Article

Mapping ICT Use along the Citrus (Kinnow) Value Chain in Sargodha District, Pakistan

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Abstract: The value chains of fresh fruits and vegetables are sensitive to timeliness and require a quick information flow. Keeping in view its importance, this study has focused on mapping the use of information and communication technologies (ICTs) along the citrus value chain, including information channels being used, factors influencing ICT use, challenges, and weaknesses faced by value chain stakeholders. Cross-sectional data were mainly collected by structured and semi-structured interviews with value chain stakeholders and key informants. The citrus industry is very important for Pakistan as it is the 4th most important export commodity. There are two product flows in the citrus value chain, one is more traditional with abundant intermediaries, in which contractors, commission agents and wholesalers are the main stakeholders, and the other is export-oriented with processors and exporters (P&Es) as the main stakeholders. It has been noticed that growers are not using ICT extensively at the production stage. Logit analysis has proved that education significantly has influenced ICT use while age has a negative impact on ICT use at the production stage. Mobile usage is quite common at the production stage and intermediary trade; however, the use of the internet is very limited as the majority of intermediaries have lower education. Moreover, both mobile phones and internet are used to a significant extent along the export oriented flow. The results have indicated that there is a vast digital divide among value chain players. Processors and exporters are high ICT users followed by growers and intermediaries. In order to develop an effective information system, all the stakeholders in the chain need to have a certain level of knowledge and expertise of ICT use to improve information use efficiency. This study presents a whole picture of ICT use along the citrus value chain as well as challenges faced by different stakeholders. It also provides suggestions for policymakers to establish an ICT-based information system and enhance ICT adoption at each stage, especially production and intermediary trade, which can further increase growers' market participation and improve market efficiency. In addition, it is necessary to make policies under the value chain framework rather than just focused on one stage or one stakeholder.

Keywords: ICT use; citrus; value chain; logit analysis; Sargodha; Pakistan

1. Introduction

ICT is an important tool of connectivity and information delivery in the modern era [1]. The Group of Twenty (G-20) Agriculture Ministers' Action Plan 2017 has recognized that ICT is a key and important approach for innovation and sustainable agriculture [2]. ICT use is one of solutions to improve the sustainability of food systems by increasing efficiency, enhancing transparency and creating a network between food chain actors [3].

ICT is also an important component of a value chain (VC) network [4]. ICT serves as a glue to supply chain stakeholders to work together [5]. The ICT usage along the supply chains has

become a performance enabler and causal factor of competitive advantage [6]. Information is critical in agricultural development as it helps in assessing the trends and shaping decisions [7]. Moreover, the role of ICT is to reduce transaction costs in agriculture by enabling timely and affordable communication [8]. ICT has a strong role along the whole VC until the end consumers [9]. Connecting and creating networks between different actors are also benefits of ICT that can provide opportunities for increasing sustainability [10]. In this context, the internet can provide new opportunities for growers to connect and distribute farm produce directly to the consumers (via e-commerce) [3]. ICT is likely to be especially important for highly perishable food products such as fresh fruits and vegetables that are differentiated and possess varied quality dimensions; are sensitive to timeliness in supply and susceptible to damage in transit; and require a quick response at the supply end [11]. The internet serves a way to organize communities, build interactions and spaces to share the knowledge [12]. These could be in the form of online discussion forums or public information centers. The introduction of “internet plus agriculture” is a China’s plan to link the whole agricultural value chain from production to marketing by internet-connected networks [13]. India had linked the growers with markets through IT from 2000–2007, by establishing 6400 internet kiosks (named as e-Choupals) in 38,000 villages of nine Indian states to link 4 million farmers with markets [14]. Information sharing means information sharing between VC actors, governmental organizations, non-governmental organization, and research institutes.

Pakistan is one of the least-connected countries (LCC), ranked 136th for access in the ICT Development Index (IDI) [15]. According to the Pakistan Bureau of Statistics [16], 92% of households have a mobile phone (96% in urban areas and 90% in rural areas). According to the Broad Band Commission [17] 15.5% individuals using the internet and 24.7% households have access to the internet. Lack of reliance on ICT in government institutions is a reason that Pakistan is held back from improving its IDI ranking [18]. The CABI (Centre for Agriculture and Bioscience International) published a report on knowledge gaps and ICT prevalence along the citrus value chain (mainly television, mobile phone, and computer) [14]. This report discussed briefly the role of ICT and focused more on the value chain itself. However, with the advent of smartphones and 3G and 4G internet technology, the scenario of information system and connectivity has changed in the last decade. Systematic mapping is essential to understand ICT use along the chain, identify the vulnerabilities stakeholders faced, and design effective policies [19]. Hence, there is a need to conduct detailed research about ICT-based VC mapping in Pakistan. The objectives of this study include mapping information channels, level of usage of ICT, and factors influencing ICT use along the value chain. This study also focuses on system weaknesses and challenges at different stages such as production, intermediary trade, and processing and export. The results of this study may serve as a guideline for policymakers to improve system functionality by improving information availability in a sustainable way.

The remainder of the paper is as follows: Section 2 presents the overview of citrus industry in Pakistan and Section 3 describes the methodology used in the study. Section 4 describes the results of the study including general information about respondents, factors influencing ICT use at production stage using logit analysis, and level of use of ICT along the chain. The discussion part describes the current situation of ICT and policy suggestion. Section 5 gives the conclusions of the study.

2. The Citrus Industry in Pakistan

Citrus is the most important fruit crop and 4th most important commodity after rice, alcohol, and wheat or meslin flour for Pakistan [20]. Pakistan is the 12th largest citrus producer in the world [21], which is a major source of employment in many citrus producing districts, particularly Sargodha district [22]. Kinnow is one of the citrus fruits and of significant importance in Pakistan as its share in citrus fruit is 89.43% [23]. It has been reported that the Kinnow exports exceeded 370,000 tons with the worth of 222 million USD in 2017–18 [24].

There are two main product flows along the citrus value chain. One is more traditional with growers, contractors, commission agents and wholesalers as important stakeholders [23]. This kind of

chain takes up to 80% of total citrus supply in Sargodha, Pakistan, with characteristics of insufficient traceability and low food safety standards. The other is more modern and export-oriented with growers and processors and exporters (P&Es) as the main stakeholders. This kind of chain is of high-quality, higher margins and high value-addition, which takes up to 20% of the total citrus supply. Nowadays, supermarkets have played an increasingly important role in the value chain and they can directly connect producers to consumers [25]. However, the role of supermarkets in Pakistan is much weaker than China and India [26]. Metro cash and carry stores are only operating in big cities like Lahore, Islamabad, and Karachi selling fresh fruits and vegetables [27].

The citrus from Sargodha district is exported to around 40 countries of Gulf, Far-east, Central Asia, Europe, and Africa. The main countries include Afghanistan, Russia, Saudi Arabia, United Arab Emirate (UAE), Indonesia, and Philippine, see Figure 1. For Afghanistan, citrus is always transported in open containers by road, while for other countries, citrus is delivered through reefer containers (cold chains) to Bin Qasim port (Karachi) by road and then shipped to next destinations. The duration of transportation varies according to destinations i.e., 2 days for UAE, 4–6 days for Saudi Arabia and 40 days to Russia.

Figure 1. Citrus export from Pakistan to various countries (Data source: UN comtrade, 2016).

Figure 2 shows the geographical supply routes from Sargodha district to other provincial and interprovincial markets. About 40–50% of the supply of fruit go to Punjab markets, 30–40% go to Khyber Pakhtunkhwa (Peshawar market) province while 5–10% go to Sindh and Baluchistan provinces (Karachi and Quetta markets). In an open auction, fruits are sold in these markets to wholesalers and further distributed to other small cities.

Citrus harvesting usually starts from middle of November and lasts till mid-April. A small amount of products (5%) appear in market in the 2nd half of November, and can receive higher prices. Most of citrus are sold in December (35%) and January (40%). February has supplied 15% of citrus, and March has provided about 5%. However, the temporal mapping of P&Es vary among growers as most citrus is processed in January and February.

Figure 2. The geographical routes for provincial and interprovincial markets in Pakistan (Source: Prepared by author using ArcGIS).

3. Methodology

The cross-sectional data were collected through structured and semi-structured interviews. In the case of structured interviews, five questionnaires were designed, for growers, contractors, commission agents, wholesalers, and P&Es separately. Data about demographic characteristics, information channels, level of use of ICT, role and activities at each stage were collected. In the case of semi-structured interviews, group discussions were conducted to further collect information from important VC stakeholders and key informants. The participants of group interviews were selected carefully based on their previous experience and education as well as recommendations of key stakeholders, including P&Es managers, progressive growers, commission agents, and key informants as shown in Table 1. Both structured and semi-structured interviews were conducted with the help of extension officers in local and national languages i.e., Saraiki, Punjabi, and Urdu. The selected respondents were typical and reflect the diversity within each VC stage.

Table 1. The structured and semi-structured interviews with stakeholders.

Data Collection Tools	Stakeholders	Data Collected
Structured Interviews (Questionnaires)	121 growers, 25 contractors, 27 commission agents, 39 wholesalers, 10 processors and exporters (P&Es)	Demographic characteristics, information channels, level of information and communication technologies (ICT) use, membership of online discussion forums, role and activities at particular stage, value addition, production, contracting, marketing and export system
Semi-structured Interviews (Group interviews)	3 P&Es managers, 5 progressive growers, 2 commission agents, 2 contractors, key informants (1 extension officer, 1 transporter, 1 social worker, 1 village leader, 1 fruit market president)	Their roles in the citrus value chain, impact of ICT on business operation, weaknesses and challenges they faced, suggestions to improve value chain (VC) efficiency through ICT use

There are 7 tehsils (subunits of districts) in Sargodha district. Data were collected in 2 randomly selected tehsils i.e., Bhalwal and Sargodha. Subsequently, 4 union councils (subunits of tehsils) from each tehsil and 4 villages from each union council were selected. Around 5 growers were interviewed from each village. Interviews with contractors, commission agents, and wholesalers were conducted in the central fruit and vegetable market. We also visited three best performing enterprises and 7 other randomly selected enterprises from the list prepared by the P&Es association. They were located in

different places as shown in Figure 3. The data were collected from July to September 2017. In total, 121 growers, 25 contractors, 27 commission agents, 39 wholesalers and 10 P&Es were interviewed for this study. The group interviews were conducted with 3 P&Es managers, 5 progressive growers, 2 commission agents, 2 contractors, 1 extension officer, 1 transporter, 1 social worker, 1 village leader, and 1 fruit market president.

As for the data analysis, firstly, the main operational stages were recognized along the VC, such as production, intermediary trade, and P&Es. Then, in-depth analysis of ICT use at each stage was done using descriptive statistics and econometric model (Logit model) was built at production stage. Finally, the system deficiencies, challenges, and weaknesses faced by VC stakeholders were identified and discussed.

Figure 3. Map of Sargodha district and location of sampling (Source: Prepared by author using ArcGIS).

The logit analysis was used to detect the main factors influencing growers' use of ICT at the production stage.

The logit model based on the logistic distribution is specified as:

$$P(y = 1|x) = F(x, \beta) = \Lambda(x'\beta) = \frac{\exp(x'\beta)}{1 + \exp(x'\beta)} \quad (1)$$

$$p = P(y = 1|x) = \frac{\exp(x'\beta)}{1 + \exp(x'\beta)} \text{ and } 1 - p = P(y = 0|x) = \frac{1}{1 + \exp(x'\beta)} \quad (2)$$

The odds ratio is given by:

$$\frac{p}{1 - p} = \exp(x'\beta) \quad (3)$$

Taking a natural logarithm of Equation (3) we obtain,

$$\ln\left(\frac{p}{1 - p}\right) = x'\beta \quad (4)$$

p = the probability that $y = 1$ if the respondent use ICT,

$1 - p$ = the probability that $y = 0$ if the respondent does not use ICT,

x = vector, the explanatory variables,

β = vector, the coefficients of the explanatory variables, usually estimated by the maximum likelihood procedure,

$\ln(\frac{p}{1-p})$ = the log odds ratio of the probability that a grower use ICT.

Here, mobile use, internet use, apps use, willingness to invest in ICT, online network membership and ICT's role in price determination were selected as indicators of ICT use; and age, education, farming experience, landholdings, distance from local market, distance from extension office and distance from road were explanatory variables. The expected signs were shown in Table 2.

Table 2. Expected direction of impact of explanatory variables used in logit model.

Variables	Different Tools to Obtain Agricultural Information			Willingness to Invest in ICT	Online Network Membership	ICT's Role in Price Determination
	Mobile	Internet	Apps			
Age	-	-	-	-	-	+
Education	+	+	+	+	+	+
Farming experience	-	-	-	-	-	-
Land holding	+	+	+	+	+	+
Distance from local market	+	+	+	+	+	+
Distance from extension office	-	-	-	-	-	-
Distance from road	+	+	+	+	+	+

4. Results and Discussion

Three main stages along VC i.e., production, intermediary trade, and P&Es were analyzed in this study. The following sub-sections showed current status of each stage, ICT use, factors influencing ICT use, and challenges and weaknesses faced.

4.1. Citrus Production Stage

The production stage included orchards establishment, cultural practices, irrigation, pest and disease control, and fertilization etc., which was dominated by growers and contractors. The majority of growers (84.3%) preferred to sell their harvesting rights (see Table 3) because they wanted to lower the risks due to lack of labor, finance and market information. After signing the pre-harvest contract, growers and contractors together manage orchards (91.7%) and growers were usually responsible for labor. The contractors always paid for inputs expenditure as well as organized harvesting, grading, transportation and marketing. They have determined orchard purchase price based on several factors including number of trees per hectare, number of fruits per tree, fruit weight and appearance, orchard general appearance, expected A-grade, and B-grade yield (A-grade is zero tolerance to damaged outer appearance, usually for export or high-end domestic market in big cities. B-grade has no standard on size and weight, usually sold in domestic markets in medium and low-income areas). One of major structural deficiencies at the production stage was that growers did not have much information about the market. Only 14.9% of them produced international quality-oriented products. Almost 71.9% of them did not care about product destination because they had weak awareness of quality standards and were unable to meet the high-end market demand.

Table 3. Grower's orchard contracting system and orientation to consumer markets.

Parameters	Percentage
Sell orchard to contractors	84.3%
Sell orchard to P&Es	13.2%
Sell orchards at fruiting stage	82.2%
Sell orchard at ripening stage	15.7%
Orchard management by both contractors and growers	91.7%
Lack of knowledge of destination of product	71.9%
International quality-oriented growers	14.9%

ICT use at production stage. The important sources of information at production stage were mobile phone (79.3%), private companies (44.6%), internet (41.3%), extension department (24.8%), TV (18.2%), and agricultural helpline (10.7%). About 28.9% of growers were members of online discussion forums on Facebook or WhatsApp. These forums were established by progressive growers where they share experiences, production technologies, solutions for problems, and market trends etc.

For growers, the number of times they used ICT per month during VC active period was used to measure level of ICT use at each stage, mobile, internet and apps separately. In the case of mobile, 15.6% were non-users, 44.6% were low users, 28.1% were medium users and 11.6% were high users. As for internet, about 62% were non-users, 9.9% were low users, 19.8% were medium users, and only 8.3% were high users. App use was similar to the internet with 72.7% of non-users, 5% of low users, 15.7% of medium users and 6.6% of high users.

As mentioned earlier, a logit model was built to identify the factors influencing the growers' use of ICT tools, their strength, and direction of influence. The description of dependent and independent variables was given below in Table 4.

Table 4. Descriptive statistics of variables used in model.

Characteristics	Mean	Minimum	Maximum	Std. Deviation
Age (years)	45.17	24	73	12.797
Education (years)	11.83	0	22	4.435
Farming experience (years)	16.84	2	50	11.939
Landholding (acre)	29.19	3	200	37.474
Distance from local market (km)	15.58	1	50	11.267
Distance from extension office (km)	15.02	1	45	10.848
Distance from metal road (km)	1.52	0	7	1.844
Use of mobile phone	0.85	0	1	0.357
Use of internet	0.44	0	1	0.498
Use of apps	0.34	0	1	0.475
ICT's role in price determination	0.79	0	1	0.407
Willingness to invest in ICT	0.82	0	1	0.387
Membership of the online network	0.29	0	1	0.455

1 hectare = 2.471 acre.

The mean age of respondents was 45 years representing that the majority of growers were at active age. As shown in Table 5, age had significant positive or negative effect on use of ICT. More specifically, odd ratios were 0.938, 0.93, 1.078, 0.933 and 1.051 respectively which showed that one-year increase in age, the odds ratio of membership of online networks and ICT's role in price determination increased by 7.8% and 5.1%, respectively, and the odds ratio of internet, apps and the willingness to invest in ICT decreased by 6.2%, 7.0% and 6.7%, respectively. In accordance with the findings of Jan et al. [28], on the one hand, age had the positive effect as older growers, as they could better understand advantage of modern technology, on the other hand, they may be risk-averse and less likely to use modern technology. Furthermore, this negative effect might be due to prejudice towards ICT as the entertainment tool.

Education was also very important for ICT use. About 4.1% of growers were illiterate, 1.7% had primary education, 6.6% had middle education, 24.8% finished high school, 43.8% had college education, and 19% had university education. This showed that the majority of growers had high school or above education (mean education is 11.83). They were most likely to use ICT as education was an important factor in technology adoption and use [29]. More specifically, the odds ratio is 1.176, 1.350, 1.380, 1.017, 1.185 and 1.141 respectively, which shown that with one-year increase in education, the odds ratio of mobile, internet use, apps use, willingness to invest in ICT, membership of online networks and role of ICT in price determination increased by 18%, 35%, 38%, 1.7%, 18.5% and 14.1%, respectively.

Farming experience was negatively related to ICT use but the effect was not significant except the willingness to invest to obtain ICT. The reason might be that growers who had higher

farming experience were likely to use their own knowledge rather than using ICT to obtain new agricultural information.

Landholding was also an important determinant of technology adoption as growers who had more land were likely to use ICT. Table 5 showed that landholding (mean 29.19) had only a significant impact on willingness to invest in ICT tools with a positive sign. This result was in accordance with Jan et al. [28] as they argued that respondents with more land were expected to have high income and likely to adopt the technology.

Table 5. Results of logit analysis of influencing factors of ICT use.

Variables	ICT Tools to Obtain Agriculture Information			Willingness to Invest in ICT	Membership of Online Network	ICT's Role in Orchard Price Determination
	Mobile	Internet	Apps			
Age	0.031 (1.032)	−0.064 *** (0.938)	−0.067 *** (0.93)	0.075 ** (1.078)	−0.069 *** (0.933)	0.049 * (1.051)
Education	0.162 ** (1.176)	0.300 *** (1.350)	0.322 *** (1.38)	0.017 (1.017)	0.169 *** (1.185)	0.132 * (1.141)
Farming experience	−0.013 (0.987)	−0.018 (0.982)	−0.001 (0.99)	−0.096 *** (0.909)	0.001 (1.001)	0.025 (1.025)
Landholding	0.014 (1.015)	−0.004 (0.996)	−0.006 (0.99)	0.024 * (1.024)	−0.012 (0.988)	0.011 (1.012)
Farm distance from local market	0.274 *** (1.315)	0.029 (1.030)	0.061 (1.06)	0.047 (1.048)	0.062 (1.064)	0.181 ** (1.198)
Farm distance from extension office	−0.070 (0.932)	−0.045 (0.956)	−0.072 (0.93)	−0.008 (0.992)	−0.087 ** (0.917)	−0.132 * (0.876)
Farm distance from metal road	−0.809 *** (0.445)	−0.120 (0.887)	−0.115 (0.89)	−0.163 (0.849)	−0.260 (0.771)	−0.627 *** (0.534)

* means $P < 0.1$, ** means $P < 0.05$, *** means $P < 0.01$.

Farm distance from the local market also had significant positive influence on use of mobile and ICT's role in price determination as shown in Table 5. This might be because growers who lived far from market were more likely to use mobile to obtain agriculture and price information. Ahsanuzzaman [30] also argued that the farther farmers were from the town center (market), the more likely they adopted ICT tools.

The farm distance from the extension office had significant negative effects on membership of online network and ICT's role in price determination. Farm distance from the road also had significant negative effects on mobile use and ICT's role in price determination as shown in Table 5. These results were in contrast to our expectation and probably the reason was that remote areas were likely to have poor physical infrastructure such as no internet access, which might result in growers lacking ICT awareness and not realizing what ICT can offer.

4.2. Citrus Intermediary Trade

The main stakeholders along citrus intermediary trade were contractors, commission agents, and wholesalers. After harvesting and grading, contractors transported citrus to fruit markets of Sargodha district and other provincial markets of Karachi, Quetta, Peshawar and Lahore. About 76% of contractors reported they sold produce to commission agents only, while 24% reported they sold produce through P&Es and commission agents. In detail, A-grade citrus were usually sold to P&Es and the rest of the fruits were sold through commission agents. The commission agents reported that they sold products to wholesalers or directly to retailers. Then wholesalers sold the produce to retailers. The powerful stakeholder in citrus intermediary trade was commission agent which governed the whole process. The offices of commission agents were located in the central fruit market where fruit is sold in an open auction (before harvesting each year there is a meeting between growers and P&Es associations and they decide a reference price and float around that price). The role of commission agents was to help actors make a deal such as contractors and wholesalers and they

take 4–6% (sometimes even more than 6%) from citrus sales. Commission agents usually finance the contractors to buy the orchards with land or vehicle registration papers as mortgage.

ICT use during intermediary trade. The majority of respondents in the intermediary trade were below 45 years old and at active age (mean age of contractors 46.1, commission agents 36.7, and wholesalers 37.8 years). In the case of education, majority of the contractors and wholesalers had education below middle school and commission agents had high school or above education. Most intermediaries (100% of contractors and commission agents; 89.7% of wholesalers) used mobile phone to obtain trade-related information as depicted in Table 6. This was because a mobile phone was the easiest way to convey price and market information even though they were less educated. The internet use of intermediaries was relatively lower with 32% of contractors, 7.4% of commission agents, and 10.3% of wholesalers. Specifically, as depicted in Figure 4, 68% of contractors were high users of mobile, 20% are high users of internet and no contractors used apps. About 96.3% of commission agents are high users of mobile phones, 92.6% were non-users of internet, and no commission agents used apps. About 66.7% of wholesalers were high users of mobile, 94.9% were non-users of internet and no wholesaler used apps. There was high use of mobile phone but limited use of internet and apps along intermediary trade.

Intermediaries do not participate in online discussion forums, which made information sharing difficult with other stakeholders and was a system weakness. Intermediaries preferred personal communication over group discussion because they thought that information sharing could affect their businesses. Other system weaknesses included lack of traceability, lack of storage facilities, lack of trust among intermediaries, and information asymmetry.

Figure 4. Level of use of ICT by stakeholders (per month). Low use = 1–25, Medium Use = 26–100, High use = 101–above.

4.3. Citrus Processing and Export Stage

Interviews were conducted with managers coming from three leading processing and export enterprises. Enterprise-A had processed citrus after it received orders from buyers, about 26–150 metric ton citrus per day. It had exported 90% of its processed products and the remaining 10% were sold to high-end domestic market. Enterprise-B exported 70% of the processed product and the remaining 30% were sold domestically. Enterprise-C exported 50% of processed product and sold 50% domestically.

The P&Es sourced the harvesting rights directly from growers and hired specialized staffs to contract citrus orchards. Once the contract had been signed, the staff regularly visited the orchard and managed it together with growers. Enterprise-A had its own orchards as well as a contract for the orchards with growers. After processing and cold treatment (keeping them in cold storage for 3 days), then products were exported or sold in domestic markets. The P&Es performed activities including sorting, washing, drying, waxing, packaging, and pre-cooling to add value to the citrus, and further meet the demands of export markets and high-income domestic markets. The products were packaged in food-graded corrugated packaging of 6, 8 or 10 kg and labeled with brands.

Table 6. Demographic characteristics and sources of information being used along intermediary trade.

		Intermediary Trade		
		Contractors % N = 25	Commission Agents N = 27	Wholesalers % N = 39
Demographic characteristics				
Age	below 25	0	3.7	17.5
	26–35	16.0	66.7	37.5
	36–45	40.0	18.5	22.5
	46–55	20.0	7.4	12.5
	56–65	24.0	0.0	2.5
	65 or above	0	3.7	5.0
Education	Illiterate	36.0	0.0	43.6
	Primary	16.0	0.0	20.5
	Middle	8.0	11.1	17.9
	High School	28.0	11.1	2.6
	College	4.0	33.3	15.4
	University	8.0	44.4	0.0
Sources of Information				
Mobile		100	100	89.7
Internet		32	7.4	10.3
TV		24	25.9	0
Extension Department		16	0	0
Newspaper		0	0	5.1
Magazine		0	7.2	5.1

The deficiencies identified in the citrus export sector were the failure of most of the exporters to meet the high food safety standards of European and Asian markets. That is why most exporters prefer Afghanistan and Gulf countries. The challenges for the citrus industry in Pakistan include increasing demand for seedless citrus and competition with Turkey and Egypt. Moreover, price fluctuation in international markets, currency exchange rates, and lack of insurance were important risks for citrus export. Pakistan's citrus industry faced a serious setback in 2016 because of price fluctuation in the international market.

ICT use at processing and export stage. P&Es were significant users of the internet. It facilitated upstream communication, browsing, market research, knowledge of import tariffs and laws, quarantine and quality control laws, shipping and tracking, and feedback. Communication, collaboration and

record keeping (orders and transactions) was done using emails. Social media apps such as WhatsApp were used to share fruit pictures and audio/video calls were used for negotiation with new buyers. Other apps include Skype and Facebook but their use is limited. During the inactive period, voice interactive messages are used to keep buyers in the loop. Exporters spend VC active time in research, planning, discussing future changes, market trends, value chain modifications, and exchange of ideas with buyers and other exporters keeping in view the need to avoid over-communication. Mobile phones were used for domestic communication with enterprise staffs, transporters, contractors, and growers. P&Es also didn't take part in online discussion forums that makes information sharing difficult.

4.4. Discussion

This study has focused on ICT use along the citrus value chain, mainly at the production, intermediary trade, processing and export stages, factors influencing ICT use, digital divide among stakeholders, problems and challenges faced at different stages. This study has also provided an understanding of stakeholder's characteristics and their influence on value chain and other VC stakeholders. Figure 5 has summarized two product flows in the citrus value chain; one was more traditional with abundant intermediaries, and the other was export-oriented. It is a comprehensive picture to show stakeholders, activities, weaknesses, and challenges faced separately when following different product flows.

Figure 5. Flowchart of product flow and contribution of each node along different VCs operating and ICT usage at functional stages of citrus (Source: Prepared by Author).

Compared to other stakeholders, growers use multiple information sources to obtain information. At production stage, the mobile phone is the most important source of information and used to obtain information in a grower's social network. The second most important source of information is still farm

visits by private input supplier companies who mainly provided agricultural information. Besides, the use of the internet to obtain information is very low. It is necessary to improve ICT-based information system to raise awareness, as growers are disconnected from the market and sell pre-harvesting rights to contractors. There is a need to build up knowledge portal, online discussion forums, and cross-function teams for all stakeholders along citrus value chain to improve the information system [14,31].

The logit analysis has proved that education is the most important factor influencing ICT use at production stage. The majority of growers have an education above high school (English literate) and policies for capacity building on ICT (particularly for internet) can produce fruitful results. The model has also proved that growers with large landholdings is likely to invest in ICT because they are raising awareness of the potential advantages of ICT. Age has negative effects on the use of the internet or apps as well as participation in online network, which has indicated that youth can be the focus of policymakers in order to improve information system.

Among VC stakeholders, only growers and extension agents have online discussion forums. It should be a focus for policymakers to increase membership of these forums, which can reduce market risks, improve procedural justice, increase members' margins, and in the longer run contribute to sustainable agriculture and food systems. Stakeholders have different demands for information and researchers can play a role to identify the specific needs at each stage. For example, Pandey et al. [31] have identified several information requirements by growers regarding pest control, market linkages, insurance schemes, government schemes, subsidies and scientific agricultural practices. In particular, the lack of government market regulations leads to growers' reluctance to participate in the market.

There is a lack of value addition, food safety standards, marketing or management strategies and immediate returns along the intermediary trade [32]. The abundance of intermediaries is a burden of the distribution system and limit the capacity of producers to improve production as mentioned by Makokha et al. [33]. On the other hand, Alarcon et al. [32] have also argued that these markets are important because they offer cheap products for low-income people as well as livelihoods for intermediaries. Structural changes in these markets could have negative impact on food supply and livelihood, which should be considered carefully by policymakers. The problems associated with intermediary trade are the lack of traceability, lack of branding, lack of information sharing, and mutual trust. The government and research institutes always pay more attention to production and export rather than intermediary trade, even though it takes up much of the product flows.

There is a lack of information provision from extension department, non-governmental organizations (NGOs), research institutes, and universities along the intermediary trade. The main information tools for intermediaries are mobile phones. Despite having low education, they are high users of mobile as the United Nations Conference on Trade and Development (UNCTAD) [34] has reported that the mobile technology in developing countries have even surpassed the developed countries. The intermediaries are low users of the internet and unable to reap its potential advantages. The intermediary trade system could be the focus of policymakers to improve information availability. Research institutes, universities and Ministry of Commerce can use ICT as a tool for capacity building of intermediaries.

Few P&E enterprises in Pakistan have certifications like Global-GAP (Global Good Agricultural Practices) and HACCP (Hazard Analysis and Critical Control Points), which is an important hindrance for Pakistani citrus to access the high-end markets of Europe and Asia. The enterprises require institutional supports to obtain food safety certifications and export their produces to other countries.

The internet has played the most important role in export, and is mainly used for building social networks and doing market research. Social networks can help exporters to increase value addition, retain the customers, and influence consumers' behaviors [35]. Exporters are high users of ICT but the uses of ICT are different in terms of enterprise internal system, trade volume, and access to high-end markets. This is a very important point but beyond the use of ICT, because education and research skills of exporters are key to reaping maximum advantages from ICT. As Liu & Nath [36]

mentioned, ICT access will not produce significant positive outcomes if ICT skills are not sufficiently high. Effective and timely price and product information transfer using ICT will help exporters to gain more market share.

As P&Es have reported that they only process fresh fruits, there is a need for policymakers to encourage processed products such as citrus juice, pulp, dried citrus, and citrus tea. This will make sure the availability of citrus all year round in domestic as well as export markets and reduce the wastage of unsold products. Long-term policies also need to involve this kind of processed products into the food chain in order to improve their consumption.

The majority of stakeholders are high users of mobile, but for internet, there is wide digital divide among VC stakeholders as P&Es are high users, followed by growers, and intermediaries are lowest users. This internet divide hinders the functioning of the internet-based information system.

5. Conclusions

Two VC product flows have been identified as intermediary and export-oriented flows. About 80% of citrus products were sold through intermediary flow and the main players are growers, contractors, commission agents and wholesalers. Export-oriented flow constitutes 20% of citrus and important players are growers and P&Es. There is a high use of mobile and low use of internet and apps at the production and intermediary trade stages. The internet divide is wide among VC stakeholders. The results from the logit model shows that education, age and landholdings are the main factors influencing growers' ICT use, and growers who have more education are likely to use ICT. Also, human capital and skills rather than possessions of ICT are key to reaping maximum advantages from ICT. As observed, P&Es are high users of ICT but there is a difference in their efficiencies. The weaknesses have been detected at various stages, including low use of internet in production and intermediary trade, lack of information sharing in intermediary trade, and lack of certifications at the export stage. It is necessary to improve the ICT-based information system to raise awareness, improve mutual trust, and increase market research to access the high-end market.

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