Identification of Climate Smart Agricultural Practices in North Eastern States of India

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ABSTRACT

Climate change has significantly impacted agriculture in food production. Agriculture not only victim of climate change but also contribute in generating greenhouse gases. To increase agricultural production without further increasing greenhouse gas emissions from agricultural activities, Climate-Smart Agriculture (CSA) has been introduced. The domains of Adaptation, Mitigation and Food Security apropos of CSA practices and its dimensions need to be ascertained before its dissemination and hence it requires appropriate examination. The study unveiled that agricultural practices viz., 'Farming system model for food & nutritional security' and 'Integrated organic farming system model' were the first and second important CSA practices taking into consideration the composite score on the portfolios of Nutrient, Water, Soil, Carbon, Energy and Knowledge Smart dimensions of CSA practices. Further, the study also identified CSA practices viz., 'Enriched compost prepared from local biomass' and 'In-situ soil moisture conservation in Maize-mustard cropping system' under Adaptation; 'Bio char for acid soils amelioration & soil carbon sequestration' and 'Multi-tier IFS for hills' under Mitigation; and 'Micro irrigation for high value crops' and 'Farming system model for food & nutritional security' under Food Security. On administering the Jonckheere -Terpstra Test for testing the conformity given by respondents of the study, it was divulged that the CSA practices in the domains of Mitigation and Food Security were significant @ 1% level of significance with p-values of 0.001 and 0.006 respectively; however the CSA Practices in the domain of Adaptation was found insignificant having p-value 0.786. The research strongly advocates that more research and refinement are needed to generate champion CSA options for effective adoption by farmers.

Key words: *Climate change; Climate smart agriculture; Adaptation; Mitigation; Food security;*

Agriculture is diverse in terms of Climatic zones, food production system and socio-economic conditions. Over the last 100 years, an increase of 0.4°C in annual average surface air temperature has been recorded in the Indian subcontinent, and by the 2050s, average temperature is expected to rise by 2–4°C *(Ministry of Environment & Forests, 2004*). The climate change and variability may lead to greater instability in food production and threaten the food security of millions. Development of appropriate adaptation strategy under smallholder production condition is important to cope with the progressive climate change and variability. CSA is being promoted for the adaptation and mitigation of climate change and variability in many places. The relationship between the three pillars of CSA is not well-defined and further scientific investigations are essential. Broadly, the CSA focuses on developing resilient food production systems that lead to food and income security under progressive climate change and variability (*Vermeulen et al., 2012*).There is a debate about what practices and technologies should be considered in CSA. Many conservation agricultural practices such as minimum tillage, different methods of crop establishment and residue incorporation can improve crop yields, water and nutrient use efficiency and reduce GHG emission from the agricultural fields (*Jat et al., 2014*). Similarly, researchers also consider rain water harvesting technologies and use of improved seeds as climate smart because they help to cope with extreme climatic events (*Altieri and Nicholls, 2013*). A wide variety of CSA options has been proposed to reduce the negative impacts of climate change, build climate resilient agricultural production systems. In the context of India and North Eastern region, CSA is highly complex. CSA needs to consider multiple dimensions of the agricultural production systems in the country. Hence, a CSA approach is needed for improving and transforming existing agricultural system to promote national food security while adopting sustainable adaptation measures, respecting local concerns and contributing to global climate change mitigation targets. Agriculture is the main source of livelihood for the people in this region. Due to climate change the region face frequent flood, severe drought like situation, landslide, frost, *etc.* and affect the yield of many crops. Out of hundred most vulnerable districts in the country seventeen districts are from the region (*Venkateswarlu et al., 2012*). It is expected that implementation of CSA practices and technologies could improve crop yields, bring abandoned land under cultivation and increase the income of farmers. Although the FAO definition has provided three major pillars of CSA, the relationship and priorities between the three pillars of CSA (namely food security, adaptation, mitigation) needs to be well defined. Therefore, more context specific investigation is essential.

METHODOLOGY

The study followed descriptive research design. Multi-phase convenience sampling has been adopted in the study; thereby the questionnaire developed for the study has been delivered, in the first phase, to forty five respondents encompassing the eight states of North East India. The respondents in the study were agriculture and allied professionals having at least two years of experience in climate change research and extension services. Out of Eight North eastern states a total of twenty six respondents from the six states *viz.,* Assam, Arunachal Pradesh, Manipur, Meghalaya, Nagaland and Tripura had concomitantly responded generating a total of seventy three CSA practices. In the second phase, the refined questionnaire has been delivered to thirty five respondents for ascertaining the domains of CSA practices and of them only seventeen respondents have constructively replied. *Jonckheere - Terpstra Test* was administered for testing the conformity.

Table 1. Important CSA Practices with the CSA Domains

Domains	Code	Scores
Nutrient Smart (NS) CSA Practices		
Enriched compost prepared by local biomass	N1	72
Organic carbon stock in soils.	N2	
Organic farming system in cluster approach	N3	
Agri-Horti-Duckery-Fishery farming system	N4	
Fish-pig-tuber crops based farming system	N5	61
Water Smart (WS) CSA Practices		
Micro rain water harvesting structures	W1	100
Roof top water harvesting.	W2	
In-situ soil moisture conservation	W3	92
Micro irrigation for high value crops.	W4	88
Rain water harvesting for multipurpose use	W5	
Soil Smart (SS) CSA Practice		
Contour/graded bund on sloppy land.	S1	100
Soil testing & soil health card.	S2	91
Bench terraces for cultivating slope.	S3	86
Half-moon terraces for in-situ conservation.	S4	77
Horticulture based farming system	S5	68
Carbon Smart (CS) CSA Practices		
Soil organic carbon pool.	C1	100
Bio char for acid soils amelioration	C2	83
Biomass management in cropping system	C3	57
Organic conservation agriculture practices	C4	48
Integrated organic farming system model.	C5	48
Energy Smart (ES) CSA Practices		
Farming system model for security.	E1	100
Multi-tier IFS for hills.	E2	
Three tier agro forestry system.	E3	85
No-tillage in pea, lentil & rapeseed	E4	77
Intensive organic vegetable production	E5	
Knowledge Smart (KS) CSA practices		
Low cost structure for propagation	K1	100
RC-Seed Bin: low cost seed storage	K2	84
Backyard farming.	K3	79
Bio-rational management of insect pest	K4	7474
Mushroom cultivation using farm waste.	K5	

RESULTS AND DISCUSSION

To identify the Climate Smart Agricultural Practices in North Eastern states of India, Seventy three (73) Practices were identified considering the composite score on the portfolios of Nutrient, Water, Soil, Carbon, Energy and Knowledge Smart dimensions of CSA practices. Thirty most important identified CSA

Practices with their respective CSA domains are presented in table 1 below. The Practices *Viz.,* 'Enriched compost prepared from local biomass' and 'Organic carbon stock in soils' under Nutrient Smart (NS); 'Micro rain water harvesting structures *(Julkund)'* and 'Roof top water harvesting' under Water Smart (WS); 'Contour/graded bund on sloppy land' and 'Soil testing & soil health card' under Soil Smart (SM); 'Soil organic carbon pool' and 'Bio char for acid soils amelioration & soil carbon sequestration' under Carbon Smart (CS); 'Farming system model for food & nutritional security' and 'Multi-tier IFS for hills' under Energy Smart (ES) and 'Low cost structure for propagation of horticulture crops through cutting' and 'RC-Seed Bin: low cost seed storage technology' under Knowledge Smart (KS) are identified as the most important CSA practices with respect to the six domains of CSA *viz.,* NS, WS, SS, CS, ES and KS.

Also the Half Violin Graph in fig. 1 below depicts five most important CSA practices each for the six main domains of CSA with their Standardized score.

Again, Ten CSA Practices that has composite of

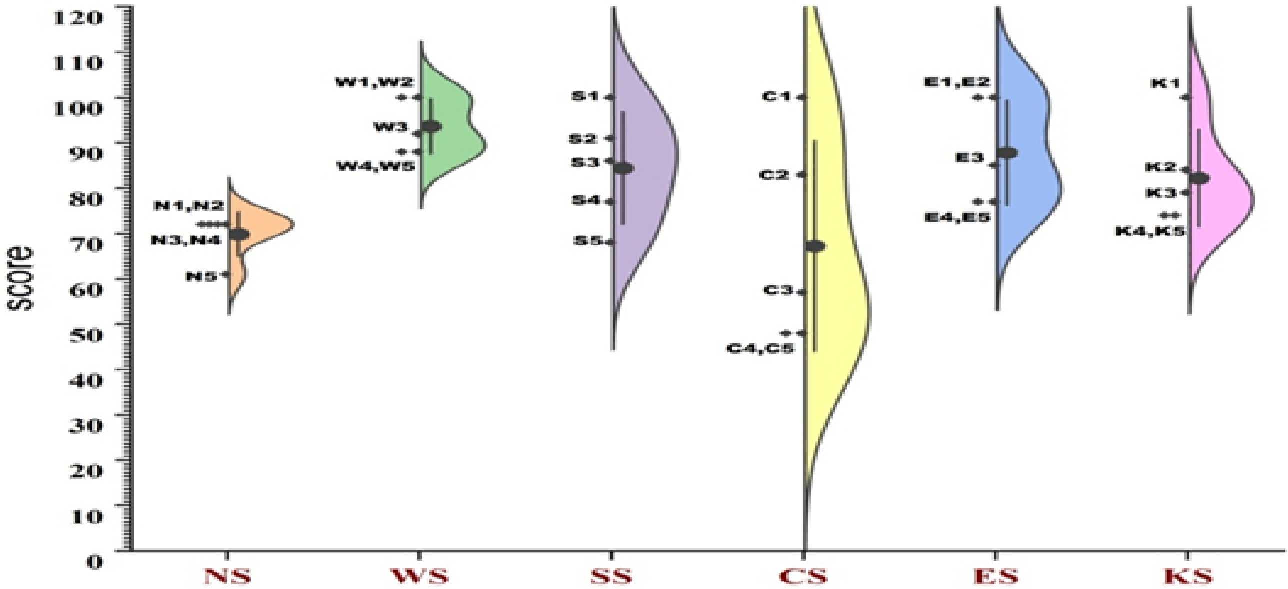

Fig. 1. Half Violin Graph with the important CSA practices *w.r.t* six domains of CSA

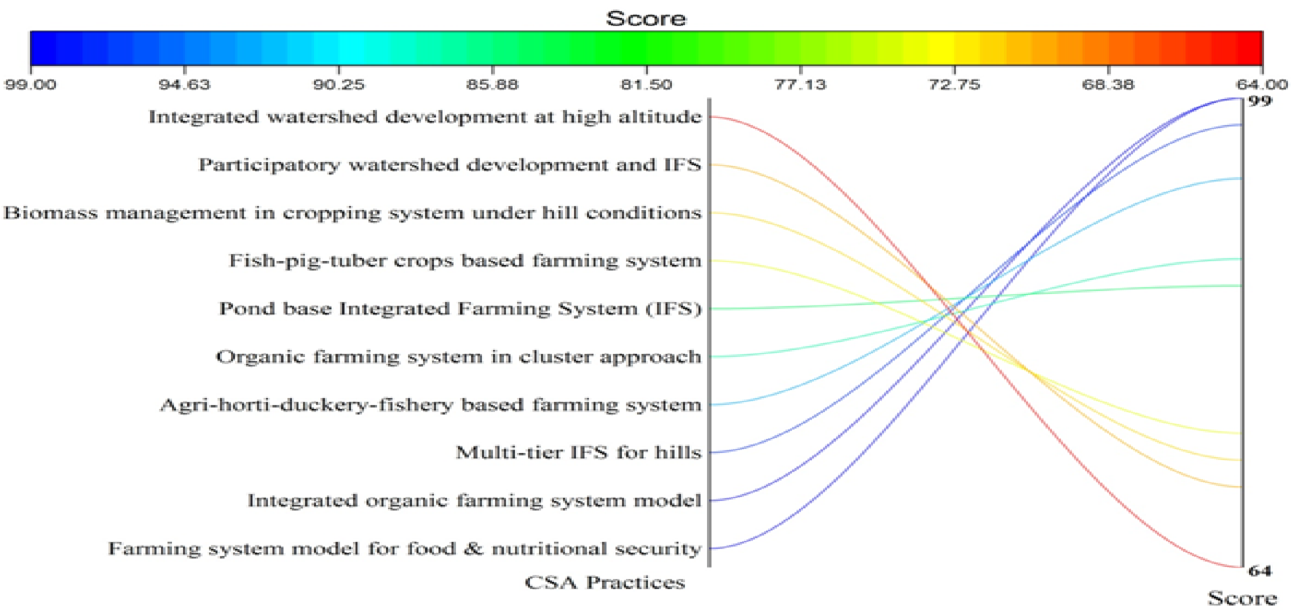

Fig. 2: Parallel plot showing Ten Champion CSA Practice

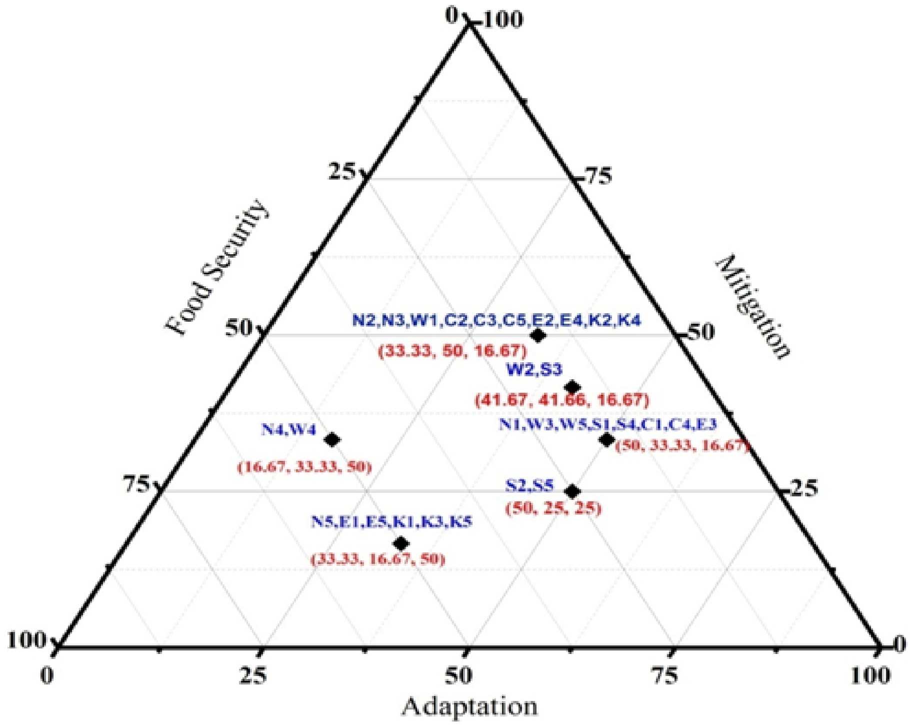

Fig. 3. Ternary Diagram on CSA Practices based on the three pillars of CSA

maximum CSA domains are shown by the Parallel plot in Fig. 2 and Table 2. The CSA Practices *viz.*, 'Farming system model for food & nutritional security' and 'Integrated organic farming system model' has highest composite of all the CSA domains with a score of 99 each; followed by the CSA practice 'Multi-tier IFS for hills' with composite score of 97; 'Agri-horti-duckery-fishery based farming system' with score of 93; 'Organic farming system in cluster approach' with score of 87; 'Pond base Integrated Farming System' with score of 85; CSA practice 'Fish-pig-tuber crops based farming system' with score of 74; 'Biomass management in cropping system under hill conditions' with score of 72; 'Participatory watershed development and IFS' with score of 70 and 'Integrated watershed development at high altitude' with score of 64 were found having high composite and balance of all the six domains of CSA and can be consider as champion CSA practices with respect to CSA domains. *Neufeldt et al., (2015)* also categories CSA Practices *viz.*, Zero-tillage, minimum-tillage or conservation tillage; Erosion control as 'Soil management practices'; CSA Practices *viz.*, Integrated soil fertility management using inorganic and organic fertilizers; management of nitrogen fertilizer; as 'Nutrient management practices'; CSA Practices *viz.*, Water harvesting, Groundwater development, Construction or enhancement of dams as 'Water management practices'; Also CSA Practices *viz.*, Wind and geothermal energy, Solar power, Energy-efficient cook stoves, Solar-, wind- or bioenergy-operated water pumps as 'Energy management practices'.

Table 2. Ten most important CSA Practices with composite domains

CSA Practices	Composite Score
Farming system model for food & nutritional security	99
Integrated organic farming system model	99
Multi-tier IFS for hills	97
Agri-horti-duckery-fishery based farming system	93
Organic farming system in cluster approach	87
Pond base Integrated Farming System (IFS)	85
Fish-pig-tuber crops based farming system	74
Biomass management in cropping system	72
Participatory watershed development and IFS	70
Integrated watershed development at high altitude	64

Chhetri et al., (2018) also identified practices *viz.*, Rainwater Harvesting- Farm Ponds and Drip Irrigation as 'Water Smart'; Minimum Tillage and Solar Pumps as 'Energy Smart'; Site Specific Integrated Nutrient Management and Green Manuring as 'Nutrient Smart'; Agro Forestry/Horticulture and Concentrate Feeding for Livestock as 'Carbon Smart'; Contingent Crop Planning

Table 3. Jonckheere-Terpstra Test of CSA Practices

CSA Pillars	Jonckheere-Terpstra (J-T)Test	Score
Adaptation	Observed J-T	742
	Mean J-T	717
	Std. Deviation of J-T	92.28
	p-Value	0.786
Mitigation	Observed J-T	569
	Mean J-T	884
	Std. Deviation of J-T	98.46
	p-Value	0.001
Food Security	Observed J-T	944
	Mean J-T	696
	Std. Deviation of J-T	89.83
	p-Value	0.006

and Improved/Short Duration Crop Varieties as 'Knowledge Smart'; those are major CSA technologies for different crop and cropping system. The fig. 3 of Ternary diagram shows the CSA practices based on the three pillar of CSA *viz.*, 'Adaptation', 'Mitigation' and 'Food Security'.

The CSA practices depicted by N2, N3, W1, C2, C3, C5, E2, E4, K2 and K4 shows of 'Mitigation' CSA practices. Similarly, the CSA practices depicted by N4, W4, N5, E1, E5, K1, K3 and K5 shows 'Food Security' CSA practices. The CSA practices depicted by W2 and S3 were found of having balance of Adaptation and Mitigation. The *Jonckheere- Terpstra* test presented in table 3 shows that, the *Jonckheere- Terpstra test* value were 569 and 944 with p-value 0.001 and 0.006 for Mitigation and Food security respectively, which shows significance at 1% level. While, the *Jonckheere-Terpstra test* value was 742 with p-value 0.786 for Adaptation which shows of non-significant.

CONCLUSION

Since technology generation is a continuous process and is context specific more research and refinement are needed to generate champion CSA options for effective adoption by farmers. In addition, greater coordination and continuous learning among researchers, extension workers and policy makers is needed to scaling up of champion CSA practices. Climatic risks and socio-cultural contexts are vary so verification, and refinement of CSA Practices for location specific and need based of farmers are needed. It is time to systematically integrate CSA into local and also to National development plans. The research strongly advocates that more research and refinement are needed to generate champion CSA options for effective adoption by farmers. Also, coordination and continuous learning among researchers, extension workers and policy makers is vital for effective scaling up of CSA practices in the fragile North Eastern hill states of India.

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