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CASE STUDY

# Blockchain-based secured traceability system for the agriculture supply chain of ginger in Nepal: A case study

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**ABSTRACT**

For the past few years, ginger export to India and through India to other countries has become a perennial problem for the farmers and traders. In this paper, we discuss about the impact of blockchain technology in ginger supply chain, which faces intermittent deterring of ginger worth millions in the Nepal-India border. Extensive literature reviews and execution of Delphi method in the study showed that blockchain as an emerging technology capable of transforming the food supply chain maintaining transparency in each step. In this paper, we study the potentiality of blockchain technology in transforming the ginger supply chain system through its potential benefits in Nepalese agriculture. The technology is capable of making various aspects of supply chain like tracing, monitoring and sustainability efficient. Thus, can reduce the trade-trust deficit between nations with technology.



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## INTRODUCTION

Nepal is a land-linked nation with a various bioclimatic zone located at the lap of Himalayas (Rana and Karmacharya, 2014) Agriculture has dominated the economy of Nepal (MoF, 2015; Thapa *et al*., 2021). Agriculture is the mainstay of not only income but also the main component of food and employment in most of the rural areas of Nepal (CBS, 2009). The agriculture sector of Nepal contributes USD 29.04 billion to Nepal's GDP, which in percentage translates to 26.4% (MoF, 2019). The various stakeholders in the agriculture sector of Nepal spring with farmers, suppliers of goods and services, food diversifiers, distributor, wholesaler, retailers, consumers, national and international governmental organizations (NGOs and INGOs), different branches of governmental organization. The food must go through various stages of value chain before it reaches the customers. The complex phenomenon has various value chain members, who have a distinctive role in delivering the goods and services to the consumers (Leng *et al*., 2018). The onset of Information and communication technologies, (ICT) and the Internet of Things (IoT) have revolutionized a large number of fields and the agriculture supply chain is also touched from the revolution (Tian, 2017) .These technologies have simplified the agri-food value chain. Even though the revolutionary technology is in use, still food value chain which is currently in use is central, monopolistic, asymmetrical, and opaque, all in all is bears a huge trust deficit. Therefore creating a trust deficit among the consumer to be carefree to consume the food, which comes to their plate passing through various stages that are verified by a spike in numbers of food safety incidents in a couple of years (Tian, 2017). Most of the supply chain that are currently in use often depends on the age-old supply chain system, which is centralized, unreliable, and have many disadvantages. It is the need of the hour to make a reliable and trustworthy supply chain system, which is much efficient, and trust-worthy (s) (Nakamoto, 2008). A small error in the centralized supply chain system corrupts the whole system and makes the system prone to error, hacking, corruption, and other ways of attack (Dong *et al.*, 2018). Some of the key areas that need to be addressed in the supply chain systems are security, transparency, the secureness of knowledge or information (Bhargava *et al.*, 2013; Tachizawa and Wong, 2014), (Caridi *et al.*, 2010). It is easy to know the origin, access all the required information, and understand the shortcomings during the supply of the goods and services (Grimm *et al.*, 2016).

Keeping in mind about all the illustrated contents above, the chief purpose of the paper is to propose a robust food supply chain traceability using the disruptive technique of the current time, blockchain technology for helping the safety of foods and maintain the quality, in the meantime, considerably subduing the losses by the different value chain actors. To start, small overview of the literature review is carried out at the beginning of the application of blockchain technology in the agri-food supply chain. We purpose the congenial theoretical framework to transform Nepal's agri-food supply chain. Likewise, the benefits and detriments of using the blockchain in the context of Nepal's agri-food supply chain are also discussed. At the end of the paper, the conclusion is drawn. Until now, no sorts of work being carried out to develop blockchain framework in Nepalese agriculture. However, the blockchain technology in agriculture is promising framework to make robust and reliable supply chain system.

## METHODOLOGY

There are many problems plaguing farmers'; digitization is one of the key ways to fight against many (Fleming *et al.*, 2018). Fleming *et al.* (2018) has given more priority to the introduction and use of Big Data to solve the problems of farmers. Sharma *et.al* 2018 has gone one step forward to the purpose of the use of cloud-based and GIS systems to come out the problems farmers are facing (Sharma *et al.*, 2018). Araby *et al.*, 2018 purposed the introduction of a cloud-based system to buttress the farmers' strength to overcome the repeated problems (Araby *et al.*, 2019). Likewise, Ginge (2016) purposed the introduction of a mobile-based system to disseminate the information to the farmers and solve the problems as earliest as possible. Soon after the blockchain conceptual framework was postulated, the first application that emerged out in the world is in the form of bitcoin—an electronic way of transacting assets or coins (Foroglou and Tsilidou, 2015). After the advent of the application of the blockchain in the form of bitcoin, various applications followed (Kosba *et al.*, 2016). A research paper published in 2014 by Foroglou *et al.* (2014) highlighted that the application of blockchain in a wide array of fields like finance, currency, bidding, the supply chain of various goods in the future, however he also pointed some of the pressing highlights. Bastian *et al.* (2013) Bastian and Zentes (2013) underscored the importance of transparency as the necessity to make a strong agro-supply chain.

There are various applied cases of blockchain in the agriculture sector. Mainly, AgriChain does the iconoclastic works focusing to activate the peer-to-peer transactions in the agricultural processing of goods and services and thereby obliterating the major roles of the intermediary. Likewise, Agriledger, the UK based project is assisting farmers to trace the origin of foods, easy route to get the financing and funding to support and buttress the agriculture, keeping the records of transactions in the process safely (Hammerwich, 2018). Both projects use the immutable and unalterable ledger which is immune to any sorts of cyber risks. Caro *et al.* (2018) did a comprehensive study to trace how food travels in the supply chain by building and using AgriBlockIoT. The author was fruitful to apply the IoT to consume and produce digital data throughout the supply chain. Hyperledger Sawtooth and Ethereum Tharun were used for the implementation of the project. Dong *et al.* (2020) used the Blockchain technology in the cloud storage in a bid to validate the data provenance mainly, the authors used to confirm the collection, storage, and validation. The paper further showed that the blockchain produced un tamper able to evidence and user privacy.

A research master thesis completed by Tian (2017) developed a model for proper traceability by using the Hyperledger Sawtooth Platform and contrasted with the archaic but still in use the mechanism to track the foods worldwide. Walmart, a superstore worth multi-billion has been collaborating with tech giant company IBM on food safety solutions using the disruptive technology blockchain. The tech company has been using Hyperledger Fabric—an open-source digital ledger that uses IBM cloud to operate efficiently (Miller, 2018). The biggest and most vividly observed achievement after introducing blockchain in the supply chain was the reduction in time to reduce the trace of the food from 7 days to 2.2 seconds. That can be extrapolated that the chances of infection of the customer from the food decrease significantly by the introduction of the blockchain in the supply chain system, while other perquisites also followed with them (Miller, 2018).

### Identification of the problems of farmers

There are many issues plaguing the farmers of Nepal. The problems faced by farmers were collected by doing extensive literature reviews published in different journals national newspaper, the visual observation of the problems farmers was going through was also observed during the field visit. There are various newspapers articles with shreds of evidences published in the newspaper as article about the rampant corruption in the agriculture sector of Nepal. Though different techniques were considered for the identification of the problem, the issues were taken into final consideration by using the scientific method called the Delphi technique. The technique is handy in a wide array of fields including policy formulation, choosing out of many options, forecasting the outcomes or prediction of the cause (Linstone and Turoff, 1975). The method is widely used in social science research (Skulmoski *et al.*, 2007). The method is highly useful in the agriculture field because it gives opportunities to experts of agriculture to be in line with everyone's opinion through the mutual agreement by conducting various questionnaires many times (Dalkey and Helmer, 1962). As we have not

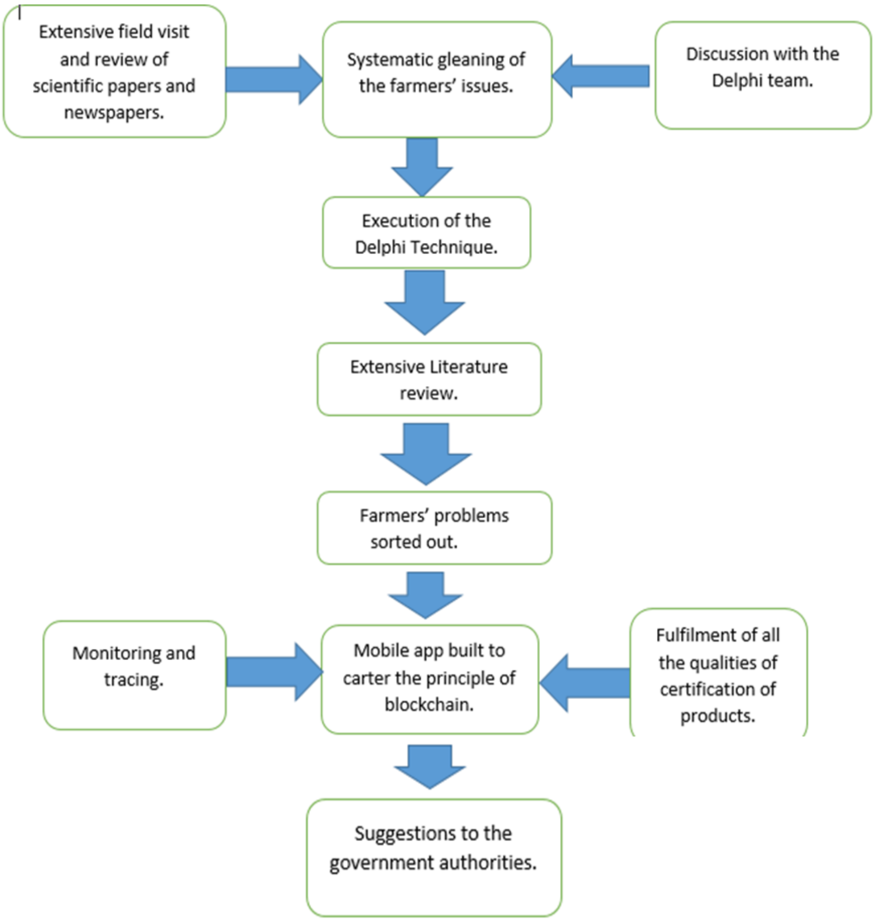


**Figure 1.** *Method used to evaluate the farmers' problem.*

**Table 1.** Listing farmers' issues using literature review and Delphi method.

| Farmers' Issues | Sub-category | References |
|---|---|---|
| Laggards | Lethargy in adaptation to the new technology<br>Limited use of processing and poor packaging technology<br>Unavailability of advanced machinery for packaging | Diederen *et al.* (2003); Shetty (1968) |
| Lack of transparency and traceability in agro-business | Many intermediaries involved in the supply chain<br>No minimum support price fixed for products in agro-business | Gardas *et al.* 2019; Raut *et al.*, 2011; Budhathoki *et al.*, 2019 |
| Repeated trouble in trade with trade partners | Intermittent trade hindrance citing phytosantiary causes and sometimes due to poor quality causing losses worth millions Rupees to farmers. | Henson and Loader, 2001; Hammerwich, 2018 |
| Price discrepancy | Un uniformity in the selling price of the same goods<br>Lack of certification of the goods<br>High production cost<br>Fragmentation of cultivable land and small land holding capacity. | Bhatta *et al.*, 2010; Pokhrel and Pant, 2009; Shrestha *et al.*, 2010<br>Result of Delphi |
| Infrastructures | Very few processing facilities in Nepal<br>Lack of proper laboratories to test pesticide residues for quality grading.<br>Lack of proper sanitary and phyto-sanitary measures | Result of Delphi<br>Result of Delphi |

figured out which problem or issue of the farmer to settle, even though the paper mostly deals with the dealing with the intermittent blocking of the supply chain of the ginger export that could be easily solved by the use of blockchain. In a bid to finalize the issue scientifically Delphi team was formed which could come with the consensus. The team constituted a few farmers, and research scholars. The meeting was called on mutual consent to run the Delphi process. The report coming out of the meeting was written down. As many as eighteen farmers' issues were collected by conducting field visits and later doing the literature reviews. Likewise, serious thinking to come out of the problem was done with the scholars, professors, and farmers. The issues that could be solved by using the blockchain technology in agriculture was taken into account (Figure 1 and Table 1).

## Way forward

The recurring problem, which is plaguing farmers for many years now, could be solved to most of the extent by introducing the web or mobile-based blockchain technology in the agriculture practice. Mobile is omnipresent; the issue is with the proper internet connectivity, which is also reaching every corner of the country, thanks to the long sight vision of the Government of Nepal.

## Case study: Ginger supply chain

The rhizome of ginger is the modified underground stem of the plant that belongs to the family Zingiberaceae. Ginger is one of the valuable crops of Nepal, which has high export value. Due to the medicinal purpose of the plant and used for the various diversification of the plant-like cooking, baking, making drinks, and high herbal properties the product has high demand in the nation and abroad (ABPSD, 2016*)*. Out of many priority export products, ginger makes it into the top 12 as defined by the Nepal Trade Integration Strategy (NTIS), Government of Nepal. Nepal is the world's fifth-largest producer of ginger. Nepal produced 271.86 thousand metric tons of ginger in 2018 A.D, with average productivity of 12.35 Metric Ton per hectare. The crop is cultivated in 70 districts of Nepal, mainly concentrated in the mid-hills including Illam, Taplejung, Makwanpur, Terathum, Sindhuli, and other western districts (Sharma, 2009).

The total production is not consumed in Nepal, the data shows 40 percent of the produce is used for domestic consumption while the rest 60 percent is used to export (ABPSD, 2014). Due to a lack of proper lab facilities and inchoate information about the medicinal, physical, and biochemical properties, the competitiveness of the Nepali ginger in the global market is utterly low (Samarth-NMDP, 2014). The major market of Nepal ginger export in India. Most of the research papers claim that 99 percent of the total ginger is exported to India, which has drastically decreased since 2009 A.D (ABPSD, 2014). Likewise, the export of ginger to India faced a significant slump by 62 percent in 2017-18 A.D, largely due to intermittent export bans by India. Among many reasons, the main reason behind intermittent deterring of ginger worth millions in the border is due to low trust in the ginger produced in Nepal, which they deem Nepalese traders have mixed with the Chinese gingers laced with high pesticides. In this paper, we study the potentiality of blockchain technology in transforming the agro-food supply chain system through its potential benefits in Nepalese agriculture. The supply chain could be traced easily by using trusted information in the supply chain system. Thus, can ward off the trust deficit with technology.

**Tracing:** There are multiple cases of fraud during the packaging of goods. The gingers exported from Nepal to India are halted citing the mixing with Chinese ginger. These kinds of fraudulent and misallocations of the goods can be solved through proper monitoring and tracing using the blockchain technology (Kshetri, 2018). Moreover, the certification process becomes hassle-free through the concerned stakeholders by putting them on the blockchain system. Consequently, farmers will be able to fetch the uniform and higher prices. Overall, the consumer will get quality products, which, when necessary, could be easily traced. Tian (2017) proposed a novel visual analysis method of food safety risk traceability based on the blockchain using a hyper ledger. Likewise, Tian *et al.* (2017) also purposed a swift traceability and monitoring using blockchain, HACCP (Hazard Analysis and Critical Control Points). By implementing the umpteen of techniques illustrated by the research scholars the problems plaguing farmers can be easily solved, for instance, the providing minimum support price, checking the fraudulent and middle-man activities in the supply chain, monitoring the disbursement of subsidies given to the farmers by government and other organizations.

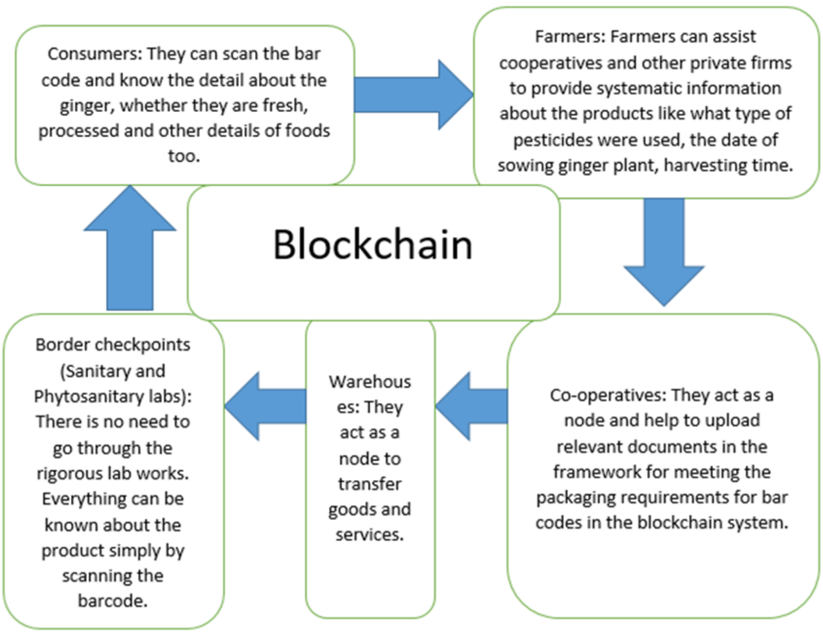


**Figure 2.** *Conceptual framework for ginger supply chain using blockchain in Nepal.*

**Monitoring:** In a bid to comply with the quality and safety of the supply of agriculture goods and services, after proper tracing, proper monitoring is a prerequisite to decrease the fraudulent in the supply chain. Unlike, involving a large number of human resources in the monitoring of goods and services, incorporating blockchain does not require many human resources for monitoring, thereby reducing cost for monitoring. The quick way of tracking and monitoring of the details of the pork product in a moment is illustrated, compared, and contrasted by Yiannas, 2017. Various important information as if the origin of the product, factory, batch number, storage temperature, and shipping could be easily accessed using the blockchain technology. The details illustrated aids to assess the truth of the product. In a worst-case scenario if the product is tempered or contaminated then the product can be easily examined and recalled (Kshetri, 2018).

Blockchain-enabled to digitally track individual pork products in a few minutes compared to many days taken in the past. Details about the farm, factory, batch number, storage temperature, and shipping can be viewed on blockchain. These details help assess the authenticity of products and the expiry date. In the case of food contamination, it is possible to pinpoint the products to recall (Kshetri, 2017). In the case of Nepal ADS (2015) has envisioned a cooperative and private sector as a strategic component to accelerate governance, productivity, profitable commercialization, and competitiveness. It is the co-operative sector that collects ginger and export. The co-operatives sector must be well equipped with technologies like fast internet service. In addition, the personnel involved should be trained. The co-operative needs to provide good packaging facilities for coding with bar codes which possess the relevant information on the ginger (Figure 2).

**Sustainability:** A supply chain can be said sustainable if it becomes socially, environmentally, and economically sustainable To be fit to become socially sustainable the food supply chain should be easily monitored, traced and transparency should be accessible as fast as possible (Wognum *et al*., 2011). The higher the transparency, monitor ability, and traceability social sustainability are much enhanced. Incorporating the blockchain in the ginger and other agriculture supply chain could be a game changer in the supply chain system. To qualify the supply chain as a sustainable supply chain, the most fundamental basis is the supply chain must ensure handsome profitability (Kumar *et al*., 2012) to all the stakeholders, most importantly farmers; and the adaptation of the new technology should not be exorbitant than the loss incurred by wastage of foods. The losses incurred due to wastage of foods has been a major concern in the supply chain system (Lipinski *et al*., 2013). The majority of loss in developing countries in the sector of agriculture and agri-food supply chain occurs due to post-harvest loss whereas in the rich nations consumers tend to squander food in comparison to the low-income nations (Blakeney, 2019). Furthermore, the loss incurred due to the various barriers in the ginger supply chain system could be obliterated by using the blockchain technology.

## Conclusion

The paper brings a new approach to solve the sporadic problem of the ginger supply chain between Nepal and India. The main component of the article is the use of disruptive technology-blockchain technology to store, transact, and monitor the supply chain. However, we mostly talked about the ginger supply chain. We can use the concept to improve any other agriculture supply chain system. Everything can be tracked, from its origin to all the inputs used to produce the products. Like the proof, the transactions could be stored in a non-manipulated way. The authenticity can be maintained at any level and removing the trust-deficit between the nations. The conceptual framework suitable to solve the sporadic problem of halting the supply of the exports was proposed, which could address the problem in the supply chain to the most extent possible by introducing sustainability, traceability, and proper monitoring. The paper presents the theoretical framework of application of blockchain technology to remove the ginger-trade trust deficit between Nepal and India. However, detailed research needs to be carried out to understand the feasibility of the project. Likewise, the similar framework could be implemented on trade of other products with other countries. Though the proposal is a theoretical framework, the government and the allied organizations could use to bring sustainable prosperity and happiness to the farmers' faces. Blockchain can improve trust and security.

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