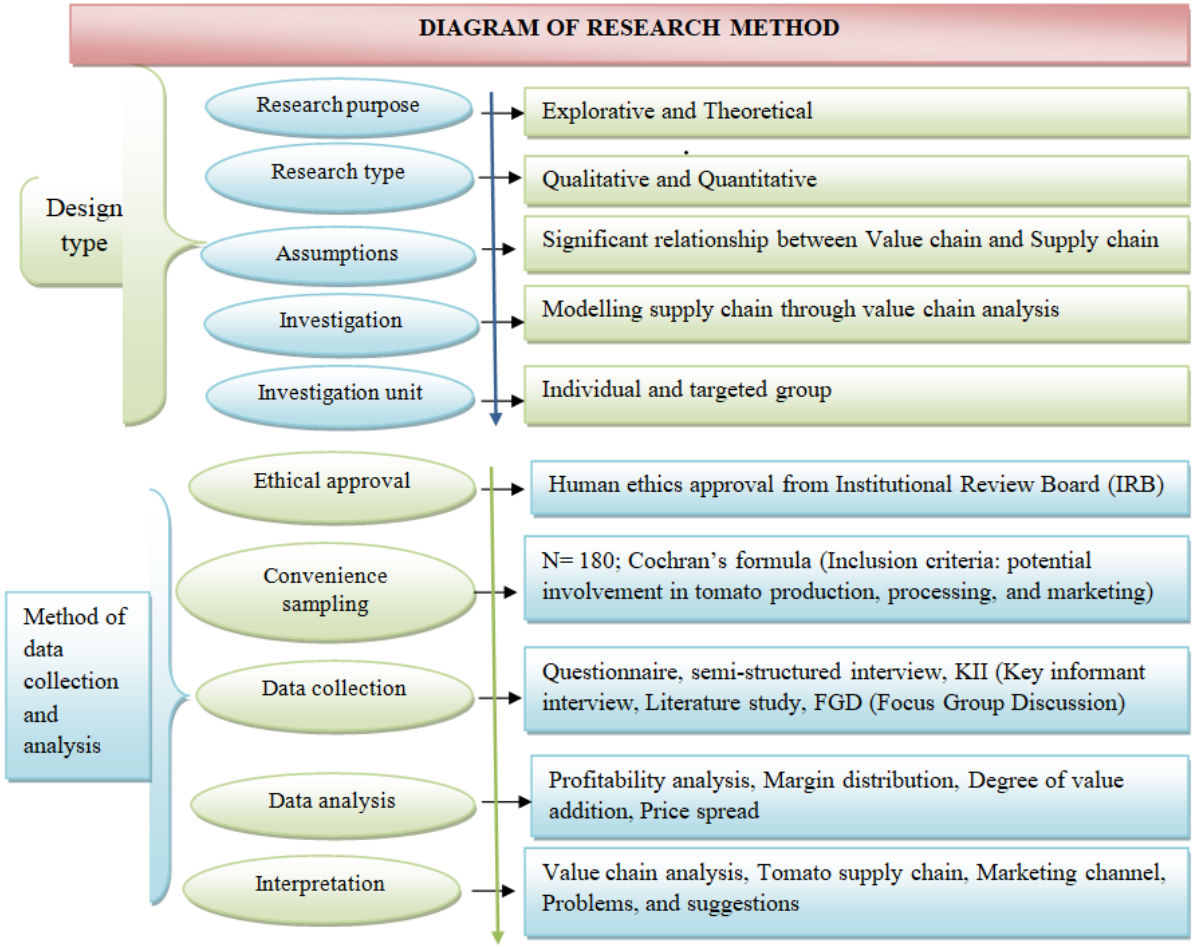

Figure 3 – Diagram of Research methodology

In order to realize the objectives of this study, from Bharatpur metropolitan city of Chitwan district, respondents were selected purposively based on tomato production potential. The sample size for our study was determined by using the formula developed by Cochran (1963) as:

$$N_0 = Z_{\alpha/2}^2\, p(1-p)/\, e^2 \qquad (1)$$

Where: $Z_{\alpha/2}$ referred to the critical value of the normal distribution at α/2, p is the estimated proportion of an attribute of the population, and q is 1-p, and e is defined as the margin of error. The value for Z is used from statistical tables which contain the area under the normal curve. In this study, we wanted to study the value chain roles in supply chain management. However, we did not have enough information on the subject to begin with, so we assume p = 0.5, which gives maximum variability. At 95% level of confidence and ±6% precision level, sample size was calculated. A 5% significance level gives us Z values of 1.96, per the normal tables. Using the equation and the data obtained, the sample size was estimated to be 180.

To collect information from value chain actors, this study employed both qualitative and quantitative approaches. Different sources were sought for the collection of data. The questionnaire survey was the primary source of data collection for this study. Prior to the preparation of questionnaire and checklists and the collection of data, both precision and reliability were taken into consideration. Focus Group Discussions (FGDs) were organized with farm households comprised of different wealth statuses (from poor to rich), sex, age, and education in each village to collect information regarding value addition activities and supply chain status. The group sizes were 8–12 farm households to make it manageable and

participants were invited randomly to speak out their ideas and opinions during discussion. One facilitator, one note taker, and one observer were assigned during discussion time. Key informant survey (KIS), and researchers' direct observation were employed to gather detailed data across the tomato marketing channel. The questionnaire was pretested and the required modifications were made to it. Secondary data was obtained through the Ministry of Agriculture and Livestock Development (MoAD), Nepal Agricultural Research Council, Agriculture and Forestry University (AFU), Chitwan Trade Association (CTA), Bharatpur Agricultural Centers, metropolitan working papers, etc.

Figure 4 – Map of Nepal showing the study area

VCA is highly focused on the interactions between different stakeholders in the process related to communication, processing, value-adding activities, and decision-making over supply chain management. All of the survey procedures involving humans were conducted in accordance with the guidelines of the Institutional Review Board (IRB), Nepal. Informed written consent was obtained prior to undertaking research, including permission for interacting with the required respondents and the study was approved by the Agriculture and Forestry University, Nepal.

The socio-economic variables of age, gender, educational level, land size, farming experience, etc. were analyzed using descriptive statistics. Chain map framework and economic formula were applied, which described the function and economy of each actor across the tomato chain. Profit-share among each actor, socio-economic data, and gross margin were calculated using the formula.

The fixed costs (FC) and the Variable cost (VC) were identified and calculated by summing up them to find the total cost. Tomato production required different factors and variable costs were included as the cost for inputs (FYM, pesticides, fertilizers, seeds, weedicides, etc.), costs for intercultural operations (tillage, mulching, irrigation, weeding, harvesting, stacking, pruning, etc.), packaging, grading, and sorting for transportation, etc. The cost for leased land was identified as the fixed cost.

$$TC = \sum TFC + \sum TVC \qquad (2)$$

Where:p TC is total cost, TFC is total fixed cost, and TVC is total variable cost.

Value chain mapping portrays the graphic chain of functions and actors involved from production to the consumption process (Monteiro et al. 2017). The entire chain was divided into three parts: support activities at the top, primary activities in between, and the actors involved in TVC at the down end. Map chain was made on the basis of data obtained from field interviews with farmers, traders, and expert panels through the value chain. Because tomato value chain consisted of all the components of Porter's value chain, it was designed according to Porter's value chain format.

A benefit-cost ratio (B/C ratio) is an indicator representing the relationship between the relative costs and profits of an enterprise, usually expressed in monetary value. If the B/C ratio of tomato enterprise exceeds 1.0, then the farmers are expected to have more positive returns, and if is less than 1.0, the production cost outweighs the benefits. BCR for tomato production was calculated by applying the following formula (Subedi et al. 2019).

$$BCR = \frac{Gross\ return}{Total\ variable\ costs} \qquad (3)$$

Where: Gross returns = Price of tomato × Total tomato production, i.e.:

$$Gross\ returns = Pt * Qt$$

In agricultural economics, the breakeven point is estimated by dividing the fixed costs of production by the price per unit subtracted with the variable costs of production. In our study, BEP is the production level at which the production cost equals the revenues from tomato sales.

$$BEP = \frac{\sum TFC}{Unit\ contribution\ margin} \qquad (4)$$

Where: TFC is total fixed cost, and Unit contribution margin refers to the selling price per unit minus the variable cost per unit i.e., (SP per unit- VC per unit). Contribution indicates the part of sales revenue that is not accounted for variable costs and so contributes to the coverage of fixed costs.

According to Kotler and Armstrong (2003), marketing margin is calculated by using the price difference of products for different actors in the supply chain. During our study, the

market margin was calculated by subtracting the farmgate price (price obtained by farmers) by the consumer's price.

$$MM = Pc - Pf \qquad (4)$$

Where: MM is market margin, Pc is consumer's price and Pf is farmer's price.

Producer's share, in the study, was calculated to find out the percentage share of tomato-growers to the price of tomato sold to the consumers. It is calculated as:

$$Ps = \frac{Pf}{Pr} * 100 \qquad (5)$$

Where: Ps is the producer's share (in percentage), Pf is the farmgate price, and Pr is the price at which the retailers sell tomatoes to the consumers.

Scaling technique was used to determine the seriousness of marketing problems during tomato supply. The TVC actors were asked to choose different categories indicating different strengths of agreement and disagreement. This category was scored and total scores measure the actor's perception of specific problems. The index of importance was calculated as:

$$Iimp = \sum \frac{Si * fi}{N} \qquad (6)$$

Where: Iimp is Index of Importance, $\sum$ is summation, Si is scale value, Fi is frequency of importance given by actors, and N is the total number of farmers.

RESULTS AND DISCUSSION

Socio-demographic characteristics of the study area. A total of 180 respondents (response rate 100%) had participated in this study. Of 180 respondents, 148 (82.22%) were male and 32 (17.17%) were female. It suggests that women are lagging behind in tomato farming, its marketing, and industrial processing which could be due to women's historic lack of land and resources ownership (Khanal et al., 2021), and due to patriarchal society where women are suppressed in decision-making process. It could also be partly due to the heavy load of household's and children's responsibilities on women. The descriptive statistics presented in Table 1 showed that slightly more than one-fourth (29.44%) of the participants were young, of age below 35. More than half (57.78%) were of middle age, between 35-59 years. As majority of the actors involved in tomato value chain are in their active and productive age, tomato enterprise is supposed to be well flourished in the study area. Usman and Bakar (2013), in their study, had observed organized management of tomato production, marketing, and supply channel when the actors/agents involved were youth of 30-40. A very few (6.67%) of interviewed respondents were illiterate, while majority (56.67%) had achieved secondary education. The involvement of 12.78% of the graduated student (Table 1) as chain actors of tomato production indicates the rising interest of educated people in farming, rather than in non-agricultural professions. The majority (68.89%) of the respondents had 9-15 years of experience in the field of tomato-related business; production and marketing. The respondents, when classified on basis of land size for tomato cultivation, more than half of respondents (57.78%) were found to own land less than 0.5 ha, while 42.22% were found to be large landholders. More people (34.44%) stated services with agriculture as their major source of income.

Economic analysis and Profitability of tomato production. In economics, the cost of production includes all the expenses incurred to obtain factors of production i.e., land, labor, capital, and management of the farm activities (CFI, n.d.). Tomato cultivation requires a comparatively higher number of inputs and thus higher costs of production. Fixed costs and variable costs form the total cost. The fixed costs, in our study, were calculated as the costs for leased land and the farm equipment.

Table 1 – Socio-demographic characteristics of the study area

Characteristics	Frequency (N=180)	Percentage	Mode category
Gender			
Male	148	82.22	Male
Female	32	17.78	
Age			
Young age (<35 years)	53	29.44	Middle age
Middle age (36-59 years)	104	57.78	
Old age (>60 years)	23	12.78	
Educational level			
Illiterate	12	6.67	
Primary	40	22.22	Secondary education
Secondary	102	56.67	
University graduate	23	12.78	
Farming experience			
Low (<8 years)	27	15	12 years
Medium (9-15 years)	124	68.89	
High (>16 years)	29	16.11	
Sources of Income			
Agriculture only	56	31.11	
Services with agriculture	62	34.44	Services cum agriculture
Abroad and Agriculture	21	11.67	
Business with Agriculture	41	22.78	
Tomato cultivated land			
Small (<0.5 ha)	104	57.78	0.36 ha
Large (>0.5 ha)	76	42.22	

Table 2 – Costs of tomato production in the study area

S. N	Particular	Unit	Quantity	Rate	Total	Share of total cost (%)
A	Variable cost					
1	Tillage with harrow (2 times)	Minute	120	22	2,640	0.8
2	Tillage with culty (2 times)	Minute	120	22	2,640	0.8
3	FYM	Quintal	100	250	25,000	7.61
4	Urea	KG	50	22	1,100	0.33
5	DAP	KG	40	50	2,000	0.61
6	Potash	KG	30	40	1,200	0.37
7	Micro-Nutrients	KG	20	700	14,000	4.26
8	Bed Preparation	Minute	120	35	4,200	1.28
9	Mulching Paper	Roll	5	5000	25,000	7.61
10	Mulching	Man days	4	500	2,000	0.61
11	Nursery Tray	No.	100	80	8,000	2.44
12	Cocopit	Kg	20	100	2,000	0.61
13	Vermicompost	Kg	40	30	1,200	0.37
14	Seed	Grams	10	200	2,000	0.61
15	Seed sowing	Man days	2	500	1,000	0.3
16	Transplanting	Man days	8	500	4,000	1.22
17	Weeding between row every 30 days for 6 months	Man days	24	500	12,000	3.65
18	Bio-Pesticides	Liter	0.5	4000	2,000	0.61
19	Micro-Nutrients	Liter	2	1200	2,400	0.73
20	Stacking bamboo for 2 seasons	No	1200	10	12,000	3.65
21	Stacking Labor	Man days	20	500	10,000	3.05
22	Plastic rope	KG	30	150	4,500	1.37
23	Silver wire (used for 2 crops)	KG	100	75	7,500	2.28
24	Irrigation				5,000	1.52
25	Pruning every 15 days for 4 months	Man days	80	500	40,000	12.18
26	Harvesting every 5 days for 3 months	Man days	110	500	55,000	16.75
27	Packing materials	Cartoon	2000	15	30,000	9.14
28	Miscellaneous	L/S			20,000	6.09
	Total Variable cost				298,380	90.86
B	Fixed cost					
1	Lease Land	Kattha	3000	10	30000	9.14
	Grand Total				328,380	100

The costs for tillage, seed, labour, fertilizers, and pesticides, and intercultural activities (weeding, irrigation, staking, pruning, harvesting, packaging, etc.) were calculated under variable costs that have the degree to vary with the output. From Table 2, the sum total of variable cost was estimated to be NRs. 298,380/ Kattha (1 NRs. = 0.0085 USD), which covered approximately 90% of the total cost. Of this amount, wages to laborers for different

activities share the major portion, which was estimated in terms of man-days. Tomato is a labor-intensive enterprise, and many workers are needed during mulching, seed-sowing, transplanting, weeding, pruning, and harvesting. Besides labor cost, the maximum cost was incurred for the items of fertilizers and pesticides. The total costs incurred for fixed inputs was NRs. 30,000. The result revealed that the total cost of production for ten katthas was NRs. 328,380 (1 NRs. = 0.0085 USD). The plausible explanation for high average cost of production in the study area is the inflating price of inputs, high wage rate for laborers, and accelerating price for management.

The profitability of tomato production was calculated as Benefit-Cost (B/C) ratio. Table 3 revealed that the gross revenue obtained from total tomato production was NRs. 617,100. The net profit was calculated by deducting the total cost of production from the gross revenue and was estimated to be NRs. 2,88,720. The B/C ratio was calculated as 2.07 which signifies the higher profitability of tomato enterprise in the study area. For an investment of every 1 rupee, the farmers would get an additional 1.07 rupee (1 rupee = 0.0085 US$). A similar study was carried out in Chitwan in 2018 to analyze the profitability of tomato production by Neupane et al. (2018) and observed a B/C ratio of 1.6. This suggests that tomato farming has developed as a profitable venture along with time series. Subedi et al. (2020) calculated the B/C ratio of tomato production as 1.34 in the Kapilvastu district of Nepal in 2020. This infers that Chitwan district is comparatively more successful in the economic production of tomato. Table 3 further revealed that the break-even yield for tomato was about 1.76 tonnes, which is defined as the minimum yield required to earn a specific return on investment. At this point, the farmers realize neither profit nor loss (Kagan, 2021). During the calculation of break-even point, the unit was taken as 18700 kg, which was the average tomato production in the study area. Break-even price equals the amount of revenue a farmer needs to earn so he neither makes nor losses money. Break-even point in price was estimated NRS. 58,235.10. Elfadil et al. (2015) found the break-even point (BEP) of tomato production of about 1.9 tons in Khartoum, Sudan.

Table 3 – Profitability of tomato production

Items	Costs (NRs.)
Total fixed cost (TFC)	30,000
Total variable cost (TVC)	298380
Total cost of production (TC)	328,380
Gross Revenue	617,100
Net Profit	288,720
B/C Ratio	2.07
Selling Price per Unit	33
Variable cost per Unit	16
Contribution Unit (SP per unit- VC per unit)	17
Break-Even Point (BEP) for yield in unit	1,764.70
Break-Even Point (BEP) in price (NRs.)	58,235.10

Tomato value chain (TVC) mapping and components. This study is based on porter's value chain design as presented in figure 4. Value chain mapping gives an insight into visualizing the tomato flow from the farmers to the end consumers through various actors (McCormick and Schmitz, 2002). Figure 1 and figure 4 enable the readers to know about the different actors involved in tomato value chain and to extrapolate their roles and linkages in supply channel. In competitive term, value is the price that the consumers are willing to pay (Porter, 2008). Thus, tomato value chain is the building blocks of tomato enterprise by which the farmers and other actors create a product valuable to its buyers.

As portrayed in tomato value chain map, value activities were divided into two types; primary activities and support activities, following the design of Porter's value chain. Primary activities comprised of those activities that were involved in physical creation of the product and transfer to the consumers. These activities, in the figure, run along the right hand which were further divided into five categories from Inbound logistics to Service. Those activities that support the primary activities were categorized as support activities, which is shown in the top of the map (Figure 4), running downward the vertical axis, from firm infrastructure to procurement.

During the study of value chain of tomato in the study area, the primary activities were divided into five categories as:

a) *Inbound logistics:* Tomato production requires different inputs such as seed, labor, pesticides and fertilizers, credit, land, irrigation, equipment for intercultural processes, etc. All the activities like receiving, storing, and disseminating inputs, inventory control, and vehicle management were included under inbound logistics. Simply, inbound logistics in our study referred to the process of bringing in purchased inputs into the tomato farm;
b) *Operations:* Tomato is processed through different stages from seed sowing to harvesting. The activities associated with converting raw materials into final product form (tomato as a vegetable, puree, juice, ketchup) such as weeding, harvesting, collecting, packaging, machining, sorting, and grading were included under categories of operation;
c) *Outbound logistics:* The activities that involved the process by which tomatoes produced in the farm reached the buyers were defined under this category. It includes out-farm transportation, trading, order processing, delivery, and distribution of tomato products;
d) *Marketing and Sales:* The profit that the tomato-growing farmers obtained is not merely attributed to the high production and more yield, but also relied on how the producers manage to maintain the relationship with the consumers. This category includes the activities of producer-buyers relationship, product advertisement, communication with buyers, and consumer information management. Supply and demand are directly related terms, so marketing and sales enable the farmers to flow information about the tomato product;
e) *Service:* The consumers, after consuming tomatoes, might not be satisfied or might complain about the produce. This category, in the tomato value chain, referred to all those activities that involve consumer service focus, product adjustment, quality improvement, labor-training programs, and so on.

Support value activities were divided into four generic categories, as shown in figure 5. They act the role of helping to make the primary activities more efficient. An increment in the efficiency of any of the four support activities benefited at least one of the five primary activities during tomato supply (Tardi, 2020):

a) *Procurement:* It included the function of purchasing inputs used in tomato value chain that support primary activities, not to the purchased inputs themselves. Procurement of pruning and harvesting equipment, water, land, funding management, and storage inventory were included. It concerned with how the farmers obtain inputs for tomato production;
b) *Technology:* Tomato is highly perishable in nature and is severely affected by altered climatic condition. The activities like risk management, storage-designing technologies, production and processing framework were listed under this category;
c) *Human Resource Management (HRM):* As already mentioned, tomato enterprise is highly labor-intensive. Different actors were found to involve in different processing stages from farm to distribution to consumers. HRM included all factors associated with management of labor, trainings, rewards to actors, and profit-sharing;
d) *Firm Infrastructure:* This entailed all the management, financial, and legal systems the tomato farm has in place to make enterprise decisions and effectively manage resources.

In view of the current TVC in the study area, tomatoes are grown primarily for the domestic supply, difficult to differentiate as value-added products, and usually sold as bulk. The major tomato value chain actors identified in the study area were input suppliers, producers, collectors, wholesalers, processors, retailers, consumers, and also other value chain supporters.

Input suppliers: Nepal Agricultural Research Council (NARC), having headquarter in Kathmandu, is the leading organization of Nepal that works for the supply of farm inputs in Chitwan district of Nepal. FYM, chemical fertilizer, pesticides, seeds, and farm equipment

were the inputs required for tomato production. The tomato-growing farmers of the study area depend largely on the local input dealers. The majority (81%) of the growers purchased farm inputs from agro-vets, while nearly 11% obtained from informal sectors like neighbors, relatives, etc. Others use to get seeds and other inputs from Research centers, agricultural institutions, farm cooperatives, etc.

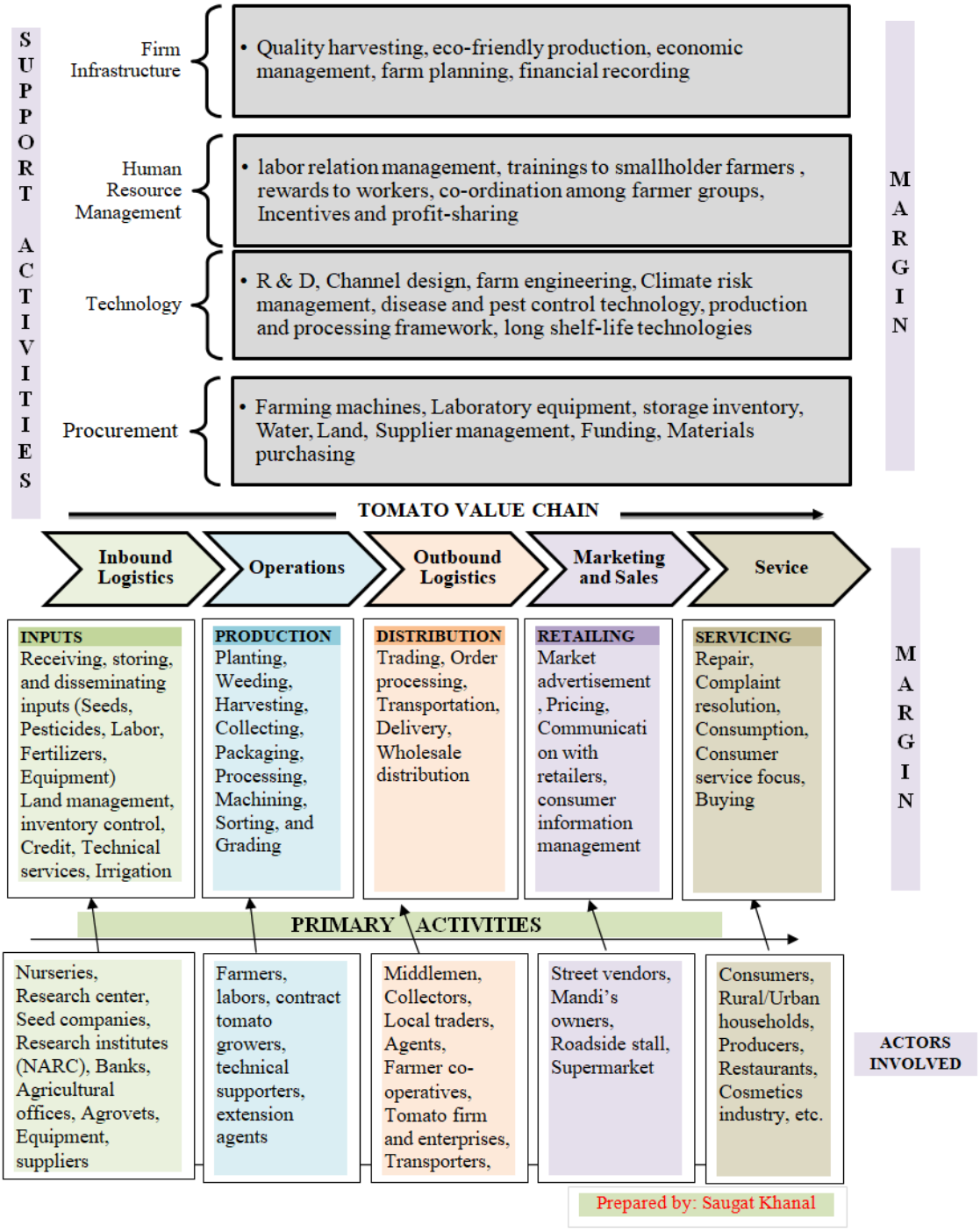

Figure 5 – Value chain mapping of tomato enterprise in Chitwan, Nepal

Growers / Producers: The Key Informant survey (KIS) and Focus Group Discussion (FGD) deduced that there were over 1300 tomato growers all over the study area. The growers were categorized as – subsistence and commercial producers. Subsistence producers produced tomatoes mainly for home consumption, while commercial growers

produced them for supply to the market and industries for processing. They were the first link in the tomato value chain and generally deal with collectors and wholesalers. In most cases, producers rely on local traders for price information; however, nowadays due to easy access to communication they get information about price determination. It was observed that the producers receive the lowest profit margins in the value chain. This is mainly because of high inputs and production costs, poor yields, heavy post-harvest losses, and paucity of economies of scale. The traders in the area used to purchase tomatoes from producers at low cost due to low bargaining power of farmers. The results inferred those growers were not much benefited than they should have been.

Middlemen/ traders/ collectors: Traders and collectors work at the early stages of the supply chain. Chitwan district is among the most tomato-producing districts of Nepal where many traders and collectors were found to have been involved. They generally purchase tomatoes from the producers at low costs and sell them into the big market at high prices. This way they get high marginal profit. The middlemen/traders create an oligopolistic market condition that makes them able to set market prices for tomato produce. These agents were usually found to purchase standing crops prior to or just after harvesting for sale to wholesale dealers, retailers, or other buyers. Some traders also go to other districts where the demand for tomatoes is high. Nearly half (46.12%) of the collectors were found to sell the collected tomato in mandi and supermarket.

Wholesalers: They purchased tomatoes either directly from a producer or local collectors in bulky and resell to rural or urban retailers, mandi, restaurants, and street vendors. During our study, we found that the collectors generally collected tomatoes from village producers and sold them to the wholesalers in the city's areas. Sometimes, the wholesalers were found to supply to industries, mills, and to exporters as well. They often used trucks or mini-bus as means of transportation when the number of tomatoes supplied to the market is large. 63% of mandi owners, street vendors, and roadside stalls were found to purchase tomatoes directly from wholesalers while remaining purchased from producers or collectors.

Processors: They are referred to as secondary processing industries or factories. After harvesting, all tomatoes were not supplied to the consumers of the study area. Some were supplied to the industries to produce tomato paste, puree, sauce, and ketchup to add value to the product. Majority (36%) of the big processors were found to purchase tomatoes directly from farmers through contract farming. The processors changed the form of raw tomatoes into other products. Tomatoes were also found to be processed in cosmetics industry.

Retailers: 31% of the retailers were reported to purchase tomatoes from producers and 12% from collectors/traders, and others (57%) from the wholesalers. It was also reported that most retailers did not have storage house and often the tomato goes waste when kept for a long time, retailers bearing the loss. The FGD provided the information that the prices at supermarkets or mandi are around 12% less than the prices at stalls or street vendors. So, the consumers try to purchase from mandi as possible. Retailers include small grocery stores, mandi, supermarkets and exporters, vegetable shops, etc. They usually purchase fresh tomatoes and other tomato processed products in smaller quantities with a higher profit margin. Furthermore, the retailers in the Bharatpur metropolitan city were found to create value addition through product advertisement and keeping the consumer's satisfaction in the focal point.

Consumers: They were the final buyers of tomatoes in the chain who bought for consumption. It is the last link in the TVC. From the consumer perspective, the shorter the value and supply chain, the lower is the product price. 79.23% of the purchased tomatoes were reported to be consumed as a vegetable.

Margin Distribution among Various intermediaries in TVC. Table 4 provides the detailed pricing buildup of tomato, the breakup of all the costs incurred at each stakeholder level of TVC, and the share of various actors of the chain in the total margin along the chain. The price realization at different levels was calculated considering the input costs, selling cost, and cost of value addition at different levels of ownership. Four main intermediaries were

considered–farmers, collectors, wholesalers, and retailers. The primary objective of any enterprise is to increase market share, profit maximization, and create value-added products (Pettinger, 2019). The price was calculated per kg. The farmgate price was NRs. 33/kg (1 NRs. = 0.0085 US$). The total value-added cost during farming was calculated as NRs. 21, including the costs for cultivation (NRs. 9.39/kg), cleaning and grading costs (NRs 4.65/kg), and 12% post-harvest losses (NRs. 1.06). The collectors/traders purchased tomatoes at NRs. 33/kg from farmers and sold them at NRs. 39/kg with 18.18% profit margin. The result presented in table 4 showed that the commission cost for collectors/agents share a major cost (NRs. 2.2/kg). This suggests that there is a strong influence of middlemen in the supply chain of tomatoes in the market. The costs for loading & unloading, packaging, weighing, wastage during cleaning, and transportation by collectors were calculated. The wholesalers sold the tomatoes to the retailers at NRs. 49/kg with a profit margin of 25.64%. Similarly, the retailers sold tomatoes to the end consumers at NRs. 56/kg with profit margin of 14.25%. The results further revealed that wholesalers were the most benefited actors in the chain. Because there were not fixed policies for selling prices of the tomato in the study area, the prices were observed to be varied largely and the average of all the prices were considered during the analysis. However, in Europe, the main aim of agro-farm is to increase their market share and profitability rather than focusing on profit margins, which results in strong competition with other retailers and the tendency to adjust costs (Pérez-Mesa et al., 2021).

Table 4 – Price buildup of tomato

Actors	Functions	Price realization at different levels	Waste % per kg	Activity-wise cost (NRs. /kg)
Farmer	Farmer's benefit (NRs. /kg)	12		
	Cultivation cost			9.39
	Transportation cost			4.65
	Cost arouses during Cleaning and Grading			5.9
	Total post-harvest losses during loading, sorting, storage, and marketing		12%	1.06
	Farmgate price (NRs. /Kg)	33		
Collectors/ Agents/Traders	Loading and unloading charges			0.71
	Cost incurred during packaging			0.64
	Weighing charges			0.74
	Wastage during cleaning and transportation		8%	1.2
	Commission to collectors/Agents			2.2
	Margin			0.51
	Selling Price to wholesalers or Mandi (NRs. /Kg)	39		
	Profit Margin (%)	18.18%		
Wholesalers	Labour charges			1.3
	Wastage during sorting, transportation, and cleaning		11.50%	3.6
	Margin			5.1
	Selling Price (NRs. /Kg)	49		
	Profit Margin (%)	25.64%		
Retailers	Transportation cost			2.3
	Loading and unloading charges			1.5
	Wastage due to transportation		6.05%	1.8
	Margin			1.4
	Selling Price to the consumers	56		
	Profit Margin	14.25%		

Degree of value addition for TVCю In economics, the value-added of tomato is defined as the difference between the price of final form of tomato and the cost incurred to produce it (Hayes, 2020). Table 5 showed the degree of value addition for produced tomatoes from production to consumption. The degree was found to vary at each stage of value chain. Keeping the price differences at the focal point of our study, margin was calculated by subtracting the cost from price difference. As the product transfer from one actor to another, the actors act the role of adding value to the tomato product, thus improving the quality of the product that has the power to increase the utility of the consumers. The various actors who are involved in the tomato value chain indicate value addition by the farmer (63.84%), collectors/traders (8.69%), wholesaler (17.17%), retailers (5.92%), and consumers (4.38%). The highest value was added by farmer followed by wholesalers, middlemen (local traders),

and retailers. Consumers were found to add the least. The value analysis for degree of addition was calculated per quintal (100 kg) of tomato as a unit base for the all actors. The selling price for each actor in TVC was the purchase price from previous actor. The study found that the highest margin was estimated in farmers/producers (NRS. 1754.8/quintal), followed by wholesalers (584.38), retailers (556.73), collectors (389.64), and the consumers (394). The margin per quintal of tomato at farm level was NRs. 1754.8, collector's level was NRs. 389.64, and NRs. 584.64 for wholesalers, NRs. 556.73 for retailers, and for consumers it was NRs. 394. This suggests that farmers in the study area added highest margin per quintal of tomato production.

Table 5 – Degree of value addition share different actors (NRs. /Quintal)

Value chain actors	Sale Price	Purchase Price	Price difference	Value addition cost	Degree of value addition (%)	Margin (NRs.)
Farmers	3300			1545.2	63.84	1754.8
Traders/Collectors	3900	3300	600	210.36	8.69	389.64
Wholesalers	4900	3900	1000	415.62	17.17	584.38
Retailers	5600	4900	700	143.27	5.92	556.73
Consumers	6100	5600	500	106	4.38	394

Price trend analysis, Market margin, and Producer's share analysis. Price fluctuation is commonplace with vegetable crops particularly tomato owing to its highly perishable nature and seasonality (Yercan and Adanacioglu, 2012). Figure 6 showed that the average price for farmers in the study area was found to be fluctuating. The study revealed that 31% of the tomatoes produced in the study district were usually exported to other districts; Kathmandu, Pokhara, Butwal, Lumbini, Biratnagar, etc. The farmer's price was in decreasing trend upto 2017, and then slightly increased in 2018. In 2020, the average farmer's price of tomato was NRs. 33/kg (1 NRs. = 0.0085 US$). The consumer's price, market margin, and producer's share in 2020 was NRs. 56/kg, NRs. 23/kg, and 58.93% respectively (Figure 6). Market margin is the price gap between the price paid by consumer and the amount received by the producers (Khanal et al., 2020). Similarly, producer's share is the fractional part of the consumer's payment received by the farmers (Kumar et al., 2017).

Marketing margin = Consumer's price (P_c) – Amount received by farmers (P_f) = 58.93%

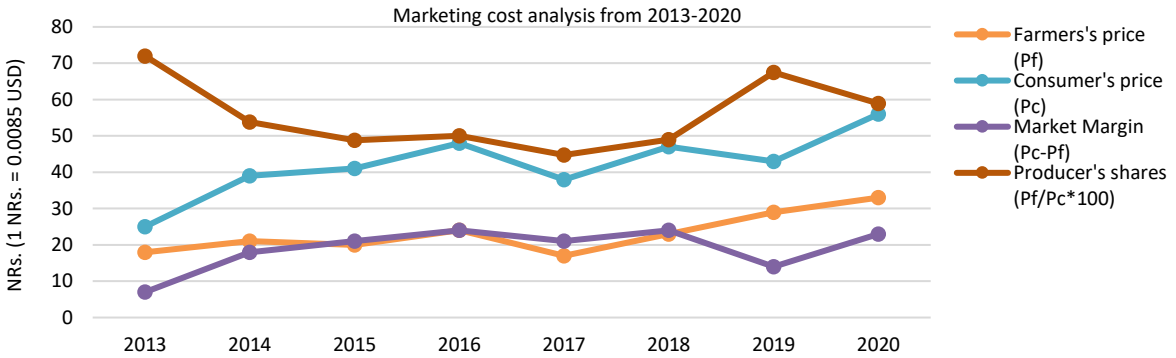

Figure 6 – Price trend analysis, Market margin, and Producer's share analysis

Tomato Supply Chain (TSC). Supply chain has become an important concern of competitive advantage for agricultural enterprises (Sukati et al., 2012). Tomato SCM (Supply chain management) focuses to maximize the overall value of the farm by better allocating the resources, inputs, and quality supply of tomato products. TSC consisted of multiple marketing channels as there were multifarious actors involved in TVC. A total of 6 marketing channels were observed, through which the tomato reached to the end consumers– Subsistence channel (7%), Agent channel (3%), Wholesale channel (28%), Direct channel (11%), Industrial channel (12%), and Retailer channel (22%). Consumers were found to purchase from street vendors, mandi, directly from producers, retailers, and restaurants

(Figure 7). The study of marketing channel is very important for the supply chain management, strategies development, performance improvement, and quality delivery of value-added product.

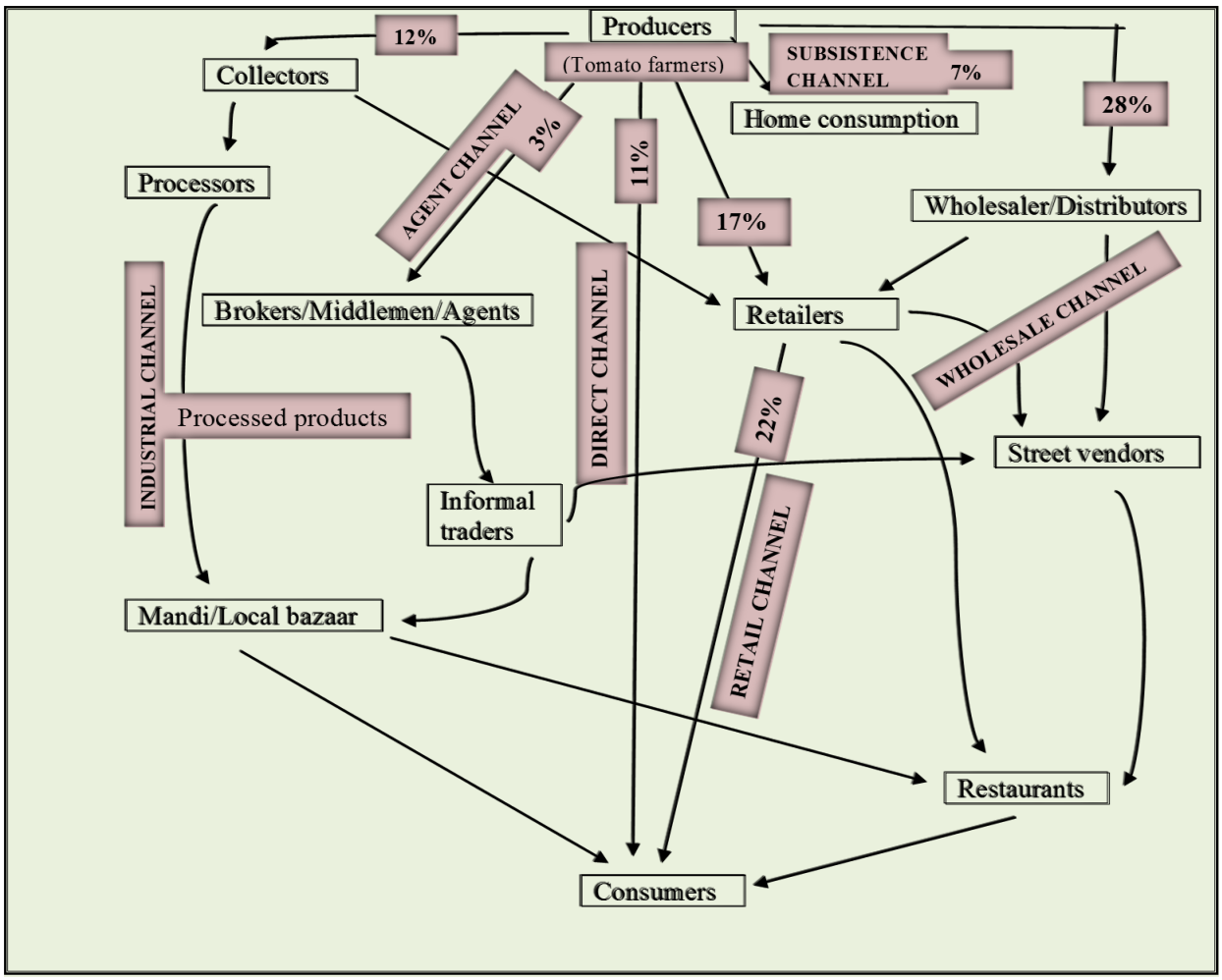

Figure 7 – Supply channels of tomato to end consumers

Modelling the efficient supply chain: Recommendations. Tomato supply chain modelling deals with the questions like; how to produce, market identification, finding the best supply channels, effective tomato delivery to the market, distribution of the final product, price determination, and so on. From the study, it was found that the components of supply chain in the study area act in an isolated manner with poor coordination, which lead to unsystematic supply chain management. The ultimate goal of farmers and all other actors involved in tomato value chain is to satisfy the end consumers. To achieve this, after analyzing the TVC in Bharatpur metropolitan city, some recommendations are made to develop right supply chain model. Tomato supply chain (TSC) in the study area, as discussed above, consisted of multiple intermediaries and handling, which sometimes resulted in high crop wastes or value loss of the tomato. Figure 8 suggests that the actors in the supply chain can make multiple decisions during the supply of tomato. Thus, while modelling the supply chain, it is recommended that they make decision in such a way that add the maximum value to final form of tomato and hence the maximum utility to consumers.

The authors attempt to provide both a general and specific view on the subject, providing a base for relevant issues not yet discussed in the analysis, which will need further research. The past report suggests that the adoption of advanced technologies would be useful to the collection and management of information about the product that helps in remodeling of the whole supply chain model (ICAP, 2014). For instance, Big Data (FAO,

2013; Anastasiadis and van Dam, 2014), IoT (Keivan and Simons, 2006), Artificial Intelligence and business intelligence, Blockchain (Vukatana et al., 2016, Crisp, 2014), and so on, can be employed to transform and enhance collaboration in the framework of an effective supply chain, making them aspects that require further research.

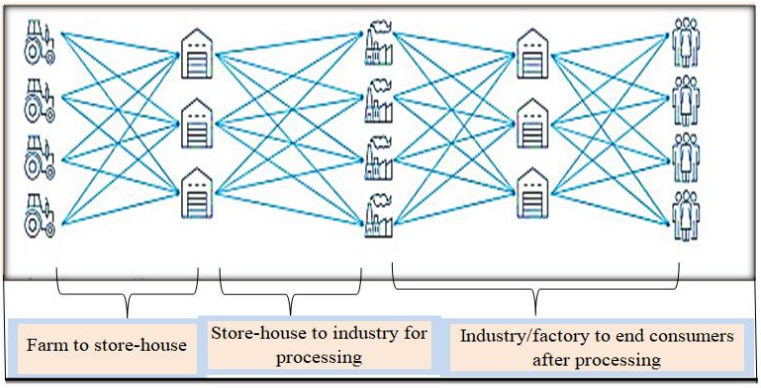

Figure 8 – Intricate supply model of the tomato for processing Source: Denis et al. (2020)

Following recommendations are made after study TVC and TSC in the study area:

- As per the survey, 57% of the sampled population falls under small farmer's category and there were lots of constraints especially to this section. Because 56% of interviewed respondents had agriculture only as a source of income, a slight change in supply chain may disrupt the entire channel affecting the farmers worse. Thus, value chain analysis may act as an effective tool to plan to make the disrupted tomato supply chain resilient. The more the value added to tomato, the stronger would be the supply chain;
- Though Bharatpur is one of the largest cities of Nepal, there were not many tomato-processing industries. Tomato has short shelf-life, and if it is not processed it cannot survive for a long duration. From our study, it was made clear that processing is only an option for better price realization of tomato. Therefore, there is a need of primary (Sorting and Grading) and secondary processing units, storage houses so that post-harvest loss is lowest, and adds more value to end product. The municipal administration is suggested to focus on processing industries in the needed area of the study district;
- The retailers and processors in the study area were found to purchase tomato in bulk quantities. However, small-scaled farmers, sometimes, may not produce tomatoes enough to sell to the retailers. Therefore, the study suggests that smallholder farmers should collaborate and form a farmer's group so that they could sell together profitably to the buyers. It falls under human resource management (HRM) of support activities of the tomato value chain, where different resource person manages to add value to the product;
- The fluctuation in price of tomato was observed in study area, which was determined by the unscrupulous traders and middlemen. Sometimes, the producers even do not get return as per the costs of production. Therefore, it is recommended that the government should fixed market price for per kg of tomato so that producers received profitable return;
- The survey result revealed that about 43% of the farmers used to be misled by traders and 28% reported that they had limited information about market system, value-chain, and the supply chain system. Therefore, mobile-based information facilities are recommended to be initiated. Also, the extension agents are suggested to provide information to the farmers about value-adding activities.

Problems of tomato production and marketing. The problems during tomato production, processing, and marketing in the study area were identified and ranked on the basis of seriousness of the problems. During the marketing of tomato, the major problems were found to be unpredictable seasonal price fluctuation, followed by poor marketing information regarding value chain and supply chain, wholesaler's dominancy over retailers, lack of

storage facilities, faulty marketing system, and high middlemen margin (Table 6). Other problems were lack of availability of inputs on time, pests and diseases outbreak, difficulties with credit acquisition to the farmers, and lack of transportation facilities for distant market.

Table 6 – Ranking of the problems faced by the farmers during tomato farming in the study area

Marketing Problems	Index Value	Rank
Unpredictable seasonal price fluctuation	0.87	I
Lack of marketing information to the farmers	0.8	II
Wholesaler's dominancy over retailers	0.56	III
Lack of long-term storage facilities	0.39	IV
Faulty marketing system	0.38	V
High middlemen margins	0.35	VI
Other Problems		
Farmer's lack of getting inputs on time	0.82	I
Severe outbreak of Pests and diseases	0.74	II
Difficulties with credit acquisition to farmers	0.68	III
Lack of transportation facilities for distant market	0.51	IV

CONCLUSION

This research has contributed to the literature on supply chain modeling that uses porter's value chain components to investigate logistic outsourcing in several stakeholders, involved in tomato production and marketing, in Chitwan district of Nepal. The study reveals that the value chain analysis is an effective tool for modeling the tomato supply chain through understandings of interaction between different players and components in the tomato enterprise. The major actors involved in the value chain are input suppliers, producers, collectors, processors, wholesalers, retailers, and end consumers. B/C ratio for tomato production is calculated to be 2.07, indicating that tomato is a profitable enterprise; with an investment of NRs. 1 (0.0085 US$) in tomato, farmers earn additional 1.07 rupees. The Break-even yield is 1764.7 kg and the break-even price is estimated to be NRs. 58,235. The result further reveals that wholesalers are the most benefited actor in the chain, gaining the highest profit margin. Producers in the study area are found to add the highest margin and value per quintal of tomato production. The marketing margin and Producer's share are NRs. 23/kg and 58.93% respectively. Several constraints are found to disrupt the supply chain of tomatoes. Price fluctuation, lack of market information, and wholesalers' dominancy are observed as major marketing problems. There is a need for government intervention in price determination, incentives to small-holder farmers, and organized marketing channel to reduce unscrupulous trading. Tomato supply chain and value addition in Nepal demands further researches on developing efficient supply chain and encouragement of value-addition activities.

Limitations and future directions. Although this study attempts to describe the impacts of value addition in supply chain modeling of tomato products, however, several other factors can affect the designing of the supply chain network, such as economic policy of the nation, industrial status of the area, human resource quality, logistic quality, and governmental interventions. Also, the sustainable management of supply chain can be investigated using different district's samples for different commodities other than tomato alone to compare the modeling of supply chain for different commodities.

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