Original Research Article

Assessment of factors on Assimilation of Climate Smart Agricultural Practices in the North Eastern Hill Region of India: A SWOT-AHP analysis

ABSTRACT

Aims: To appraise the factors for smooth assimilation of Climate Smart Agriculture (CSA) practices in the North Eastern Hill Region (NEHR) of India.

Study design: Exploratory Research Design was followed for the study.

Place and Duration of Study: The study was conducted in the three states Arunachal Pradesh, Manipur and Meghalaya representing the Tropical, Sub-Tropical and Temperate Agro-Climatic Zone respectively in the region. The study was conducted during 2020-21.

Methodology:A Total of twenty-six (26) Extension agents including the Scientist of Indian Council of Agricultural Research (ICAR) centres, faculty of Colleges under Central Agricultural University, Imphal, and Subject Matter Specialists (SMS) in the KVKs who are working for more than three years in Climate change were selected purposively for the study. The study employed Delphi technique. On the subsequent three (3) iterations only seventeen (17) subject matter experts/specialists, scientist and faculties had responded for the study. To identify the factors of assimilation, Strengths, Weaknesses, Opportunities, Threats- Analytic Hierarchy Process (SWOT-AHP) analysis was employed in the study.

Results:The study uncovered that 'Crop and Livestock Diversification due to existence of different Agro-Climatic Zones'; 'Overly long Return on Investment span of CSA technologies on Adaptation and mitigation of Climate Change Consequences'; 'Successful Market-aligned supply chain infrastructure from farm to fork'; and 'Food insecurity & unsustainable livelihood due to negative impact of Climate Change on agriculture & allied enterprises' were the most important Strengths, Weaknesses, Opportunities and Threats, respectively determining the assimilation of CSA practices in the region. The judgement given by the extension agents were found acceptable with inconsistency ratio below 10%.

Conclusion:Reflecting the reliable judgement amongst the experts, it shows a helpful scope for modifying the CSA practices that are developed in the region and need to focus on the bottleneck that need to be tackle for successful dissemination of CSA practices in the region.

Keywords: Climate Smart Agriculture Practices, Climate Change, SWOT-AHP analysis, Assimilation, North East India.

1. Introduction:

Climate changeis the real challenge to mankind. The impact of Climate change is affecting directly and also indirectly in our day-to-day activities. These led to drastic changes in the production and productivity of many crops which deteriorate our economic condition. Climate Smart Agricultureis “a way for food security in a varying climate. It aims to improve food security, help farmers adapt to Climate Change and assist to Climate Change mitigation by adopting appropriate practices, developing enabling dogmas& institutions and mobilizing needed finances” (FAO, 2013). CSA prerequisites to concentrate on developing resilient/robust food& nutritional production systems that lead to food, nutrition & income securities under progressive Climate Change. CSA Practices are the need of today to deal with the changing climate. Despite of availing good number of potential CSA practices in the North Eastern region of India, theassimilation of CSA Practices by the farmers of region still very low. The specific reasons for the low rates of assimilation of potential CSA Practices by the farmers are not clearly known.There arises the need for appraisal of factors that are affecting the assimilation of CSA practices by the farmers of the region and the situations face by the extension agents disseminating the CSA practices. Involving extension agents is found to be critical in understanding barriers to dissemination of CSA practices and is recognised as key for bridging theassimilation gap.Suitable tools are required toensure successful consultation of extension agents in identifying the factors determining assimilation rate and situations of farmers in the ground level. So far, severaltools are available for the purpose, but one of the most popular is the analysis of strengths, weaknesses, opportunities and threats (SWOT). The method has been widely used for participatory decision making (Okello *et al.,* 2014), to evaluate the social, economic and environmental impacts (Liu *et al.,*2011) and also for planning the strategic development in the industry (Xingang *et al.,*2013). The main weakness of the SWOT analysis, however, is that the results are not quantified and therefore it is difficult to attach levels of importance to the individual identified SWOT factors. Consequently, Kurtilla*et al.,*(2000) developed a method that incorporates the results of SWOT analysis in the analytical hierarchy process (AHP). The method, commonly abbreviated as SWOT-AHP or A’WOT has been widely used in forest policy decision analyses (Stainback*et al.*, 2012), studies in the field of safety and environment (Eslamipoor&Sepehriar, 2013), agriculture (Shrestha *et al.*2004), and water resource management (Gallego-Ayala &Juizo 2011). However, all these studies are limited to the quantification of SWOT factors for a single scheme of intervention. Against this background, the objective of the study was to identify the potential factors for successful assimilation of CSA practices in the region.

The North Eastern Hill (NEH) region of India is comprised of eight states, namely Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura. The region shares an international border of 5,182 Km with several neighbouring countries – 1,395 Km with Tibet Autonomous Region of China in the North; 1,640 Km with Myanmar in the East, 1,596 Km with Bangladesh in the South-West, 97 Km with Nepal in the West, and 455 Km with Bhutan in the North-West. These eight states with the total geographical area of 2,62,230Km^2 is sharing almost 8% in the total area of country, India. The NEH region host very important agricultural biodiversity hotspots not only in India but also worldwide, nonetheless, it is highly vulnerable to negative impact on agricultural growth due to climate change.The region faced varied natural calamities including frequent flood, drought like situation and landslide almost all the years.Out of 100 most climate vulnerable districts of India, 17 districts are in the North Eastern region (Venkateswarlu*et al*., 2012).

2. MATERIALS AND METHODS

2.1 Locale of Study

The Delphi technique was implemented in the discourse to identify and appraised the factors on Assimilation of CSA Practices in the three NEH states *viz.,* Arunachal Pradesh, Manipur and Meghalaya were selected purposively to represent the three major ACZs *viz.,* Tropical, Sub-Tropical and Temperate respectively for the study.

The state Arunachal Pradesh, the ‘Land of the Dawn-Lit Mountains’ is situated between Latitude of 26°30' N and 29°30 ' N and Longitude of 91°30' E and 97°30' E. The state experienced extreme climatic events, including two extremely dangerous cloudbursts in the years 2008 and 2010, respectively, which produced devastating flash floods, causing many deaths and massive loss to the forested and cultivated land.The state Manipur‘Jewel of India’ is situated between 23^{o}80’ to 25^{o}68’ N Latitudes and 93^{o}03’ to 94^{o}78’ ELongitudes. About 80% of the populations count on agriculture for livelihood, nevertheless the state is facing the consequences of Climate change, projected to experience more of tremendous rainfall and lessening in crop yields.The state Meghalaya ‘Scotland of the East’is tucked away in the hills of eastern Sub-Himalayan region of the North East India. The state located between 20°1” N and 26°5” N *Latitude* and 85°49”E and 92°52” E *Longitude*.The state is highly inclinedto the effects/consequences of Climate change because of its geo-ecological fragility, humid climate and socio-economic circumstances.

2.2 Selection of Respondents:

Total of twenty-six (26)Extension agents including the Scientist of Indian Council of Agricultural Research (ICAR) centres, faculty of Colleges under Central Agricultural University, Imphal, and Subject Matter Specialists (SMS) in the KVKs who are working for more than three years in Climate change were selected purposively for the study. The respondents were contacted through Questionnaire, Personal phone call, E-mail &through direct interviewfor identifying and appraising the factors determining the assimilation of CSA practices by farmers in the first instance. Though, on the subsequent three (3) iterations only seventeen (17) respondents including the SMS, scientist and faculties had responded for the study and identify the factors *viz.,* Strengths, Weaknesses, Opportunities and Threats that determined the assimilation of CSA practices by the farmers of the selected Climate Change vulnerable districts of the three states.

2.3Tools and Techniques:

In the present study, the SWOT-AHP Analysis has been undertaken in a three-step process. In the first step, possible SWOT factors relating to the proposed strategy or decision are identified. In the second step, pair-wise comparisons of factors within each SWOT category are made. Pair-wise comparisons were conducted separately for all factors within a category and a priority value for each factor is computed using the Eigen value method. The factor with the highest priority value under each SWOT category is brought forward for comparison with the highest priority value factors from other SWOT categories. In the third step, participants make pair-wise comparisons of the four factors that are brought forward and a scaling factor or global priority value for each category is computed. Scaling factors and priority values are used to calculate the overall or global priority of each factor as shown below:

Overall priority of factor$_{ij}$ = (Priority value of factor$_{ij}$) *(scaling factor of SWOT category)
Where,
i= number of factors in a SWOT category, and
j= 4(strength, weakness, opportunity, and threat).

The overall priority scores of all factors across categories sum to one and each score indicates the relative importance of each factor.

The contribution to the strategic planning process comes in the form of numerical values for the factors. New goals may be set, strategies defined and such implementations planned as take into close consideration the foremost factors.

The matrix of pair-wise comparisons (Eq. 1) is constructed in Step 2. In this matrix, the element a_{ij} = $1/a_{ji}$and thus, when*i* = *j*,a_{ij} = 1. The value of $w_i$may vary from 1 to 9, and 1/1 indicates equal importance while 9/1 indicates extreme or absolute importance.

$$A = (a_{ij}) = \begin{bmatrix} 1 & w_1/w_2 & \ldots\ldots. w_1/w_n \\ w_2/w_1 & 1 & \ldots\ldots.\ w_2/w_n \\ w_n/w_1 & w_n/w_2 & \ldots\ldots \quad 1 \end{bmatrix} \ldots\ldots\ldots\ldots (1)$$

In the comparisons, some inconsistencies can be expected and accepted. When 'A' contains inconsistencies, the estimated priorities can be obtained by using the matrix (Eq. 1) as the input using the eigenvalue technique (Eq. 2)

$(A - \Lambda_{max} I)q = 0$………… (2)

Where, Λ_{max} is the largest eigenfactor of matrix **A**; **q** is its correct eigenfactor; and **I** is the identity matrix. The correct eigenfactor, **q**, constitutes the estimation of relative priorities. It is the first principal component of the matrix of pair-wise comparisons. If the matrix does not include any inconsistencies, i.e. the judgments made by a decision maker have been consistent, **q** is the exact estimate of the priority vector. Each eigenfactor is scaled to sum up to one to obtain the priorities. Saaty (1977) has shown that Λ_{max} of a reciprocal matrix **A** is always greater or equal to *n* (=number of rows = number of columns). If the pair-wise comparisons do not include any inconsistencies, Λ_{max} = n. The more consistent the comparisons are, the closer the value of computed Λ_{max} is to *n*. Based on this property, a consistency index, CI, has been constructed (Eq. 3).

CI = $(\Lambda_{max} - n)(n - 1)$ ………….. (3)

The CI estimates the level of consistency with respect to a comparison matrix. Then, because CI is dependent on *n*, a consistency ratio CR is calculated, which is independent of (Eq. 4). It measures the coherence of the pair-wise comparisons. To estimate CR, the average consistency index of randomly generated comparisons, ACI, has to be calculated. ACI varies functionally, according to the size of the matrix (e.g. Saaty, 1980).

CR = 100 (CI/ACI) ……….. (4)

As a rule of thumb, a CR value of 10% or less is considered to be acceptable. Otherwise, all or some of the comparisons must be repeated in order to resolve the inconsistencies of the pair-wise comparisons.

Thus, the results of the comparisons are quantitative values expressing the priorities of the factors included in SWOT analysis. Thereby, persons formulating strategies gain access to new quantitative information about the environment surrounding their firm to support their decision making. They can concentrate on connecting the most important and compatible opportunities and strengths in the strategy-building process or see if the firm is facing some critical threats or weaknesses that must be reacted to.

The SWOT analysis was explicated to examine the strengths to exploit opportunities, and limit the weaknesses against external threats of the CSA systems. Standalone, the SWOT analysis identifies these factors but does not give a virtual priority of the factors in each category or allow estimation of the relative priority of the different categories. To complement and intensify the research in the present study, the AHP was executed in estimating the relative priorities for each factor and domain. The relative priorities of factors and domains are estimated using the eigenvalue technique

(Pickton & Wright 1998, Schmoldt& Peterson 2001, Ananda & Herath 2003,Masozera*et al.,*2006). The SWOT-AHP analysis conceded the following steps.

In order to reflect the relative importance amongst factors of each domain, the extension specialists were requested to perform pair-wise comparisons of the putative factors in each domain by using the Graphic Anchored Rating Scale –'Pair-Wise Comparison Scale for AHP Preferences' with a rating of '1 – 9' as expounded in Table 1.

Table 1: Pair-Wise Comparison Scale on AHP Predilections

Anchored Rating	Judgement of Preferences
1	Equally Preferred
2	Equally to Moderately Preferred
3	Moderately Preferred
4	Moderately to Strongly Preferred
5	Strongly Preferred
6	Strongly to Very Strongly Preferred
7	Very Strongly Preferred
8	Very Strongly to Extremely Preferred
9	Extremely Preferred

Pair-wise comparison between factors of different domains of SWOT by implying AHP:

The factor with the highest local priority has been chosen from each domain to represent the domain. The identified four factors were subjected to perform pair-wise comparisons by following the same Graphic Anchored Rating Scale as mentioned in previous para. The scores obtained were the scaling factors of the four SWOT groups and they were used to calculate the overall, that is, global priorities of the independent factors within them.

3. RESULTS AND DISCUSSION

3.1 Identification of SWOT Factors on CSA Practices:

A semi-structured questionnaire was mailed to seventeen (17) extension specialists who are serving in the locale of research in three states to identify factors in each SWOT category on CSA Practices.In the outset, all factors identified by individual members of the focus group were listed and shared. Unanimously, in the ensuing step, similar factors that expressed the same or very similar broad issues were combined into one descriptive factor, resulting into four factors each in domains of Strengths, Weaknesses, Opportunities and Threats as lucidly explicated in Table 2.

The detail of both local and global priority scores are also depicted in Table 2. Local priority scores are the relative priorities amongst the factors in each domain of SWOT. Within each domain, the sum of score remain unity i.e., one. The column of global priority scores represent the relative priority scores of between different domains, this was determined by performing pair-comparisons between the factors of different domains of SWOT by implying AHP. The bolded numerical pertaining to the column of global priority scores depicts the respective scaling factor which is the priority of each SWOT domain relative to the other domains. The sum of four scaling factors scores stands unity i.e., one. The other numerical (in maroon colour) in the column of global priority scores columns represent the global priority of each individual factor determined by multiplying its local priority by the priority of its domain. The graphical representations of local priority scores and global priority scores with respect to domains of Strengths, Weaknesses, Opportunities and Threats are shown in Figure 1 and Figure 2 respectively.

3.2 Local priority scores amongst factors of each domain of SWOT:

A thorough examination of Table 2 and Figure 1 could unveiled that the extension specialists expressed their agreement on ranking the factor **S1** – 'Crop and Livestock Diversification due to existence of different Agro-Climatic Zones' as most important factor followed by the factors, namely**s2**– 'Availability of inventories on Climate Smart Farm Technologies', **S3** – 'Existence of ICT enabled Knowledge Management Network at farmers' level with facility of smart phones and 4G mobile internet telephony' and **S4** – 'Vibrant agricultural extension centres for greater outreach and broad-basing farmer-market-industry infrastructure' under the domain of Strengths associated with identified CSA practices. A Practicesin the study with the local priority scores of 0.593, 0.201, 0.120 and 0.086 respectively. On one hand, it could be inferred that the relative importance of **S1** amongst the four identified factors under the domain of Strength was nearly fifty nine percent (59.30%). The inconsistency ratio was found to be 0.09 which is below the acceptable limit of 0.10. The inconsistency ratio indicates a measure of how logical or rational the decision is. An inconsistency ratio of 0.10 or less is generally considered acceptable and a larger inconsistency ratio value indicates more inconsistent judgement which needs to be re-examined for making decision (Saaty, 1980). Referring the same Table 2 and Figure 2, it could be narrated that the extension specialists expressed their agreement on ranking the factor **W1** – 'Overly long 'Return on Investment' span of CSA technologies on adaptation and mitigation of climate change consequences' as most important factor followed by the factors, namely **W3** – 'Lack of knowledge & skills on implementation of CSA technologies', **W4** – 'Absence of risk cover mechanisms and Weather Based Crop Insurance Schemes' and **W2** – 'No site specific and evidence based policy framework' under the domain of Weaknesses associated with identified CSA Practicesin the study with the local priority scores of 0.604, 0.201, 0.121 and0.074respectively. On one hand, it could be inferred that the relative importance of

W1amongst the four identified factors under the domain of Weaknesses was nearly sixty percent (60.40%). The inconsistency ratio was found to be 0.02 which is below the acceptable limit of 0.10 indicating a highly reliable judgement amongst the experts. Similarly, in case of factors under the domain-Opportunities, by referring Table 2 and Figure 1, it could be reflected that the extension specialists expressed their agreement on ranking the factor **O2** – 'Successful market-aligned supply chain infrastructure from farm to fork' as most important factor followed by the factors, namely **O3** – 'Accessibility of Climate reliable judgement amongst the experts Information Services furnished by State Governments, ICAR and College under CAU, Imphal through Agro-Advisory and Weather Forecast Platforms', **O4** – 'Pervasiveness of zealous Research & Development Institute in Agriculture &associated Enterprises to build capacity of farmers to adapt and mitigate climate change in agriculture through CSA'and **O1** – 'Existence of vibrant Local Institutions and Indigenous Knowledge on Adaptive and Mitigation Agricultural Practices' under the domain of Opportunities associated with identified CSA Practices in the study with the local priority scores of 0.445, 0.288, 0.203 and 0.064respectively. On one hand, it could be inferred that the relative importance of **O2** amongst the four identified factors under the domain of Weaknesses was nearly forty four percent (44.50%). The inconsistency ratio was found to be 0.03 which is below the acceptable limit of 0.10 indicating a very well reliable judgement.

When the factors under the domain-Threats are studied by refereeing data from Table 2 and by reflecting the quadrant graph of Figure 1,it could be narrated that the extension specialists expressed their agreement on ranking the factor **T1** – 'Food insecurity and unsustainable livelihood due to negative impact of climate change on agriculture and allied enterprises' as most important factor followed by the factors in term of importance, namely **T4** – 'Abandoning agriculture & associated enterprises as professions by farmers', **T2** – 'Despite of the application of CSA techniques, the climate change would aggravate the adverse incidences of Insects, Pests & Diseases on crops' and **T3** – 'Multiple incidence of extreme climate variability defies CSA Practices' under the domain of Threats associated with identified CSA Practicesin the study with the local priority scores of 0.484, 0.288, 0.156 and 0.072respectively. Notably, it could be inferred that the relative importance of **T1** amongst the four identified factors under the domain of Threats was nearly forty eight percent (48.40%). The inconsistency ratio was found to be 0.08 which is below the acceptable limit of 0.10 indicating a considerable reliable judgement amongst the experts.

Table 2: List of agreed upon SWOT factors, Local and Global Priority Scores and respective Inconsistency Ratios* on Pair-wise comparison amongst factors# of each domain and between factors of domains of SWOT by implying AHP.

SWOT Domains & Factors		Local Priority Scores	Inconsistency Ratio	Global Priority Scores
A. STRENGTHS				**0.555**
S1	Crop and Livestock Diversification due to existence of different Agro-Climatic Zones.	0.593		0.329
S2	Availability of inventories on Climate Smart Farm Technologies.	0.201		0.112
S3	Existence of ICT enabled Knowledge Management Network at farmers' level with facility of smart phones and 4G mobile internet telephony.	0.120	0.09	0.067
S4	Vibrant extension centres for greater outreach and broad-basing farmer-market-industry infrastructure.	0.086		0.047
B. WEAKNESSES				**0.064**
W1	Overly long 'Return on Investment' span of CSA technologies on adaptation and mitigation of CC consequences.	0.604		0.038
W2	No site specific and evidence based policy framework.	0.074	0.02	0.005
W3	Lack of knowledge & skills on implementation of CSA technologies.	0.201		0.013
W4	Absence of risk covers mechanisms & Weather Based Crop Insurance Schemes.	0.121		0.008
C. OPPORTUNITIES				**0.258**
O1	Existence of vibrant Local Institutions and Indigenous Knowledge on Adaptive and Mitigation Agricultural Practices.	0.064		0.017
O2	Successful market-aligned supply-chain infrastructure from farm to fork.	0.445	0.03	0.115
O3	Accessibility of Climate Information Services furnished by State Governments, ICAR and College under CAU, Imphal through Agro-Advisory and Weather Forecast Platforms.	0.288		0.074
O4	Pervasiveness of fervent Research & Development Institute in Agriculture & associated Enterprises to build capacity of farmers to adapt and mitigate CC in agriculture through CSA.	0.203		0.052
D. THREATS				**0.124**
T1	Food insecurity and unsustainable livelihood due to negative impact of CC on agriculture and allied enterprises.	0.484		0.060
T2	Despite of the application of CSA techniques, the CC would aggravate the adverse incidences of Insects, Pests &Diseases on crops.	0.156	0.08	0.019
T3	Multiple incidence of extreme climate variability defies CSA Practices.	0.072		0.009
T4	Abandoning agriculture & associated enterprises as professions by farmers.	0.288		0.036

***** *The inconsistency ratio of the on Pair-wise comparison between factors of domains of SWOT was 0.08.*

The greatest weight with respect to each SWOT domain is underlined.

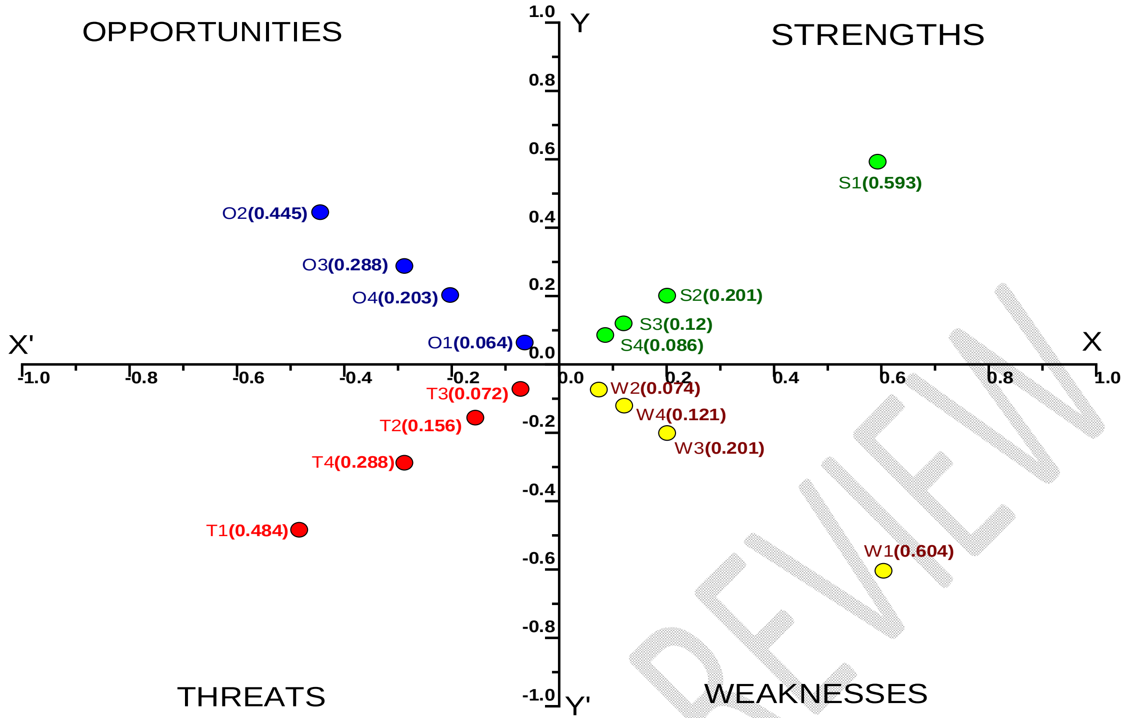

Figure 1: SWOT analysis for local priorities

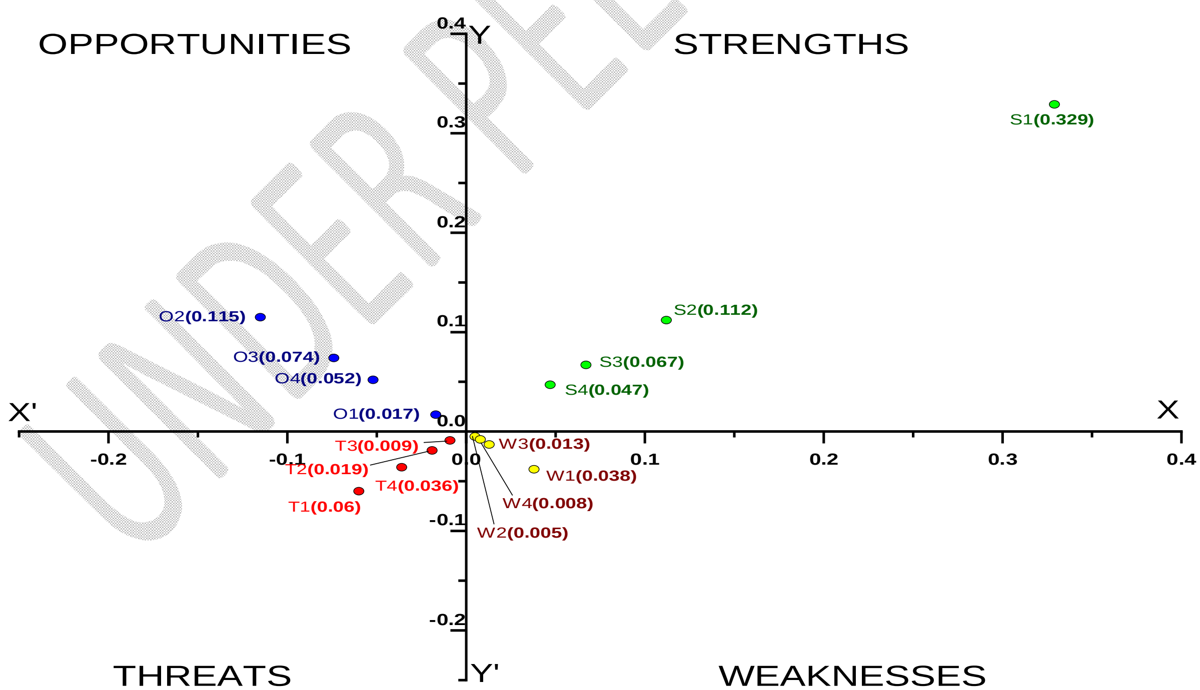

Figure 2: SWOT Analysis for Global priorities

3.3 Global priority scores between factors of different domains of SWOT:

Apropos of global priority scores between different domains of SWOT, referring Table 2, it could be perceived that the scaling factor score for the domain Strengths was 0.555, which remain to be the highest when examined against the remaining three domains *viz.,* Weaknesses, Opportunities and Threats having scaling factor score of 0.064, 0.258 and 0.124 respectively. Subsequently inferring the same Table 2 and Figure 2,it could be observed that the extension specialists expressed their agreement upon ranking the factors from highest to lowest under the domain of Strengths as **S1**, **S2, S3** and **S4** with the global priority scores of0.329, 0.112, 0.067 and 0.047 respectively. Similarly, under the domain of Weaknesses, the global priority scores for the factors from highest to lowest were in the trend of **W1, W3, W4** and **W2** with the respective scores of 0.038, 0.013, 0.008 and 0.005. Focusing toward the factors under the domain of Opportunities, the global priority scores from highest to the lowest were in the inclination of **O2, O3, O4** and **O1** with the respective scores of 0.115, 0.074, 0.052 and 0.017. Considering the factors under the domain of Threats, the factor **T1** possessed the highest global priority score followed by **T4, T2** and **T3** with the corresponding scores of 0.060, 0.036, 0.019 and 0.009. The overall inconsistency ratio was found to be 0.08 which is below the acceptable limit of 0.10 reflecting a considerable reliable judgement amongst the experts.

The study show prolong time of return on investment of CSA practices as weaknesses for the farmers to invest on farming and food insecurity due to climate variation that act as main threats leads to the unsuccessful reap of CSA practices in the region, are need to give important concerned and correction in all possible way. Also the study could showdiversification of crop and livestock as important factor that can strengthens the CSA practices since the region has varied in Agro climatic conditions, topography and farming systems. Also the study show the scope of market-aligned supply chain as factor of opportunities since the region has rich with unexplored potential resources that need to be promote not only in the region or state but also in the international market. The current study felt of thorough understanding of the factors in the Weaknesses and Threats is needed and reducing or correcting it so as to obtained maximum potential benefits from the Strengths and opportunities on CSA to bring sustainable development in the region.

4. CONCLUSION

Climate change is real and challenging to mankind. CSA Practices is the alternate option to make Agriculture sustainable dealing with climate variation. For this one need to identify and sort out all the possible and important factors affecting the CSA practices and its assimilation in the system. The study could make out important factors under the four domains *viz.,*Strengths, Weaknesses, Opportunities and Threats of SWOT. Four important factors identified under each domain were also found having overall inconsistency ratio below the acceptable limit of 0.10 reflecting reliable judgement amongst the experts showing a helpful scope for correcting or modifying the CSA practices developed, area need to be focus, and bottleneck that need to be tackle for successful dissemination of CSA practices were highlighted. Similar research study need to be carry out in large scale to spot the areas that need to give more importance for better farming and to bring sustainable development in the region.

5. **Competing Interests** - "Authors have declared that no competing interests exist.".

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