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An Exploratory Study of Drivers for the Adoption of Green Supply Chain Management in Small and Medium Sized Tanneries of Northern Tamilnadu using ISM, ANP and Fuzzy ANP

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ABSTRACT

Background: Eco Design of supply chain focuses on the responsibility of a firm in evaluating the total environmental effects of products through its entire life cycle, from the acquisition of raw materials to the final usage and disposal of products. Nowadays implementation of GSCM is indispensable, because of public awareness and government commandment. **Objective:** This project aims to examine lot of drivers which are acting as a prominent factor for the execution of green supply chain management in tannery industries. In this work, drivers have been pinpointed through literature review and also from expert's opinion. Then the identified drivers are classified depend upon its competency. The relationship among the diagnosed drivers is complex and mutually dependent. **Results:** So an Interpretive Structural modeling (ISM) is enforced to establish a structural Model. ISM is a computer-assisted learning process that enables individuals or groups to develop a map of the complex relationships between the many elements involved in a complex situation. A dynamic evaluation technique, Analytical Network Process (ANP) and Fuzzy Analytical Network Process (FANP) is used to identify the priorities of drivers for the adoption of green supply chain management in northern Tamilnadu tannery Industries. The Analytic Network Process (ANP) is a generic mode of the Analytic Hierarchy Process (AHP) used in multi criteria verdict evaluation. FANP is a Fuzzy multi-criteria decision-making (MCDM) tool that has been widely used in many applications related to decision-making problems. **Conclusion:** In this research it is gleaned that only Stakeholder's Cooperation has the highest authoritative potential for consummating the GSCM in a lucrative manner.

KEYWORDS: Fuzzyness, Interpretive Structural Modeling, Analytical Network Process, Eco-design, Multi criteria Decision Making.

INTRODUCTION

Spreading alertness of environs problems and replying to them hastily without impediment is decisively inevitable to deal with the global environmental problem effectively. It is rightly said by Mr. Paul Hawk [1], the Environmentalist in his book "The Ecology of commerce".

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"Business is the only mechanism powerful enough to produce the changes necessary to reverse global environment and social degradation".

Business organizations including various industries have to come up to solve these environmental issues and avert this environmental destruction. Numerous organizations responded to this by adopting green mores to their firm, such as using eco-friendly raw material, downsizing the practice of petroleum power, and using the reprocessed papers for packaging. Many of them have also realized their responsibilities and started implementing various environment friendly practices like cleaner production, adoption of ISO certification, etc. to meet their environmental objectives. More and more Indian companies are adopting 'green practices'. It helps the environment; of course it also helps the business. Indian Companies are feeling the pressure to go green, as many of their Western counterparts are building environmental sustainability into their business practices. According to Hansmann and Cloudia [2], every blooming induction of green creation may afford novel ways to reckon value to core trade plans. Therefore, market leaders in numerous firms have taken a step forward to green their intrinsic function. Environment Management System helps industries to upgrade environment performance only within the firm's function confines in preference of through the supply chain [3].

Literature Review:

A supply chain consists of all parties involved, directly or indirectly, in fulfilling a customer request. The supply chain includes not only the manufacturer and suppliers, but also transporters, warehouses, retailers, and even customers themselves. Within each organization, such as manufacturer, the supply chain includes all functions involved in receiving and filling a customer request.

A typical supply chain may involve a variety of stages. These supply chain stages include:

1. Customers
2. Retailers
3. Wholesalers/distributers
4. Manufacturers
5. Component/raw material suppliers

Each stage in a supply chain is connected through the flow of products, information and funds. These flows often occur in both directions and may be managed by one of the stages or an intermediary. Green supply chain management (GSCM) is a developing field that strings out of the conventional supply chain perception. Srivastava [4] stated that "quality revolution in the late 1980's and the supply chain revolution in the early 1990's" have flickered trades to become environmentally judicious.

GSCM has secured fame with both academics and professionals to intent in shortening waste and sustaining the worth of product-life and the inherent wealth. Eco efficiency and remanufacturing processes are currently imperative capitals to attain peerless system [4-5]. Realizing the significance of the GSCM implemented by the organizations, Sarkis [6] developed a diplomatic decision structure that helps managerial decision making in electing GSCM alternates, and product life cycle, functional life cycle (including procuring, manufacturing, spreading and reverse logistics (RL)), industrial performance evaluation and environmentally conscious métier practices act as a base for the decision framework [7]. "Perusal of the literature shows that a broad frame of reference for green supply chain management is not adequately developed" [4]. Therefore, "researchers persist to strife with diagnosing a crystal, incorporated structure for green supply chain practices" [8].

Research Hiatus:

Green supply chain is a very good practice to be done for dealing and minimizing with the environmental issues that we are facing today. Many researchers contribute in this topic in various respects. Several researchers have given various definitions of GSCM in different perspective. Number of definitions of GSCM exist [9]. Similar to the concept of supply chain management, the frontier of GSCM is reliant on researcher goals and the problems at hand, e.g., should it be just the procurement stage or the full logistics channel that is to be investigated [10]. From the findings of Srivastava [4-11], it reveals that the key themes from the perspective of practice and performance of GSCM that has been presented over the last two decades are the conception of: green configuration, green operations, reverse logistics, offal management and green production. Apart from operations, perspective considerable work has been done to facilitate the implementation of GSCM in organization at various levels by analyzing the barriers for the implementation of GSCM.

Sharma [12] suggests that lack of commitment from top management is a chief barrier for successful adoption of green business practices. Also the success of any environmental management practices relies significantly on the maturity level of senior management leadership and commitment [13].According to Ravi and Shankar [14], Reverse logistics can lead to economic benefits by the recovery of the returned products for reuse, remanufacturing, recycling, or a combination of these options for adding value to the product and implementation of the same leads to direct benefits to the environment too. Few researches have also been done for identifying the motivation factors or drivers for implementing GSCM. Kleindorfer, Signahl, and

Wassenhove [15] split the key drivers of viability in the supply chain into two clusters: systematizations and public anticipations. These drivers can be derived from the 3 Ps (People, Profit & Planet). Zhu and Sarkis [16] also ranked the drivers that instigate green supply chain management rituals into: systematizations, marketing, vendors, contenders and innate factors.

According to the research done so far is evaluating different techniques and obtaining solutions to achieve GSCM in various contexts such as green purchasing, green manufacturing, green supply and distribution. But there is no work done regarding the contribution of each driver (environment, organisation and technology) and the impact of green supply chain management to organisational performance hence we found this as the research gap for our project.

Problem Description:

The leather and its related subsequent industries can assert to be the world's prime industrial sector based upon a by-product. In the case of leather, the primal matter is a by-product of the meat industry. Hides and skins and their subsequent products are vivacious earners of foreign exchange and they correlate very well with the other agricultural products and, in fact, with any internationally traded commodities. This industry helps an adaptable and putrescible material into an immutable and vendible product. The tanning industry is known to be very contaminating especially through effluents high in organic and inorganic diffused and deferred solids content accompanied by proclivities for high oxygen demand and comprising potentially noxious metal salt residues. Displeasing odour emanating from the decomposition of protein solid waste, presence of hydrogen sulphide, ammonia and impulsive organic compounds are normally allied with tanning activities. A significant part of the chemical used in the leather processing is not actually absorbed in the process but is discharged into the environment.

In India, nowadays environmental issues are more pertinent. So it is imperious for the industries to be ecofriendly. From an environmental point of view, the companies in this sector have always been listed as highly polluting, due to the emissions of the tanning process. In this process the skins of animals (such as cattle, sheep, and swine) are transformed into leather through different stages. In northern part of Tamilnadu, the underdeveloped and artisanal manufacturing processes aggrandize the environmental repercussion. This problem can be seen in micro, small, medium-sized enterprises. So in tanning industries supply chain plays an imperative role in reducing the green rating. So it is crucial to discriminate the drivers which help the industry to achieve environmental feasibility.

Tanneries Database:

The tanneries located in the northern region of Tamilnadu have been pointed in this research. According to the leather Industry database of northern Tamilnadu, 15 tanneries were identified. The respondents were general manager, in-charge of the entire process of tanneries who had an adequate knowledge about the function and management of supply chain habit in the Industry. The enclosure concerns endeavour to improve its role towards the environmental performance. Management of the companies aspires to identify and evaluate the drivers in contriving their plan of action in adopting and implementing GSCM concept in a successful manner.

Solution Methodology:

Based on Literature review and expert's opinion the drivers are discovered which induce the adoption of GSCM in Northern Tamilnadu leather industries.

Those Drivers are basically sorted into 6 categories

The categories are:

1. Technical Capabilities
2. External Stake-Holder Cooperation
3. Environmental Performance
4. Economic Performance
5. Internal Management
6. Regulatory Requirements

These Categories assist:

1. To examine the impact of drivers by considering their contribution to achieve green supply chain management using various techniques (ISM, ANP, Fuzzy ANP)
2. To examine the impact of adopting Green Supply Chain Management to organizational performance.

Questionnaire preparation & Data Collection:

Based on Literature, a pervasive questionnaire which covered multifarious aspects of the categories of the drivers was developed. This questionnaire was sent to tannery general managers. Managers were thoroughly briefed regarding the parameters and the drivers. The respondents were required to evaluate the parameters in

the categories on the scale of 5 with respect to their importance and their applicability in motivating the organization for transiting to GSCM from conventional Supply Chain.

Interpretive Structure Modelling (ISM):

Interpretive Structural Modeling (ISM) was firstly developed in 1970‘s by Warfield [17]. ISM is primarily deliberated as a congregate lore process, but can also be used independently. The ISM method renovates vague, feebly lucid rational forms of systems into perceptible, distinct models useful for many purposes [18]. The ISM methodology is an interactive learning process. In this a systematized function of some rudimentary concepts of graph model is used in such a way that hypothetical, conceptual and computational power are subjugated to define the intricate pattern of circumstantial relationships among a set of fickle [19]. According to Rajesh Attri and Nikhil Dev [19], this technique has two enticing factors when compared to the identical approaches namely flatness in the perceptive of not requiring from the manipulator i.e. viewpoint of advance mathematical lore and effectiveness in terms of retrenchment in computer time. The various steps involved in ISM Methodology are [19-20-21],

Step1:

List the Variables related to Problem

Table 1: Drivers for the adoption of GSCM

Criteria	Sub Criteria	Source
Internal Management (IM)	I1- Environmental issues part of strategy	[8-9-16-22-23-24-25-26-27-28-29-30-31-32-33-34]
	I2-Environmental Management Systems (EMS) and ISO 14001 Certified	[16-22-23-28-29-31-32-33-34-35]
	I3- Knowledge flow among the employees	[36-37-38]
	I4-Performance on green initiative effects, employee evaluation & compensation	[23-29-31-32-33-34-35-39-40]
Technical Capabilities (TC)	T1- Sufficient internal expertise and R&D capability	[41-42-43-44]
	T2- Cross-functional Teams to Minimize environmental impacts	[16-17-29-37]
	T3-Adequate training and incentives to the employees	[37-42-43-45]
	T4- Eco Design tanneries	[46-47-48-49]
Regulatory Requirements (RR)	R1- Adheres to international environmental laws	[9-38-39-40-50-51-52-53-54-55]
	R2-Adheres to national environmental laws	
	R3-Adheres to regional environmental laws	
Stakeholders Cooperation (SC)	S1-Financial benefits from government for green initiatives	[16-29-31-38-52-54-56-57]
	S2-Loans from financial institutions for green practices.	
	S3-Technical advice & consultation service from external parties	
Environmental Performance (EN)	EN1-Reduction of pollution emission	[22-26-28-29-32-33-34-58-59-60]
	EN2-Decreased consumption of hazardous / toxic materials	
	EN3-Decreased Frequency of Environmental Accidents	[22-25-26-28-32-33-34-58-59-60]
	EN4-Improved Overall Environmental Situation.	
Economic Performance (EC)	EC1-Reduction of Energy Consumption of Cost	[22-35-60-61]
	EC2- Increased Market Share	[29-30-31-32-33-34-38-62]
	EC3-Increased return on investment	[35-60-62]

Step 2:

Establishment of Contextual Relationship.

Step 3:

Development of SSIM

From the findings of Rajesh Attri and Nikhil Dev [19], it reveals that the contextual relationship for each variable and the existence of a relation between any two criteria (i and j), the associated direction of the relationship is questioned. Four symbols are used to denote the direction of relationship between the criteria (i and j)

V: Criteria i will help alleviate criteria j;
A: Criteria j will be alleviated by criteria i;
X: Criteria i and j will help achieve each other; and **O**: Criteria I and j are unrelated.

Table 2: Structural Self Interaction Matrix (SSIM)

Criteria	EC	EN	SC	RR	TC	IM
IM	X	V	O	A	O	-
TC	V	V	A	O	-	
RR	O	X	O	-		
SC	X	V	-			
EN	O	-				
EC	-					

Step 4:

Development of Reachability Matrix

Table 3: Reachability Matrix

Criteria	EC	EN	SC	RR	TC	IM	Drive Power	Rank
IM	1	1	0	0	0	1	3	II
TC	1	1	0	0	1	0	3	II
RR	0	1	0	1	0	1	3	II
SC	1	1	1	0	1	0	4	I
EN	0	1	0	1	0	1	3	II
EC	1	0	1	0	0	1	3	II
Dependence Power	4	5	2	2	2	4	19	-

Step 5:

Partition of Reachability Matrix in to Different Levels

Table 4: Level Partitions

Criteria	Reachability Set	Antecedent Set	Intersection	Level
I	EC EN I	EC R I	EC I	4
T	EC EN T	S T	T	3
R	EN R I	EN R	EN R	4
S	EC S T	EC S T	EC S T	1
	EC EN R I	EC EN S R T I	EC EN R I	2
EC	EC EN S I	EC EN S T I	EC EN S I	2

Step 6:

Draw the Graph and Remove the transitive Links

Step 7:

Convert Graph in to ISM Model

The resultant digraph is renewed into an ISM model (Fig. 1), by restoring mutable nodes with statements.

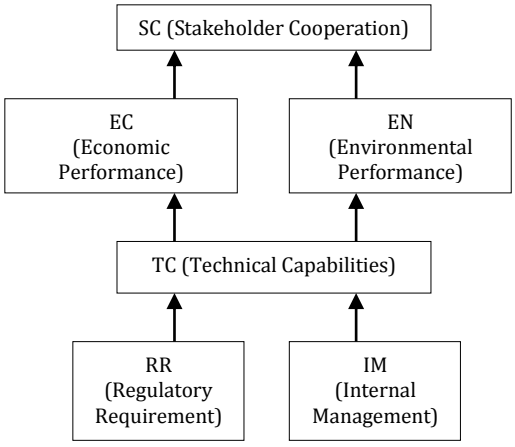

Fig. 1: ISM-based Criteria Model

Analytical Network Process:

There are lots of methods offered to solve multi-criteria decision-making problems. AHP and ANP are two methods introduced by Tomas Saaty. M.Sadeghi et al., [63] states that AHP tries to solve the decision problem by modeling it in a hierarchy while ANP is used when the problem is so complex that cannot be modeled as a hierarchy.

The Analytic Network Process (ANP) is a generalization of the Analytic Hierarchy Process (AHP), by considering the dependence between the elements of the hierarchy. Detailed review of the work carried out by Saaty [64] reveals that many decision-making problems couldn't be structured hierarchically because they involve the interaction and dependency of higher-level element. In these problems not only does the importance of the criteria determine the importance of the alternatives, but also the importance of the alternatives themselves determines the importance of the criteria. To solve these problems, ANP can be used. According to Ozturk [65], ANP developed by Saaty in 1996, is the first mathematical theory that makes it possible for decision-maker to deal systematically with this kind of dependence and feedback.

The advantage of ANP is the capability of solving the problems in which alternatives and criteria have such interactions that cannot be shown in a hierarchy [63]. When the decision-maker decides to model a problem as a network, it is not necessary to specify levels [66]. A plexus contains huddles (components, nodes or criteria) and rudiments (sub criteria). Anyhow, in generating anatomy to represent predicaments there may be a structure larger than components.

A Meticulously review of the work carried out by Saaty and Vargas [67] reveals that according to size, there is a system that is made up of subsystems and each subsystem made up of elements. M. Sadeghi et al [63] states that in the ANP, proportion scale prerogative vectors (obtained from pair-wise collating matrices) are not symphonized unswervingly as in AHP. Saaty has an enhanced "super matrix" tactics to blend ratio scales. Each ratio scale is aptly imported as a column in a matrix to represent the impact of elements in a huddle on an element in another group (outer dependence) or on elements of the cluster itself (inner dependence). In that case, the super matrix is compiled of numerous sub-matrices which each columns is a primary eigenvector that characterizes the collision of all elements in a group on each elements in another (or the same) group.

By using ANP Steps constitute by Saaty [68], the Priorities, weights and their ranking were calculated for all drivers and tabulated below.

Table 5: Rank Matrices

	C1	C2	C3	C4	C5	Priority	Rank
IM	0.137	0.08	0.25	0.12	0.11	0.13	5
TC	0.21	0.25	0.25	0.12	0.19	0.19	2
RR	0.137	0.25	0.08	0.29	0.19	0.18	3
SC	0.24	0.25	0.25	0.12	0.38	0.23	1
EN	0.24	0.08	0.08	0.29	0.19	0.17	4
EC	0.04	0.08	0.08	0.04	0.11	0.069	6

Fuzzy Analytical Network Process:

Zadeh [69] introduced the fuzzy set theory to deal with the uncertainty due to imprecision and vagueness. A foremost role of fuzzy set theory is its ability of defining ambiguous data. The premise also permits mathematical operators and programmings apply to the fuzzy realm. A fuzzy set is a group of entities with a continuum of grades of membership. Such a set is distinguished by a membership function, which allots to each object a grade of membership ranging between zero and one [70].

A tilde '~' will be positioned over a symbol if the symbol exhibits a fuzzy set. A triangular fuzzy number (TFN) $\tilde{M}$ is exposed in "Eq. (1)". A TFN is expressed simply as $(l/m, m/u)$ or (l, m, u).The constants l, m and u, respectively, indicate the least feasible value, the most reassuring value, and the largest probable value that illustrate a fuzzy affair.

$$\mu\left(\frac{x}{\tilde{M}}\right)=\begin{cases}0, & x<1,\\ (x-l)/(m-l), & l\le x\le m,\\ (u-x)/(u-m), & m\le x\le u,\\ 0, & x>u\end{cases} \tag{1}$$

A fuzzy number shown analogous left and right depiction of each degree of membership:

$$\tilde{M}=\left(M^{l(y)}, M^{r(y)}\right)=\left(l+(m-l)y, u+(m-u)y\right), y\in(0,1) \tag{2}$$

Where l(y) and r(y) represent the left side and right side illustration of a fuzzy number respectively. Lot of ranking methods for fuzzy numbers has been developed in the literature. These methods may give contrary

ranking results and most methods are monotonous in figurative manipulation requiring multifarious mathematical computation. The algebraic functions with fuzzy numbers can be found in Kahraman et al [71].

Fuzzy Analytical Network Process Method

To evaluate the decision maker's judgments, pair-wise comparison matrices are created by using TFNs. This comparison fuzzy matrix can be denoted as in Eq. (3) [72].

$$\tilde{A} = \begin{pmatrix} \left(a_{11}^{l}, a_{11}^{m}, a_{11}^{u}\right) & \left(a_{12}^{l}, a_{12}^{m}, a_{12}^{u}\right) & \left(a_{1n}^{l}, a_{1n}^{m}, a_{1n}^{u}\right) \\ \left(a_{21}^{l}, a_{21}^{m}, a_{21}^{u}\right) & \left(a_{22}^{l}, a_{22}^{m}, a_{22}^{u}\right) & \left(a_{2n}^{l}, a_{2n}^{m}, a_{2n}^{u}\right) \\ \left(a_{m1}^{l}, a_{m1}^{m}, a_{m1}^{u}\right) & \left(a_{m2}^{l}, a_{m2}^{m}, a_{m2}^{u}\right) & \left(a_{mn}^{l}, a_{mn}^{m}, a_{mn}^{u}\right) \end{pmatrix} \quad (3)$$

The element $\tilde{a_{mn}}$ which is given by $\left(a_{mn,}^{l}\ a_{mn,}^{m}\ a_{mn,}^{u}\right)$ represents the comparison of the component m with the component n. due to operational laws of fuzzy numbers [73], the matrix $\tilde{A}$ can be rewritten as in "Eq. (4)" by replacing $\tilde{a_{mn}}$ with the corresponding reciprocal values (i.e. $1/\tilde{a_{mn}}$) [74].

$$\tilde{A} = \begin{pmatrix} (1,1,1) & \left(a_{12}^{l}, a_{12}^{m}, a_{12}^{u}\right) & \left(a_{1n}^{l}, a_{1n}^{m}, a_{1n}^{u}\right) \\ \left(\frac{1}{a_{21}^{u}}, \frac{1}{a_{21}^{m}}, \frac{1}{a_{21}^{l}},\right) & (1,1,1) & \left(a_{2n}^{l}, a_{2n}^{m}, a_{2n}^{u}\right) \\ \left(\frac{1}{a_{m1}^{u}}, \frac{1}{a_{m1}^{m}}, \frac{1}{a_{m1}^{l}},\right) & \frac{1}{a_{m2}^{u}}, \frac{1}{a_{m2}^{m}}, \frac{1}{a_{m2}^{l}}, & (1,1,1) \end{pmatrix} \quad (4)$$

$\tilde{A}$ is a triangular fuzzy comparison matrix. To compute the estimates of the fuzzy priorities $\tilde{W}_i$, where $\tilde{W}_i = \left(\tilde{W}_i^{l}, \tilde{W}_i^{m}, \tilde{W}_i^{u}\right), i = 1,2,\ldots\ldots,n$ by means of the judgmental matrix which approximates the fuzzy ratios $\tilde{a_{ij}}$ so that $\tilde{a_{ij}} \approx \tilde{W}_i / \tilde{W}_j$.

The logarithmic least squares method [75] is the most effective and efficient one and was used in this study.

In this way, the triangular fuzzy weights for the relative importance of the factors, the feedback of the factors, and alternatives according to the individual factors can be calculated [72].

To compute the triangular fuzzy numbers, the logarithmic least squares method is used and it is represented in "Eq. (5)".

$$\tilde{W}_k = \left(W_k^{l}, W_k^{m}, W_k^{u}, \right), k = 1,2,\ldots\ldots,n \quad (5)$$

Where

$$W_K^{S} = \frac{\left(\pi_{j=1}^{n}\ a_{ij}^{s}\right)^{1/n}}{\sum_{k}^{n}\left(\pi_{j=1}^{n}\ a_{kj}^{s}\right)^{1/n}}, S \in \{l, m, u\} \quad (6)$$

By following the steps of Fuzzy ANP, the weights of the alternatives are to be converted to crisp numbers via the extent analysis.

Table 6: Weightage of Criteria

	IM	TC	RR	SC	EVP	EP	DFW
IM	1,1,1	2/5,1/2,2/3	1,1,1	2/7,1/3,2/5	2/5,1/2,2/3	2/5,1/2,2/3	0.0349
TC	3/2,2,5/2	1,1,1	1,3/2,2	1/3,2/5,1/2	1/2,2/3,1	1/2,2/3,1	0.1251
RR	1,1,1	1/2,2/3,1	1,1,1	2/7,1/3,2/5	1/2,2/3,1	1/2,2/3,1	0.04
SC	5/2,3,7/2	2,5/2,3	5/2,3,7/2	1,1,1	3/2,2,5/2	3/2,2,5/2	0.462
EVP	3/2,2,5/2	1,3/2,2	1,3/2,2	2/5,1/2,2/3	1,1,1	1,1,1	0.169
EP	3/2,2,5/2	1,3/2,2	1,3/2,2	2/5,1/2,2/3	1,1,1	1,1,1	0.169

Table 7: Global Weightage of Sub-Criteria

Criteria		Sub-Criteria	Local weights	Global weights
IM	0.0349	IM 1	0.126	0.0044
		IM 2	0.107	0.0037
		IM 3	0.036	0.0013
		IM 4	0.387	0.0135
		IM 5	0.037	0.0013
		IM 6	0.037	0.0013
		IM 7	0.271	0.0095
TC	0.1251	TC 1	0.082	0.0103
		TC 2	0.232	0.029
		TC 3	0.0291	0.0036
		TC 4	0.22	0.0275
		TC 5	0.029	0.0037
		TC 6	0.079	0.0099
		TC 7	0.0296	0.0037
		TC 8	0.22	0.0275
		TC 9	0.08	0.01
RR	0.04	RR 1	0.128	0.0051
		RR 2	0.7	0.028
		RR 3	0.044	0.0018
		RR 4	0.128	0.0051
SC	0.462	SC 1	0.021	0.0097
		SC 2	0.372	0.1719
		SC 3	0.28	0.1294
		SC 4	0.056	0.0259
		SC 5	0.056	0.0259
		SC 6	0.212	0.0979
EP	0.169	EP 1	0.13	0.0219
		EP 2	0.072	0.0122
		EP 3	0.072	0.0122
		EP 4	0.24	0.0406
		EP 5	0.01	0.0017
		EP 6	0.24	0.0406
		EP 7	0.234	0.0395
EC	0.169	EC 1	0.0123	0.0021
		EC 2	0.0675	0.0114
		EC 3	0.34	0.0575
		EC 4	0.014	0.0024
		EC 5	0.278	0.0469
		EC 6	0.128	0.0216
		EC 7	0.161	0.0272

Conclusions:

Based on Interpretive Structural Modeling:

In this paper some of the major criteria and sub-criteria have been highlighted and put into analyse for identifying the interactions between them. The SSIM and Reachability Matrix diagram give some valuable insights about the relative importance and the interdependencies among the criteria and sub-criteria. ISM model is developed to bring out the cohesion between the selected or identified criteria and sub criteria to enforce or implement the GSCM in Northern Tamilnadu tanning Industries. The ISM model thrived in this work can provide the decision maker with a more realistic representation of the problem in the course of conducting interactions among the criteria and sub criteria. Based on their driving power, it is revealed that stakeholder's cooperation is the key criterion in implementation of green supply chain in tanneries. Decision Matrix for this work is shown below the Table 8.

Table 8: Decision Matrix of ISM

Performance Criteria	Weights
Stake Holders Cooperation (SC)	0.3478
Environmental Performance (EP)	0.1957
Economic Performance (EC)	0.1957
Technical Capabilities (TC)	0.1304
Internal Management (IM)	0.0652
Regulatory Requirements (RR)	0.0652

Based on Analytical Network Process:

The Analytical Network Process assumes that the edifice is developed carefully to incorporate all that is significant to consider from expert understanding that also lends the judgments. Its sequel is totally subjective in this sense of using experts when needed. After decomposing the decision structure into its finest perceptible details, pair wise comparison judgments were done. The fusion of these verdicts is the finest and most precise

outcome to capture our perception of the interaction of influences that shape reality By the study through ANP methodology, it is found that stake holder cooperation is the best criteria. In this project, the decision matrix generated from the ISM model is used as input.

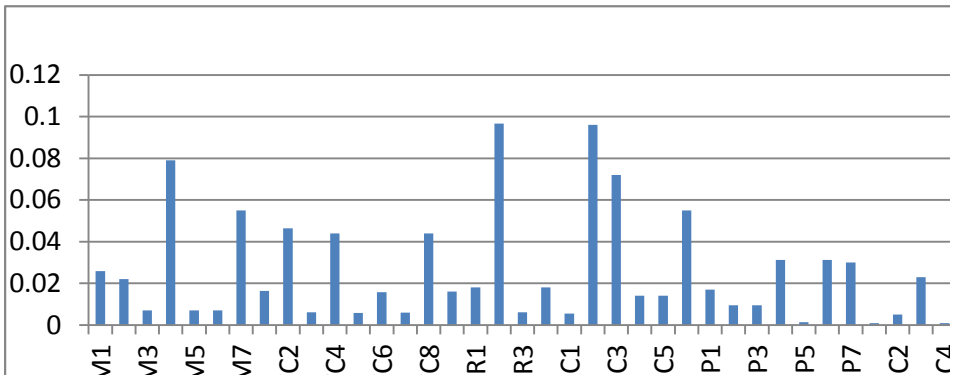

Fig. 2: Graphical Representation of Weightage of Each Driver in Analytical Network Process

Based on Fuzzy Analytical Network Process:

By using the decision matrix generated from ISM methodology as input the best criterion was found from the spectrum of criteria. ANP method is insufficient in explaining the ambiguity through the decision maker's decisions. In order to eliminate this shortcoming, Fuzzy ANP method has been used. When considered that ANP work with the same logic and their architecture, which is favourable for network structure, criteria are not only affected by the weights of the alternatives, but also by the clusters they belong to. With the help of feedbacks the data could reflect the reality in a better way. Furthermore; ambiguity has been taken into consideration with the use of fuzzy cluster approach. In this project, the most suitable criterion selection is done with the aid of Fuzzy ANP. Consequently, for green supply chain condition, a stake holder criterion is chosen as the most suitable criterion.

Fig. 3: Graphical Representation of Weightage of Each Driver in Fuzzy Analytical Network Process

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