Integrated Supply Chain and Industrial Cluster Model for Ethiopian Leather Sector using A System Dynamics Approach

Netsanet Jote, Daniel Kitaw

Abstract— Supply chain andindustrial cluster integration can definetly increase the competitive advantage of industries; it isa key to survival and development of many economic entities and enterprises. However, related research works on the merger of supply chain andindustrial cluster is still in its infancy, thus it is difficult to put theoretical results into practice. To fill this gap, this paper illustrates the advantage of the integration of supply chain and industrial cluster using Ethiopia leather sector as a case study. This paper considers a system dynamics tool to develop a model. Interviews were conducted with selected experts in governmental and non-governmental organizations. In addition, secondary data and actual visit were used as a survey instrument. The variables and parameters selected and the assumptions used in the models are decided together with the experts. Based on the findings, existing system dynamics supply chain flow diagram and proposed integrated supply chain and industrial cluster flow diagram are developed. As a result the newly developed model increases the competitive advantage of Ethiopian leather sector.

Index Terms— Ethiopian leather sector, Industrial Cluster, Integration, Supply Chain, System Dynamic

1 INTRODUCTION

Although Supply chain (SC) and Industrial Cluster (IC) are two different fields of study, it has been identified that there is a natural and internal relationship between these two theories [8]. SC support IC by integrating processes and building long-term relationships among cluster firms involved in the flow of products and services fromthe source to end-users [26]. All firms in the SC can benefit through achieving lower costs, improved customer value and satisfaction, and greater competitive advantage [15]. IC support the SC by integrating academic institutions, government agencies, association and supporting industry in order to create the innovation and enhance the knowledge in the SC[22]. Integrating SC and IC theories are becoming the key components in the survival and development of many economic entities and enterprises [27].

This paper considers a System Dynamic (SD) tool to develop a model which integrates SC and IC. To develop the model with SD, different system dynamics SC models from previous studies were considered such as Nuo& Xiao-jie, (2010)[17]; Lidia et al., (2012)[11]; Wang, (2011)[23]; Xiao-yan&Jian-hua (2010)[24]; Jianghong, (2010)[9]; Mahmodi&Minaee, (2010)[13]; Asgari&Hoque, (2013)[1].

This study proves how integrated clusters in a SC increase the competitive advantage of industries using the Ethiopian leather sector. This model is the first of its kind by integrating clusters at each stage of the SC. As far as the knowledge gained so far from the literature is concerned, this type of model is the first variant of its kind. The existing integrated SC and IC models such as DeWitt et al., (2006)[6]; Patti, (2006)[19] Sadler, (2007)[20]; Bozarth et al., (2007)[4]; Sureephong et al., (2008)[22]; Han, (2009)[7]; Nicolini et al., (2010)[16]; Bardy,(2010)[2]; Bosona&Gebresenbet, (2011)[3];Huang &Xue, (2012)[8]; Xue et al., (2012)[25]; Chen, (2006)[5]; Min et al., (2008)[14]; Liu et al., (2009)[12]; Zhu & Li, (2010)[27] and Li et al., (2012)[10] considered SC inside a cluster.

In addition to delivering new model to the body of the knowledge, the study also solves practical problems of the Ethiopian leather sector SC by increasing its competitiveness in local and global markets.The paper is organized as follows: section two explores the existing supply chain of leather sector; section threegives the methodology; section fourillustratesexisting Ethiopian leather supply chain system dynamics flow diagram; section fivediscussesexisting simulation model discussion; section six illustrates proposed Ethiopian leather supply chain and industrial cluster flow diagram; section seven presents proposed model discussion. Finally, section eight gives the conclusion and future work.

2 EXISTING SUPPLY CHAIN OF ETHIOPIAN LEATHER SECTOR

Ethiopian leather sector SC has a problem starting from livestock husbandry stage up to finished product. This is due to weak actors at each stage of the SC and weak linkages between the successive actors. Even if Ethiopia has a comparative advantage in the leather sector, it does not change this opportunity into a competitive advantage as expected by the government. The government of Ethiopia declared several policies to improve the competitive advantage of leather sector. For example, the government introduced a prohibitive export duty of 150%; first on pickled pelt and wet-blue leather exports in 2008, and then on crust leather in 2012, which nearly halted the export of all semi-processed leather. This gradually prompted commercial tanneries to invest in facilities and

- *Netsanet Jote : Industrial Development Policy Study and Reserch Department, Policy Study and Reserch Center, Addis Ababa, Ethiopia* netsijote@gmail.com
- *Daniel Kitaw : Addis Ababa Institute of Technology, School of Mechanical and Industrial Engineering, Addis Ababa, Ethiopia* danielkitaw@yahoo.com

technologies to process pickle pelts and semi-finished leather into finished leather. On the other hand, this situation transformed former Ethiopian semi-processed exporters/suppliers into competitors of their former customers. It may have taken longer than expected for the same tanneries to find new customers for their new finished leather product. In addition, fifteen years (1997-2012) leather and leather products export value data from the Ethiopian Ministry of Trade shows that the export value of leather and leather products is highly fluctuating and changing over time (Fig.1).

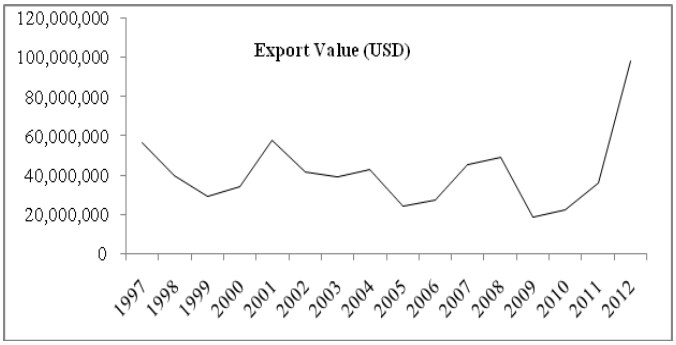

Fig.1.Fifteen years export trend of leather sector

The fluctuation on the export trade is the cumulative impact of problems at each stage of the Ethiopian leather sector SC (Fig.2). For example, as shown in Fig.2, there is longer lead time at each collection stage and in the production process of tanneries. As pointed out by Nuruzzaman et al. (2010) [18] a long lead is one of the greatest problems in integrated supply chain management (SCM). In addition, the sector has problems of quality, backward technology, limited skilled manpower, lack of coordination, policy gap, low capacity utilization, information etc. As a result, these problems put a negative edge on competitiveness. It is possible to reduce problems through supply chain and industrial cluster integration among upstream and downstream partners to make leather manufacturers more competitive. Supply chain and industrial cluster integration makes it possible to manufacture best quality finished leather before taking orders from customers but requires more collaboration among customers, raw hide and skin suppliers and tanneries in Ethiopia.

This paper illustrates the dynamic behaviour of the existing supply chain and the proposed new model which integrates supply chain and industrial cluster using system dynamics approach.

3 METHODOLOGY

A SD approach has been used to identify the dominant variables of the Ethiopian leather sector SC, which helps to increase the competitive advantage of the sector. Depth interviews were carried out with selected experts in Ministry of Industry (MoI), the Ministry of Trade (MoT), the Ministry of Agriculture (MoA), the Ethiopian Leather Industries Association (ELIA), the Leather Industry Development Institute (LIDI) and tanneries. In addition, secondary data and actual visit were used as a survey instrument. The parameters selected and the assumptions used in the models are decided together with the experts. Based on the findings, SDstock and flow diagram is proposed to help in understanding the dynamic behaviour among the variables so that the top management may take effective decisions in order to enhance the competitiveness of the Ethiopian Leather sector. AnyLogic Software has been used to model the existing and the proposed one using SD approach.

3.1 Modelling with System Dynamics

System Dynamics model is considered to be an appropriate research tool. The purpose of using SD is to improve the understanding and identification of the causal relationship in the system. SD is a methodology for studying and managing complex feedback system, such as one can find in business and other social systems. In fact, it has been used to address practically every sort of feedback system; problem- solving and policy design [1]. The purpose of SD modelling is to improve our understanding of the ways in which an organization's performance is related to its internal structure and operating policies and then to use that understanding to design high leverage policies for success [21]. SD is also a rigorous modelling method that enables us to build formal computer simulations of complex system and use them to solve long-term dynamics management problems [9] and to design more effective policies [11].

The SD modelling process starts with the identification of time dependent behaviour of one or more variables that explain the dynamics of the entire system.

3.2 Variables Identification

A number of variables were identified which increase the competitive advantage of SC through a search in the published articles, such as Wang, (2011) [23]; Asgari & Hoque, (2013) [1]; Xiaoyan & Jian-hua (2010) [24]; Jianghong, (2010) [9]; Mahmodi & Minaee, (2010) [13]. After listing these variables, it has been discussed with selected experts in LIDI, MoA, MoT and the tanneries. All the important criteria which are affecting the Ethiopian leather SC have been discussed with the experts. Comparing their views with the actual data collected for this study and with list of variables from published articles, the following variables are determined in the study (Table 1). Illustrating all variables in a single SC will be very complex; in this study the effect of lead time will be shown. The other variables will be the future work of the study.

3.3 Model Formulation

To develop the existing and newly proposed leather sector model different assumptions of parameters and equations are used. Suppose there is a complete leather SC consisting of livestock husbandry, abattoirs, collectors, small traders, big traders and tanneries. In order to ensure the upstream business an adequate supply for the downstream businesses, there exists such a relationship: the producer's stock ≥ abattoir stock ≥ collects stock ≥ small traders stock ≥ big traders stock ≥ tanneries stock. The assumptions of the parameters are based on

real data. In this study 'unit' represents hide or skin taken from one livestock. 'Time' represents one year.

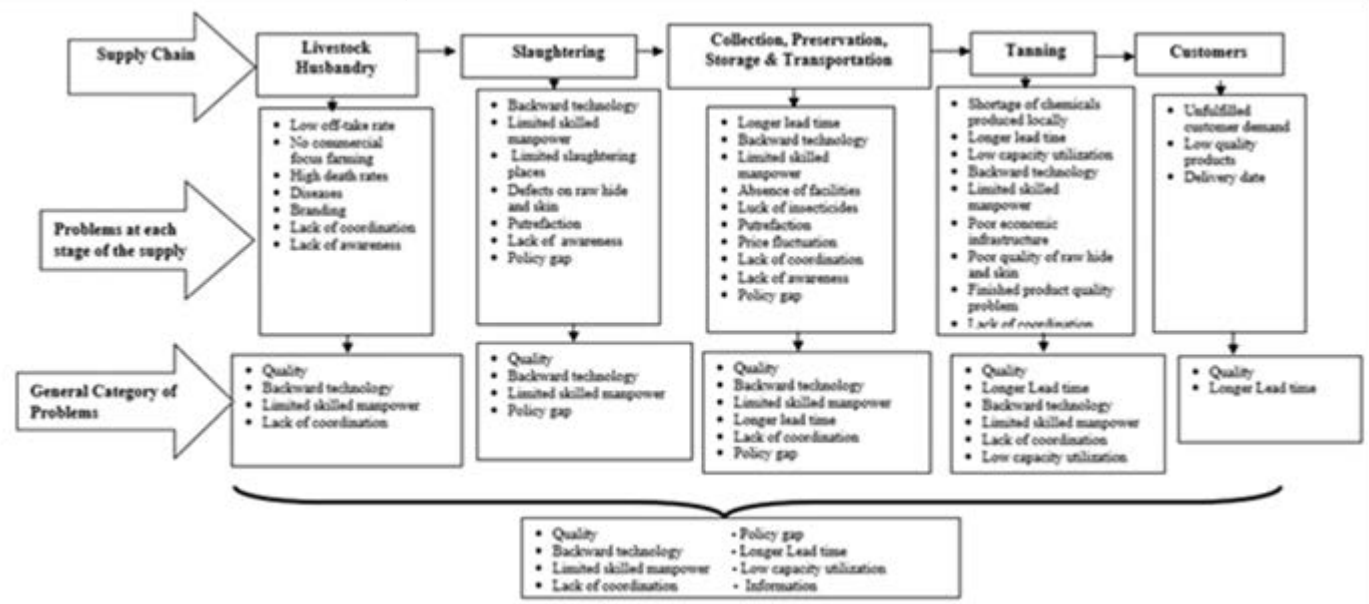

Fig. 2 Problems of the Ethiopian leather sector

The assumptions of the parameters in the model are as follows:

1. Livestock Numbers = 104,598,000 units
2. Expected Number of Livestock=90,372,023 units
3. Abattoirs Stock = 20,484,201 units
4. Expected Stock of Abattoirs = Numbers in livestock husbandry
5. Collectors Stock = 15,484,201 units
6. Expected Stock of Collectors = Number in abattoir stock
7. Small Traders Stock = 12,484,201units
8. Expected Stock of Small Traders= Numbers in collectors stock
9. Big Traders Stock = 9,103,000 units
10. Expected Stock of Big Traders = Numbers at small traders stock
11. Tanneries Stock = 2,359,207 units
12. Expected Stock of Tanneries = Number of big traders stock
13. Customers Demand = Numbers in livestock husbandry
14. Abattoirs Delivery Delay = 0.23 time
15. Collectors Delivery Delay = 0.7 time
16. Small Traders Delivery Delay =0.5 time
17. Big Traders Delivery Delay = 0.33 time
18. Tanneries Delay = 0.5 time
19. Breeding Cycle = 0.3 time
20. Slaughtering Cycle = 0.002 time
21. Collectors1 Cycle = 0.04 time
22. Collectors2 Cycle = 0.08 time
23. Collectors3 Cycle = 0.12 time
24. Production Cycle = 0.02 time
25. Customers Ordering Cycle = 4 time

The fundamental equation of the supply chain model is shown as follows:

1. Difference of Number of Livestock=Expected Number of Livestock- Livestock Numbers
2. Stock Difference of Abattoir = Expected Stock of Abattoirs - Abattoirs Stock
3. Stock Difference of Collectors=Expected Stock of Collectors-Collectors Stock
4. Stock Difference of Small Traders= Expected Stock of Small Traders - Small Traders Stock
5. Stock Difference of Big Traders = Expected Stock of Big Traders - Big Traders Stock
6. Stock Difference of Tanneries = Expected Stock of Tanneries-Tanneries Stock
7. Breeding Rate=Difference of Number of Live
8. stock/Breeding Cycle
9. Slaughtering Rate= Stock Difference of Abattoirs/Slaughtering Cycle
10. Collection Rate1=delay3 (Stock Difference of Collectors/Collectors1 Cycle, Abattoirs Delivery Delay)
11. Collection Rate2=delay3 (Stock Difference of Small Traders/Collectors2 Cycle, Collectors Delivery Delay)
12. Collection Rate3= delay3 (Stock Difference of Big Traders/Collectors3 Cycle, Small Traders Delivery Delay)
13. Production Rate=delay3 (Stock Difference of Tanneries /Production Cycle, Big Traders Delivery Delay)
14. Selling Rate= delay3(Customers Demand/Order Cycle of Customers, Tanneries Delay)
15. Final simulation time = 2 years

TABLE 1
DEFINITIONS OF VARIABLES

Variables	Meanings
Lead time reduction	One of the key order winning criteria from customers. Lead time is the duration of time from order placement to order shipment date. Lead time reduction signifies agility of the leather sector supply chain.
Quality improvement	Quality finished leather at a reasonably low price. It's very important for export market
Coordination	Working together of producers, slaughterhouses , collectors, tanneries and customers, a joint effort to solve problems, develop products or quality or system
Information sharing	Using software and hardware to share information effectively and to improve quality and production speed
Uncertainty	Effect of changing market situations; supply chain unpredictability; bullwhip effect

4. EXISTING ETHIOPIAN LEATHER SUPPLY CHAIN SYSTEN DYNAMICS STOCK AND FLOW DIAGRAM

Through the SD approach, the existing leather sector SC stock and flow model is established, which is shown in Fig.3. There are six basic stages in the existing supply chain: producers (animal husbandry), abattoirs, collectors, small traders, big traders and tanneries.Animal husbandry is the first stage in the supply chain of any leather manufacturing. And the main stake holders in this stage are farmers and pastoralists.The farmers sell their livestock to abattoirs for meat and hides and skins production. In most cases the hides and skins produced in abattoirs are delivered to collectors; then to small traders; thento big traders finally to tanneries for end product production. There are delays when abattoirs deliver hides and skins to collectors; collectors deliver to small traders; small traders deliver to big traders and big traders deliver to tanneries. The connection between the information and the flow of hides and skins can be clearly appreciated. The information flow is based on the production processes of the SC. The hides and skins start from the livestock husbandry and reaches the customer. The sales process to the lower stage and the acceptance process from the upper stage.

AnyLogic software is used for the SD simulation model. The assumed parameters and equations from section 3.3 are used in the SDstock and flow model. SD stock and flow model helps in studying and analyzing the system in a quantitative way; such models are usually built and simulated using computer software. A stock is the term for any entity that accumulates or depletes over time. A flow is the rate of change in a stock. In our case, there are six stocks: Livestock Numbers, Abattoirs Stock, Collectors Stock, Small Traders Stock, Big Traders Stock and Tanneries Stock. There are seven flows: Breeding Rate, Slaughtering Rate, Collection Rate1, Collection Rate2, Collection Rate3, Production Rate and Selling Rate. When the input in each flow changes, we can see change at each stock of the leather SC. In this simulation system, the simulation start time is 0 and stop time is 2 years. The model is built in order to understand the dynamics in the existing Ethiopian leather SC, i.e. how causalities and delays affect the performance of the leather SC. This information will be used to support further analysis and help decision-making.

5 EXISTING SIMULATION MODEL DISCUSSION

The above SD model describes the existing Ethiopian leather sector supply chain. This means that the problem as a pattern of behaviour over time will be revealed. This pattern shows how the problem has occurred and how it will appear in the future. In the existing Ethiopian leather sector SC the change of inventory overtime at producers, abattoir, collectors, small traders, big traders and tanneries stocks are shown in Fig.4. The notation of LivestockNumber, AbatorrisStock, CollectorsStock, SmallTradersStock, BigTradersStock and TanneriesStock means number of livestock, abattoirs inventory, collectors inventory, small traders inventory, big traders inventory and tanneries inventory. As shown in Fig 4 with the change of demand in two simulation years, it is very difficult to predict the change trend of demand in all stocks. The fluctuation of demand is due to delivery delays at each stages of the SC. As a result, a serious bullwhip effect is shown in the existing supply chain. Thus, it can be one of the reasons which hinder the competitiveness of the Ethiopian leather sector.

6 PROPOSED ETHIOPIAN LEATHER SUPPLY CHAIN AND INDUSTRIAL CLUSTER STOCK AND FLOW DIAGRAM

By analyzing the existing model, this study proposed integrated SC and IC model for the Ethiopian leather sector. Making each stages of the supply chain, industrial cluster i.e. livestock husbandry cluster, abattoirs cluster, collectors cluster and tanneries cluster. In the proposed supply chain and industrial cluster model, the livestock husbandry cluster supply well protected livestock to abattoirs. The abattoirs cluster delivers quality hides and skins to collectors cluster within recommended time. At the end, collectors supply well preserved hides and skins to tanneries for end product production. As explained in the introduction part, IC supports SC by integrating supporting institutions, in order to create the innovation and enhance the knowledge in the SC. Likewise, this study by introducing IC to the existing leather supply chain model, a new parameter added at each stage of the supply chain. This is Support1, Support2, Support3, Support4 and Support5 means giving supporting service for livestock husbandry farmers, abattoirs, collectors and tanneries respectively. In addition the introduction of IC in the existing SCmodel minimizes the number of collectors. It also minimizes delays at each stage of

the SC. For detailed illustration see Fig. 5

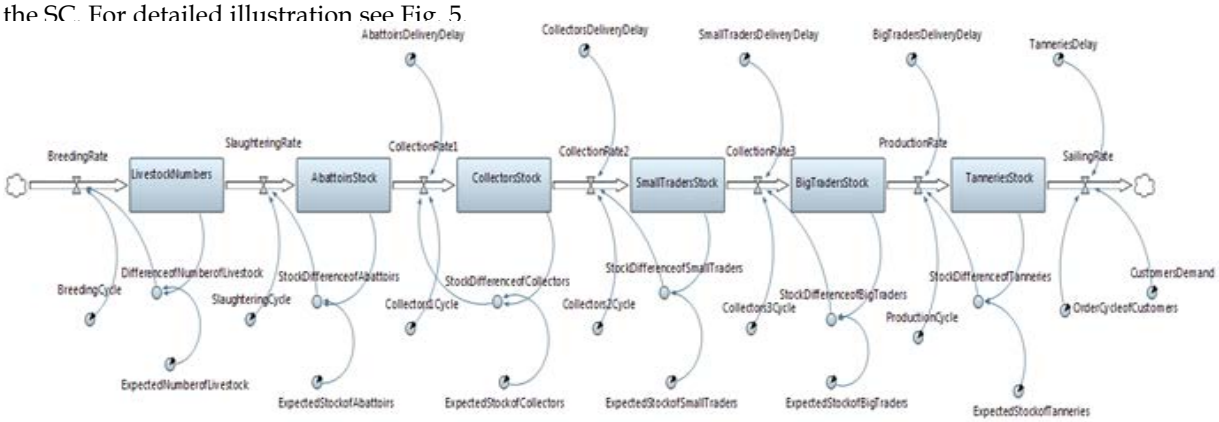

Fig. 3 Existing supply chain model

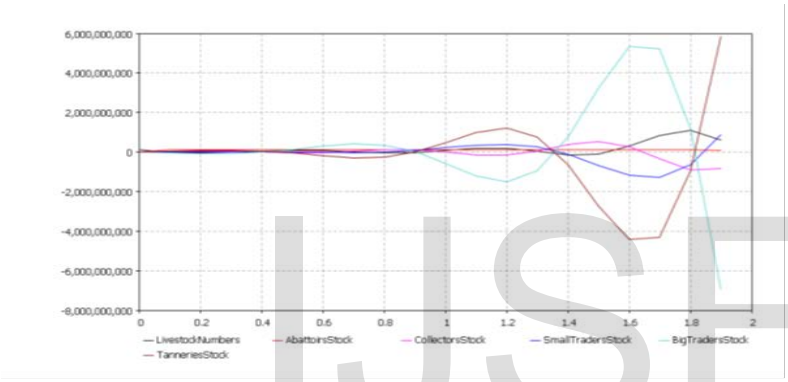

Fig.4 Inventory curve of each supply chain stages

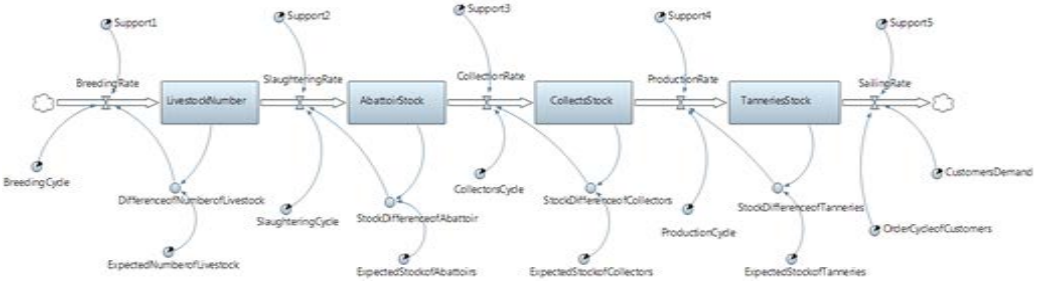

Fig. 5 Proposed supply chain and industrial cluster model

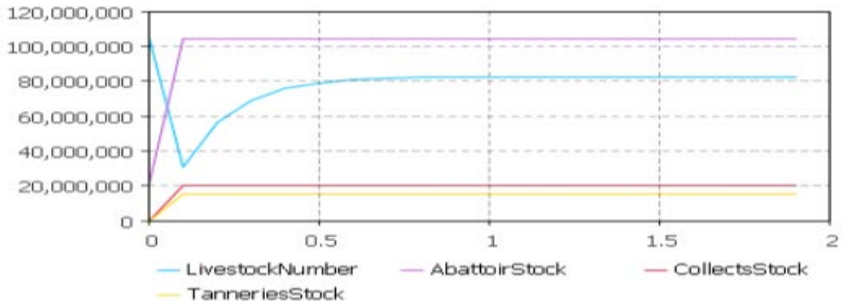

Fig. 6 Inventory curve of the proposed model

7 PROPOSED MODEL DISCUSSION

In the proposed integrated SC and IC model the change of inventory is shown in Fig.6.The notation of LivestockNumber, AbatorrisStock, CollectorsStock and TanneriesStock means number of livestock, abattoirs inventory, collectors inventory and tanneries inventory respectively. In the proposed model there was a fluctuation for few months. After that the level of inventory is the same in each SC stages for the given simulation period. This is due to the integration of IC in the SC. Although proposed model may not offer an exact prediction of future demand, it could be used as an applicable tool for analyzing and adjusting the raw hide and skin demand as well as the finished leather demand.

8 CONCLUSION

In this chapter, SD approach is used to show the dynamic behaviour of existing leather sector SC and the newly developed integrated SC and IC model. From the result of the existing leather sector SC model, the demand at each stage of the SC is unpredictable for the simulation period. This is due to long lead time and less coordination between actors of the leather SC. This hinders the competitiveness of the leather sector. To mitigate this problem this study introduced integrated SC and IC model for the Ethiopia leather sector. As the result, the newly introduced model, shorten the SC by eliminating big traders and small traders from the existing SC. This helps to minimize delays at each stage of the SC. In addition the introduction of industrial clusters adds other parameters (for example support services) to existing SC. The simulation results of the newly developed model also show an improvement in the Ethiopian leather sector. As a future study we plan to use other parameters such as Quality improvement, Coordination Information sharing, Uncertainty etc. to develop the model. In addition we plan to test the newly developed model in the other sectors also.

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