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CONTENTS

Sr. No.	TITLE & NAME OF THE AUTHOR (S)	Page No.
1.	UNDERSTANDING SEASONALITY AND ITS IMPACT ON DEMAND FORECASTING: THE CASE OF INDIAN PAINT INDUSTRY <i>RAHUL GANDHI BURRA & DR. BHARAT MEGHE</i>	1
2.	AN EMPIRICAL INVESTIGATION IN THE ROLE OF MICRO-FINANCE INSTITUTIONS FOSTERING FINANCIAL INCLUSION FOR WOMEN IN HARYANA <i>RAVI DUTT & DR. R. K. SHARMA</i>	6
3.	DOMESTIC DEBT, EXTERNAL DEBT AND ECONOMIC GROWTH OF JORDAN <i>ALI MUSTAFA AL-QUDAH</i>	11
4.	EVIDENCE AGAINST EXISTENCE OF SIZE EFFECT IN THE INDIAN CONTEXT <i>DR. G. RAGHURAM</i>	17
5.	DETERMINANTS OF MOST INFLUENCING REFERENCE GROUP IN BUYING DECISION OF RURAL CONSUMER <i>SHWETA & DR. ATUL DHYANI</i>	23
6.	DECISION SUPPORT SYSTEM IN SUPPLY CHAIN NETWORKS: A CRITICAL REVIEW <i>ARTI KRISHNAWAT & DR. SHANKAR CHAUDHARY</i>	28
7.	CONSUMER AWARENESS AND FEEDBACK TOWARDS PURCHASE INTENTION OF CSR RELATED PRODUCTS USING SEM <i>R. MANIMALAR & DR. S. SUDHA</i>	37
8.	EFFECTS OF IRREGULAR SHIFT WORK ON THE MARITAL LIFE AND PARENTING DIFFICULTIES (A STRUCTURAL EQUATION MODELING) <i>FABIAN ANDREW JAMES & DR. S. SUDHA</i>	41
9.	MEASURING CORRELATION OF SELECTED DISTRICT CENTRAL CO-OPERATIVE BANK OF GUJARAT STATE <i>RAJESH R. DESAI & DR. CHETAN C. PATEL</i>	47
10.	INDIAN A STUDY ON ADVERTISING RECALLING ABILITY OF CHILDREN <i>D. RENUKA DEVI & DR. P. KANCHANA DEVI</i>	51
11.	RETAIL CUSTOMER EXPERIENCE: A RESEARCH AGENDA <i>DR. SHILPA BAGDARE</i>	55
12.	SUPPLY CHAIN MANAGEMENT IN THE GOVERNMENT SECTOR <i>DR. SOPNAMAYEE ACHARYA</i>	59
13.	ROLE OF LEADERSHIP STYLE ON ORGANIZATIONAL PERFORMANCE <i>DR. ASHA NAGENDRA & DR. SAFIA FAROOQUI</i>	65
14.	A STUDY ON EMPLOYEE RETENTION MEASURES AND ITS IMPACT ON EMPLOYEE MOTIVATION <i>DR. MAHESHA KEMPEGOWDA & PURUSHOTHAM.C.J</i>	68
15.	A STUDY ON JOB SATISFACTION AMONG UNDERGRADUATE FACULTIES WITH SPECIAL REFERENCE TO SELF FINANCED INSTITUTIONS, BANGALORE <i>USHA SHREE.V</i>	73
16.	AN EMPIRICAL ANALYSIS ON DEMOGRAPHIC TRANSITION AND SAVINGS IN INDONESIA <i>SARI LESTARI ZAINAL RIDHO, NURLINA TARMIZI, BAMBANG B. SOEBYAKTO & AZWARDI</i>	83
17.	METHODOLOGY OF AUDITING PROCESS: THE ALARM TO MALPRACTICES <i>KRISHNA A KAPADIA</i>	86
18.	GUEST SATISFACTION IN HOTELS OF KASHMIR: THE PERCEPTION OF FOREIGN TOURISTS <i>ANJUM ARA</i>	88
19.	ADVERTISING ETHICS AND SURROGATE ADVERTISING PRACTICES: AN EMPIRICAL STUDY <i>MONIKA BANGARI</i>	94
20.	IMPACT OF PROMOTIONAL MIX ELEMENTS ON TOURIST'S SATISFACTION: A CASE STUDY OF MUSSOORIE <i>MOHAMMAD SHOAIB KHAN</i>	98
	REQUEST FOR FEEDBACK & DISCLAIMER	102

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- Kumar S. (2011): "Customer Value: A Comparative Study of Rural and Urban Customers," Thesis, Kurukshetra University, Kurukshetra.

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DECISION SUPPORT SYSTEM IN SUPPLY CHAIN NETWORKS: A CRITICAL REVIEW**ARTI KRISHNAWAT****RESEARCH SCHOLAR****PACIFIC ACADEMY OF HIGHER EDUCATION & RESEARCH****UDAIPUR****DR. SHANKAR CHAUDHARY****ASSOCIATE PROFESSOR****PACIFIC INSTITUTE OF MANAGEMENT****PACIFIC ACADEMY OF HIGHER EDUCATION & RESEARCH****UDAIPUR****ABSTRACT**

This article is a review of work published in various journals/books/conference proceedings/news on the topics of Decision Support System and Supply Chain Networks between June 2003 and March 2015. A total of 73 articles from 49 journals/books are reviewed. The article intends to serve three goals. First the article will help researchers in understanding various questions addressed, models proposed in the area of DSS and SCN with major emphasis on agriculture and food processing industry. Second, the article will be a useful resource for searching for research topics related to DSS in SCN of agriculture and food processing industry. Third, it will serve as a comprehensive bibliography of the articles published during the period. The literature is analyzed under 4 major themes and nine sub-themes.

KEYWORDS

Decision Support System (DSS), Supply Chain Network (SCN), system, model, agriculture, Food Processing Industries (FPI).

1. INTRODUCTION

Decision support systems (DSS) is the natural framework where decision models should be included in order to support farmers, advisers or livestock management specialists, supply chain management and operational team in the effective decision making process. During last years, the increment of competition between food product producers caused the marginal benefits per unit of product to reduce. In this context, there is an increasing interest in DSS tools capable of dealing with the uncertainty inherent to food production systems for practical decision support. In this paper various DSS models in supply chain networks, the development of DSS in agricultural or other industries representing either the productive and transportations over time and their mathematical foundation are reviewed. DSS in SCN is an industry-driven concept and system and is universally accepted by manufacturing industry as well as food processing industry (to a certain extent) as a practical solution to achieve integrated information system. The academic research community has been contributing to the field in various ways. A typical way of contributing to a field is by publishing archival journal papers for public benefits. This article is a review of work published in various journals/books/conference proceedings/news on the topics of Decision Support System and Supply Chain Networks between June 2003 and March 2015. A total of 73 articles from 49 journals/books are reviewed. No restrictions are imposed on the field of the journals/book/conference proceedings/reports/websites thus representing truly multi-disciplinary views on DSS in SCN.

As national and international concern over sustainable resources becomes more prevalent, the need for decision support systems (DSS) increases. The article will enable the researchers in understanding the applicable uses of successful DSS in SCN models proposed or designed in field of agriculture and allied industries as well as other industries.

The article is divided into four remaining sections. Section 2 describes the methodology followed in collecting and analyzing the articles. Section 3 provides the aggregate properties of these articles for each major theme. Some analyses of statistics on the reviewed articles along with a few obvious trends are provided in Section 4. The paper concludes with Section 5.

2. METHODOLOGY

The criteria for choosing articles/book section/reports for the review are as follows. First of all, the article must have been published in a peer-review, archival journal. The conference proceedings, book section and reports should also be from well-established publication. Second, only the articles and publications with 'DSS in Agriculture' and 'DSS in SCN' as a part of their titles were selected. The exceptions are those articles that are explicitly dealing with 'DSS in food processing industry' or 'DSS in SCN in agriculture' but for some reasons the authors decided not to use 'DSS' or 'SCN' in the title. The inclusion of such articles is inevitably *ad hoc*. Consequently, it is possible that there exist more of such articles which are not surveyed in this article. In an attempt to avoid never ending revision of the article, March 2015 was selected as the cut-off date. According to these criteria, an effort has been made to collect and compile all the available journal articles and publications through exhaustive internet browsing, database search, reference checking, etc. However, it is always possible that some of the articles are mislaid from this list. The complete list of the journals, books, conference proceedings and reports along with the number of articles appeared respectively is presented in Table 1,2,3 and 4 respectively.

TABLE 1: NUMBER OF ARTICLES IN EACH JOURNAL /BOOK SECTION/CONFERENCE PROCEEDINGS/REPORTS/ WEBSITES (ALL IN ALPHABETICAL ORDER)

<i>Name of Journal</i>	<i>Number of articles</i>
Agrociencia	1
Biosystems Engineering	1
Croatian Operational Research Review	1
Decision Support Systems	4
European Commission Report 2006 :ICT and E-Business	1
European Journal of Operational Research	3
Expert Systems with Applications	1
Food and Agriculture Organization of the United Nations	1
Industrial Journal of Productivity and Performance Management	1
Industrial Management and Data System	2
Information Systems & Supply Chain Management	1
Innovations in Agri-Food Systems	1
International Journal of Computer Science Issues	1
International Journal of Engineering and Science	1
International Journal of Information Systems and Supply Chain Management	1
International Journal of Logistics and Supply Chain Management Perspectives	1
International Journal of Logistics Research and Applications	2
International Journal of Physical Distribution and Logistics Management	2
International Journal of Production Research	4
International Journal on Food System Dynamics	1
Issues in Information Systems	1
Journal of Business and Industrial Marketing	2
Journal of Enterprise Information Management	1
Journal of Food Engineering	1
Journal of Manufacturing Technology Management	1
Journal of Marketing Channels	1
Journal of Purchasing and Supply Management	1
Omega	1
Production Planning and Control	10
Supply Chain Management :An International Journal	1
TEKNOLOGI	1
Transportation Planning and Technology	1
Total	53

TABLE 2: NUMBER OF BOOKS /BOOK SECTION ON DSS IN SCN (All in alphabetical order)

<i>Name of Book</i>	<i>Number of Chapters</i>
Agro-Industrial Supply Chain Management: Concepts and Applications	1
Decision Support Systems in Agriculture, Food and the Environment: Trends, Applications and Advances	3
Encyclopedia of Decision Making and Decision Support Technologies	1
Handbook on Decision Making	1
Total	6

TABLE 3: NUMBER OF CONFERENCE PROCEEDINGS ON DSS IN SCN (All in alphabetical order)

<i>Name of Conference</i>	<i>Number of Publications</i>
14th Euroma 2007 Conference	1
3rd Annual IEEE Conference on Automation Science and Engineering	1
8th International Symposium on Process Systems Engineering	1
AFITA 2010 International Conference	1
ESCIE-The Socializing model for online learning	1
IEEE Conference of Industrial Electronics and Applications	1
IEEE International Conference on Systems,Man and Cybernetics	1
International Hop Growers' Convention	1
Procedia Computer Science	1
Proceedings of the 38th Annual Hawaii International Conference	1
Recent Researches in Computational Intelligence and Information Security	1
The Quality Information for Competitive Agricultural Based Production System and Commerce	1
Total	12

TABLE 4: REPORTS/WEBSITES ON DSS IN SCN

<i>Name of Report/Website</i>	<i>Number of Publications</i>
Arkansas Business article	1
Vista Foods Report	1
Total	2

TABLE 5: MAJOR THEMES AND SUB-THEMES WITHIN DOMAIN OF DSS IN SCN

Themes
1. Decision Support System
Models
Case Study
General
2. IT intervention in Food Industry
3. Supply Chain Management
In Agriculture Sector
In Allied Industries
Basic outline in various sector
4. DSS in Supply Chain Network
Structural Design/Framework in a particular sector
Tools and Tactics
General study

The major themes defined in this article are (1) Decision Support System, (2) IT intervention in food industry, (3) Supply Chain Management, (4) DSS in Supply Chain Network. Under (1) Decision Support System theme, following three sub-themes are defined: (a) models, (b) case study, (c) general. For (2) IT intervention in food industry, there is no sub theme. For (3) Supply Chain Management theme further three sub-themes are there namely: (a) In agriculture sector, (b) In allied industries and (c) basic outline in various sector. For (4) DSS in supply chain network, we have three sub-theme: (a) Structural design/framework in a particular sector, (b) tools and tactics and (c) general study. Table 5 shows these themes and sub-themes used in this article.

A comprehensive table comprising of these themes and their classified references for each theme is provided in Table 6. The references are in APA style following alphabetical order. It is unavoidable to have an article that is relevant to more than one theme. For example, an article may address supply chain management issue in agriculture sector but also provide general study on DSS in SCN. In such a case, more weighted theme is chosen to classify the article according to the author's judgment.

TABLE 6: MAJOR THEMES AND SUB-THEMES WITHIN DOMAIN OF DSS AND SUPPLY CHAIN NETWORK

Themes	References
Decision Support System	
<i>Model</i>	(Agrahari and Tripathi, 2012)_(Burhanuddin, Ahmad and Desai, 2007)_(Noori and Salimi, 2005)_(Okongwu et al., 2012)_(Seema, Kaur and Kumar, 2014)_(Suroso and Ramadhan, 2012)_(Widodo et al., 2006)
<i>Case Study</i>	(Adam, Csaki, Prier and Bufacchi, 2012)_(Aragones, 2010)_(Lam and Dai, 2012)_(Laurensona, Buwaldab, and Walkerc, 2010)_(Pavlovic et al., 2008)_(Stiakakis and Sifaleras, 2010)_(Xie, Allen and Ali, 2014)
<i>General</i>	(Arason et al., 2010)_(Bakhrankova, 2010)_(Demirtas and Ustun, 2008)_(Manos, Matsatsinis, Paparrizos and Papathanasiou, 2010)_(Pavlovic and Koumbouli, 2009)
IT Intervention in Food Industry	(ICT adoption and e-business activity in 2006, 2006)_(Jayaraman, Ross and Agarwal, 2008)_(Liang, 2013)_(Van der Vorst, Beulens and Van Beek, 2005)_(Wicki and Dabrowska, 2013)
Supply Chain Management	
<i>In Agriculture Sector</i>	(Ahumada and Villalobos, 2009)_(Apaiah and Hendrix, 2005)_(Bryceson, 2005)_(Dabbene, Gay and Socco, 2008)_(Van der vorst, Silva, & Trienekens, 2007)_(Keizer et al., 2014)_(Lembito, Seminar, Kusnadi and Arkeman, 2012)_(Sutopo, Hisjam and Yuniaristanto, 2012)_(Taylor, 2005)
<i>In Allied Industries</i>	(Perez, Castro, Simons and Gimenez, 2010)_(Silvija and Soric, 2010)_(Singh, 2009)_(Soysal, Bloemhof and Van der Vorst, 2012)_(Traub, 2012)
<i>General Study of various sectors</i>	(Dreyer et al., 2009)_(Giannakis and Louis, 2011)_(Ngai, Cheng and Ho, 2004)_(Verdouw, Beulens, Trienekens and Van der Vorst, 2011)_(Wu and O'grady, 2005)
DSS in Supply Chain Network	
<i>Structural De- sign/Framework in a particular sector</i>	(Beheshti, 2010)_(Blackhurst, Wu and O'grady, 2007)_(Costantino et al., 2009)_(Dotoli et al., 2003)_(Felice and Petrillo, 2013)_(Ferrell, Rogers, Ferrell and Sawayda, 2013)_(Hernandez et al., 2014)_(Kristianto, Gunasekaranb, Heloa and Sandhu, 2012)_(Kumar and Viswanadham, 2007)_(Kumar et al., 2011)_(Lam, Choy and Chung, 2011)_(Liu et al., 2014)_(Liu et al., 2013)_(Maheut et al., 2014)_(Manuj and Sahin, 2011)_(Marimin et al., 2011)_(Marimin, Djatna, Suhartito, Nugeraha and Bahar, 2010)_(Ngai et al., 2012)_(Ngai, Peng, Alexander and Moon, 2014)
<i>Tools and Tactics</i>	(Jakhar and Barua, 2014)_(Koh et al., 2013)_(Van der Vorst, Tromp and Van der Zee, 2009)
<i>General Study</i>	(Fink, Jurgen, & Stefan, 2005)_(Koh et al., 2013)_(Vorst et al, 2007)

3. OVERVIEW OF THE ARTICLES

In this section, a brief summative of the articles for each theme is provided. It is not intended to provide detail description of each article. Rather, an attempt to draw a collective summary is made in this section. For the articles reviewed for each theme, refer to Table 6 above.

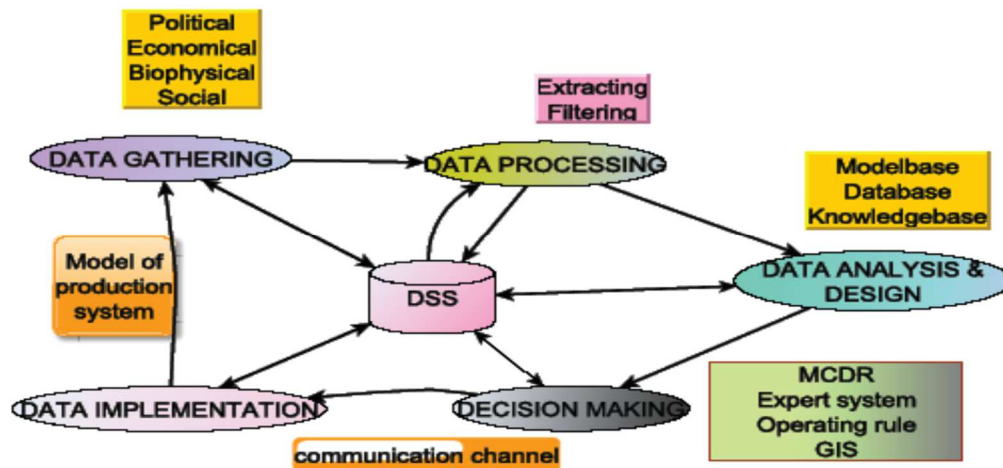
3.1 Decision Support System

Decision Support System (DSS) is an interactive, flexible, and adaptable computer based information system that utilizes decision rules, models, and model base coupled with a comprehensive database and the decision makers own insights, leading to specific, implementable decisions in solving problems that would not be amenable to management science models. Making the decision could be defined as integration of result produced at stages of process with computer, human logic and integration of previous developed model. Thus, a DSS supports complex decision making and increases its effectiveness (Tripathi, 2011).

A group of articles are classified under a sub theme of 'Model'. These articles typically utilize analytical methods, such as decision analysis, optimization algorithms, program scheduling routines, and so on, for developing models to help decision makers formulate alternatives, analyze their impacts, and interpret and select appropriate options for implementation (Adelman, 1992).

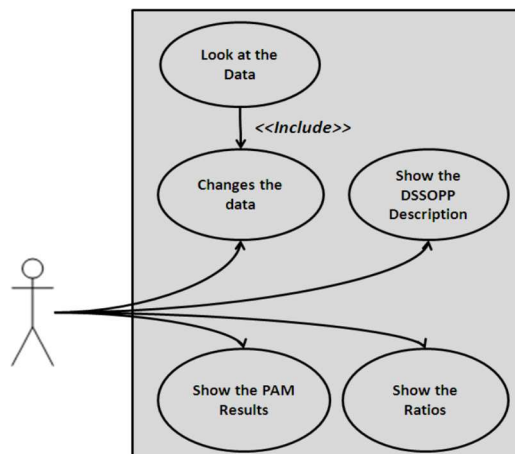
Most of the articles have used real dataset to test and compare the results. Techniques namely Decision Making Grid (DMG), cross-functional multi-criteria decision-making, customer-relationship management (CRM) and knowledge-driven marketing, Policy Analysis Matrix (PAM) are used to propose new DSS. Few models proposed by researchers under this sub theme are as follows:

FIG. 1: THE PROPOSED FRAMEWORK OF DSS BUILDING DATA DRIVEN DSS FOR AGRICULTURE



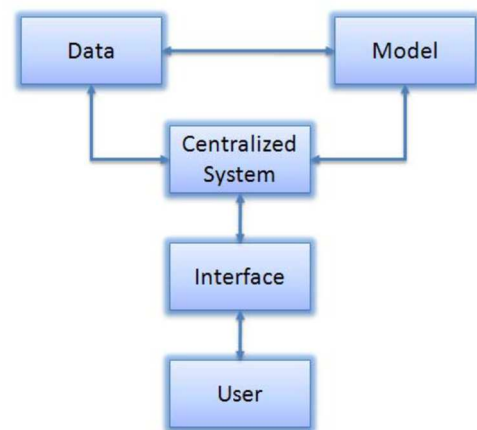
Source: Agrahari and Tripathi, 2012

FIG. 2: DSSOPP BUSINESS USE-CASE DIAGRAM



Source: Suroso and Ramadhan, 2012

FIG. 3: DSSOPP ARCHITECTURE



Major papers under sub theme 'Case Study' emphasized on computerized decision support system designed to provide a standard framework for the encapsulation of respective science into decision support "tools" for ultimate clientele. These decision support tools will thus provide information which will help decision makers with specific management decisions.

Finally, group of articles under sub -theme 'General' address agriculture sector focusing on the exposition of innovative methodologies, from web-mobile systems to artificial intelligence and knowledge-based DSS, as well as their applications in every aspect from harvest planning to international food production and land management. They aim to monitoring all functions of an agricultural process and facilitating decision making by proposing scenarios towards satisfying specific performance criteria and restrictions. Their aim is to contribute in research by bridging the gap between theory and practice.

3.2 IT intervention in Food Industry

Information is playing an increasing role in today's economy. It is treated as a more valuable resource than traditional material goods. The management of the flow of goods and services and their accompanying information is the subject of logistics. Current logistics systems in various sectors of the economy, especially that of production, are supported by dedicated integrated IT systems.

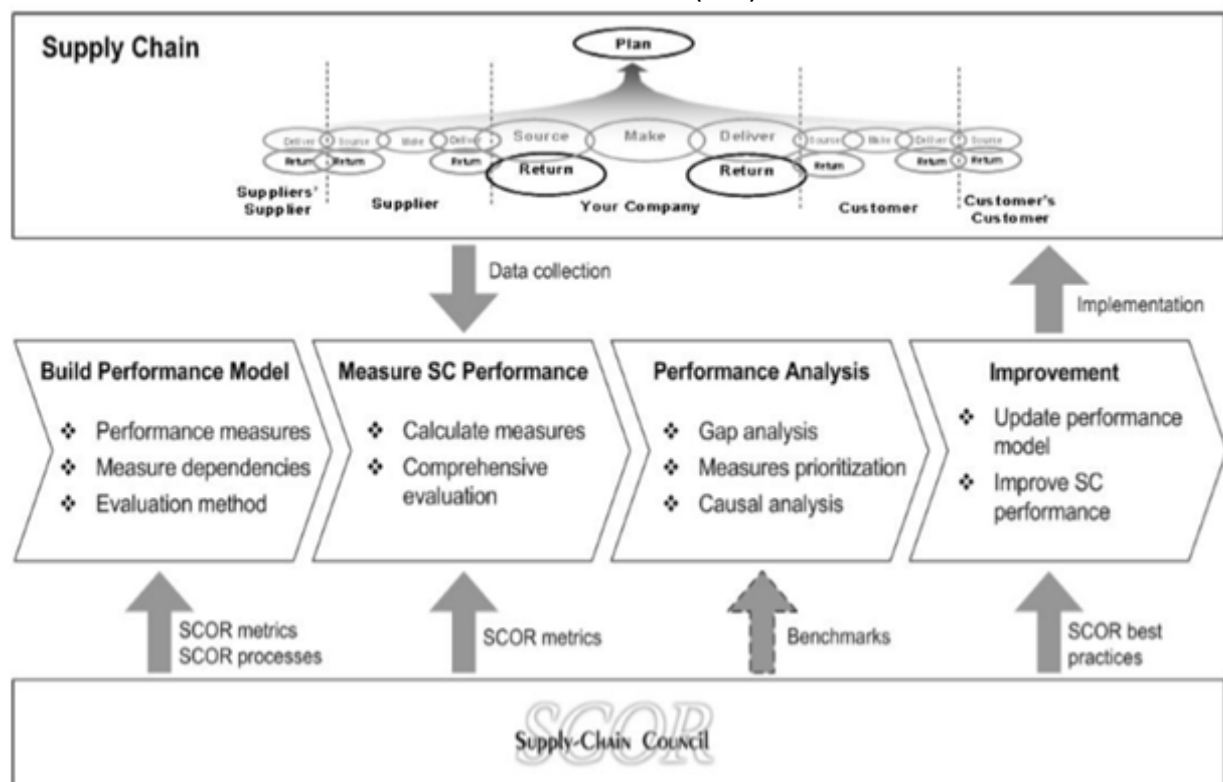
Most papers under this theme deals with identifying problems that companies face when they handle product returns along the channels and present the critical role that information technology and collaboration can play to mitigate many of the problems and deficiencies. These papers attempt to highlight a key element in reducing uncertainties in the different stages of the reverse channel of a supply chain which is access to accurate and timely information on the status, location, and condition of products moving about in the supply chain. Their analysis is based on literature, interviews, case studies and survey among decision-makers in respective enterprises.

3.3 Supply Chain Management

The supply chain of agricultural products has received a great deal of attention lately due to issues related to public health. Something that has become apparent is that in the near future the design and operation of agricultural supply chains will be subject to more stringent regulations and closer monitoring, in particular those for products destined for human consumption (agri-foods). Agribusiness firms are responding to the emerging challenges in global economy by seeking the benefit of greater collaboration and integration with both their suppliers and customers to ensure more sustainable and profitable trading arrangements.

A group of articles are classified under sub-theme of 'In Agriculture sector'. These articles typically investigate main contributions in the field of production and distribution planning for agri-foods based on agricultural crops. The articles belonging to this sub-theme tend to focus on individual cases such as VAG (a prototype animated, interactive, three-dimensional virtual environment model of a supply chain in the agribusiness sector), lean value chain improvement techniques and Supply-Chain Operations Reference (SCOR model to assist firms in increasing the effectiveness of their supply chains, and to provide a process-based approach to SCM) model to name a few.

FIG. 4: SUPPLY-CHAIN OPERATIONS REFERENCE (SCOR) MODEL WITH METRICS



Source: SCOR version 10, Supply Chain Council, 2010., Lembito et. al., 2012

Some generalisations are occasionally provided in these articles but emphasis is majorly on those models which have been successfully implemented. Articles under sub-theme 'In Allied Industries' particularly address the supply chain models for agricultural fresh products such as catalian pork, olive oil as well as retail industry. Supply chain management (SCM) models of agricultural fresh products are more complicated than the SCM models of the usual industrial products with no deterioration, because the amount of harvestable fresh products depends on the growing process of the related plants on farmland, and because the deteriorating process of the fresh products starts immediately after harvested (Widodo, Nagasawa, Morizawa, Ota, 2006). What differentiates agri-food supply chains from other supply chains is the importance played by factors such as food quality and safety, and weather related variability (Salin, 1998). Because of all these issues, in the context of agri food supply chain, under this sub-theme, three main functional areas: harvesting, storage and production, are taken into consideration. Case research methodology is generally used in the articles with a conceptual model proposal as a tool to carry out the assessment. Some articles attempt to understand the direction of various industries towards their respective supply chains. Under sub-theme 'General study of various sectors' articles mainly proposes framework of decision support system for the management disruptions and mitigation of risks in manufacturing supply chains. The operation of global supply chains is challenging due to the complexity in product and information flows, diversity in sites, localization and processes and the information processing needed for coordination and control. Most of the articles under this sub-theme presents global control model, performance measurement system, information and communications technology (ICT) and organization of roles and responsibilities. Along with this an article on Trans-Net [critical success factors (CSFs) of web-based supply-chain management systems (WSCMS)] is also covered in this sub-theme.

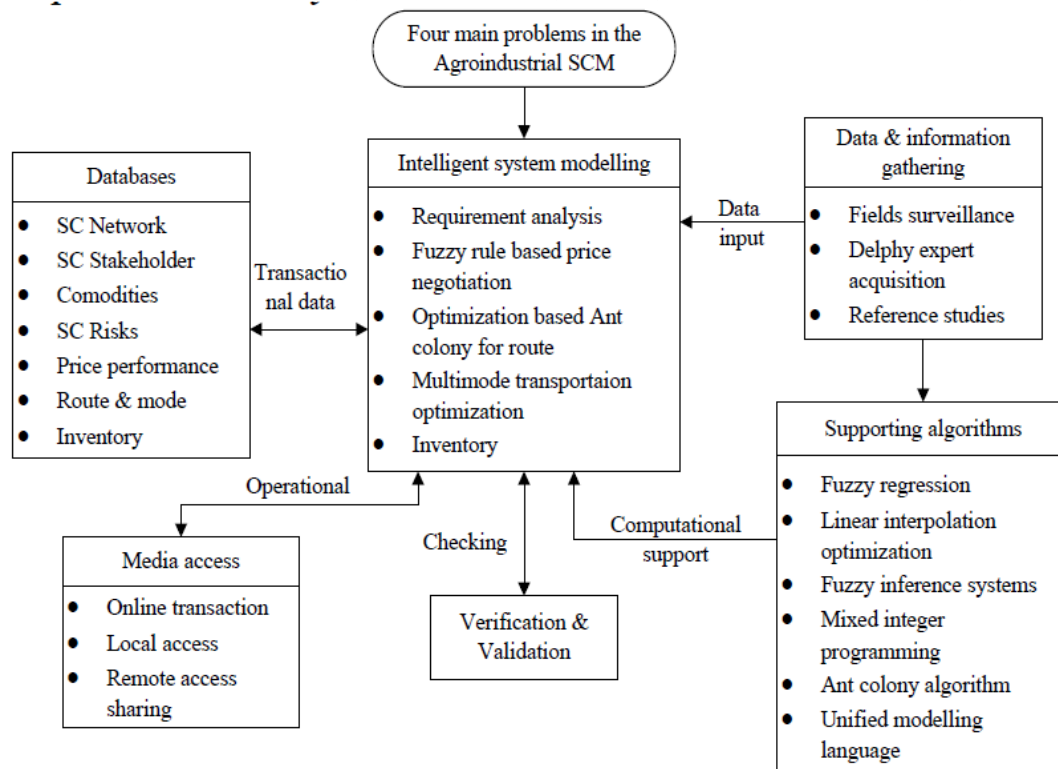
3.4 DSS in Supply Chain network

The agri-food sector is facing global challenges that can only be met with support of information technologies (IT), (Schiefer, 2004). IT opportunities are key tools in the agri-food supply chain activities and contribute to the optimization and to an efficient decision making process. The decision support systems involve the storage and processing of collected information, methods and techniques giving the new information useful for efficient decision making and in this way make the planning process more structural and promising. The most famous decision support systems are Enterprise Resource Planning (ERP) and Supply Chain Analytics (SCA), or Advanced Planning Systems (APS).

Reflecting such a level of importance, the largest number of articles belongs to this theme 'DSS in Supply Chain Network'. It comprises more than 40% of the entire articles. Some articles attempt to explain why decision making in agri-business sector, in particular, is complex and what needs to be done to achieve desirable results. Also, various models of implementation stages and different implementation methodologies are presented. Several articles present various types of framework or models of DSS in SCN. They range from a conceptual model that explains the DSS, to the taxonomy of success factors of DSS implementation and to a user acceptance model.

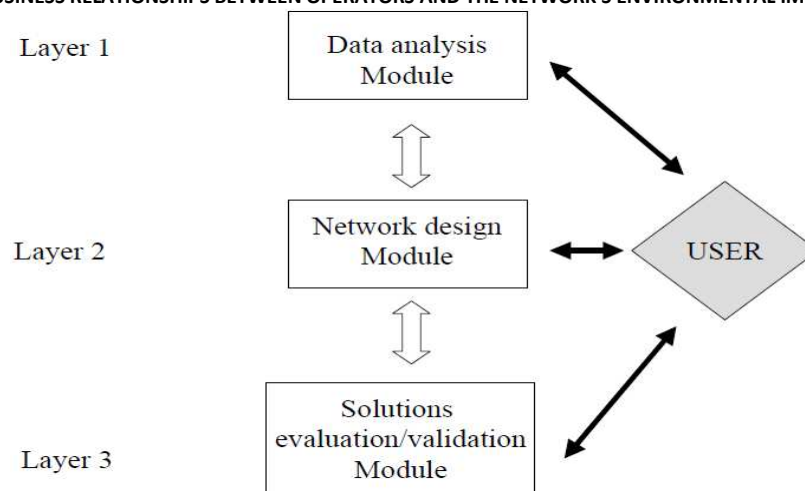
One of the popular topic in DSS in Supply Chain network is 'Structural Design/Framework in a particular sector'. The articles seek to present a decision support model for improving supply chain performance. In most of the articles focus is to develop a comprehensive model of supply chain and supply chain decision-making complexity that provides an understanding of the drivers of supply chain complexity and strategies to manage supply chain and supply chain decision-making complexity and outcomes. While there is growing concern with ethics, corporate social responsibility, and sustainability, the current state of the field is fragmented with the majority of articles reviewed focusing on specific issues rather than a more holistic approach. Major industries explored for case studies are manufacturing industry, automotive industry, machine tool industry and agri-business industry. A set of articles in this sub-theme proposes a decision-focused knowledge framework including a multi-layer knowledge model (to capture the know-why and know-with together with the know-what and know-how), system dynamic based computer simulation model, ethical decision making models and green supply chain management (GSCM) practices. Decision models have been developed using Soft System Methodology, Hard System Methodology, Montecarlo approach, analytic network process, grounded theory methodology, generalisable network based methodology (to model supply chain operations and the uncertainty of system attributes such as lead time and cost) and artificial intelligence system shells VisiRule and Flex, to name a few. Most of the articles have adopted case-based reasoning to support managers and other ultimate clientele in making appropriate decision arising in supply chain networks. They have retrieved similar cases in the past and have adapted in reference to their new model/framework and then conducted case study to illustrate the feasibility and effectiveness of the proposed system. The models proposed in various articles under this sub-theme provides the foundation for future research as well as support for decision making when various decision makers are involved. The results of the research will help practitioners better understand the sources and outcomes of supply chain complexity and how to manage it.

FIG. 5: CONCEPTUAL FRAMEWORK OF IDSS (Intelligent decision support system for Agricultural business and industry supply chain management)



Source : Marimin, Djatna, Suhajito, Nugraha and Bahar, 2010.

FIG. 6: THE THREE LAYERED STRUCTURE OF DSS (A DECISION SUPPORT SYSTEM FOR INTEGRATED PRODUCTION NETWORK DESIGN CONSIDERING ALSO THE E-BUSINESS RELATIONSHIPS BETWEEN OPERATORS AND THE NETWORK'S ENVIRONMENTAL IMPACT)



Source: Dotoli et al., 2003

The articles belonging to sub-theme 'Tools and Tactics' address important performance evaluation criteria (supply chain planning performance, supply chain partnership performance, production performance, delivery and logistic performance and customer service and satisfaction performance) and corresponding sub-criteria. As per articles covered under this sub-theme simulation tools are often used for supporting decision-making on supply chain (re)design when logistic uncertainties are in place, building on their inherent modeling flexibility. One article in particular has proposed a new integrated approach towards logistics, sustainability and food quality analysis, and implement the approach by introducing a new simulation environment as quality change is intrinsic to the food supply chains industry.

Under sub-theme 'General' authors have attempted to identify methodological shortcomings in existing tools, and proposing a supply chain (SC) framework which provide businesses with a holistic understanding of their supply chains and ensuring partners within supply chain collaborative networks. They have discussed about opportunities to use time-dependent product quality information to improve the design of food supply chain networks. Data warehouses and data mining can be used to store and analyze product, inventory, and sales information. Simulation and optimization, which can be found in advanced planning and scheduling systems, can be employed for e.g. inventory, production, procurement, and distribution planning. Intelligent agents can e.g. communicate with different partners in the supply chain, assist in collecting information, share product information, negotiate prices, and distribute alerts throughout the logistics networks. They have proposed heterogeneous yet complementary ensemble of various real world decision situations contributing to a minitrack which deals with intelligent decision support in whole field of e-logistics and supply chain management. Research carried out in these articles have implications for future sustainability research in supply chain, decisions science, management theory, practice and policy.

4. ANALYSIS

The field of DSS has matured in a relatively short period of time. As Table 4 shows, the number of journal articles published from 2003 has steadily increased, but there is a sign of stabilizing in recent years. Considering the fact that most of journal articles started appearing in late 1990s, this field certainly gained significant research interests from many researchers in a short period of time.

TABLE 7: NUMBER OF JOURNAL ARTICLES ON DSS IN SCN DURING 2003–2015 (as of March 2015)

Year	Number of publications
2003	1
2004	2
2005	6
2006	2
2007	5
2008	6
2009	7
2010	10
2011	5
2012	14
2013	6
2014	8
2015	1
Total	73

From table 6 it could be inferred that almost 40% articles have published from year 2010-2012. In early years, more articles were written to share the experiences of implementing decision support systems or based on opinion survey studies. As more experiences have been gained with the implementation process, different topics such as the importance of using DSS in supply chain network, DSS framework in agri-business and food processing industry seem to be becoming of interests to the researchers. Also, the mature status of the field is evident in the rigor and thoroughness of the articles in recent years.

5. CONCLUSION

Several areas for future research seem promising. A large scale, simultaneous survey studies might generate useful insights on this subject. Major articles present the development of DSS for managing agricultural and environmental systems, focusing on the exposition of innovative methodologies, from web-mobile systems to artificial intelligence and knowledge-based DSS, as well as their applications in every aspect from harvest planning to international food production and land management, warehouse management, logistics and supply chain management. The concept of DSS seems to be growing and expanding. As agricultural production and environmental management involve high risk decisions, risk analysis and management tools have enjoyed increased popularity over the last years as well, by the time that food supply chain management, ecosystem governance, conservation of biodiversity and global climate change have among other issues hotly entered the agenda. It will be useful to investigate topics such as how the companies (FMCG in particular) using the decision support system perceive this trends, how they will cope with the changes, what tools, methodologies, models are useful in their expansion efforts.

This article provides a comprehensive review of research articles related to the application of decision support in supply chain networks of various industries with major emphasis on agribusiness units. Data were obtained from 73 articles published from 2003 to 2015. A comprehensive list of journal articles identified in this study provides insights and relevant references for both researchers and practitioners on the application of decision support system to various stages of supply chain. In light of the developed classification framework, gaps could be identified for the use of the decision support system in the industry and suggest potential and applicable research areas for further consideration in this subject area.

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With sincere regards

Thanking you profoundly

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Sd/-

Co-ordinator

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