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Development and Standardization of Perception Scales for Farmers and Extensionists Regarding Impact of Climate Change on Nutrition

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ABSTRACT

While climate change is ravaging our planet, its nutritional health which is going to be hit even harder. Food is going to be more expensive, less nutritious and scarcer. The reduced nutritional quality of important crops could mark the beginning of a looming nutritional health crisis. Climate change is not only reducing yields, but also sapping nutrients from our meals. If climate change is predicted to cut access to nutrients then food and nutritional security is growing concern and we need to understand perceptions and implications of this burning issue for stakeholders especially farmers and extensions. The objective of the study was to develop and validate scales to study these perceptions of farmers and Extensionists regarding impact of climate change on nutrition. The locale selected for the study was from States of Uttar Pradesh (UP) and Odisha due to their nutritional vulnerability status. The sample size constituted of 100 farmers from these villages and extensionists from Krishi Vigyan Kendras and line departments of the state who were selected by random sampling technique. A total of 69 items were selected from review of literature. These were further reduced to 43 based on expert's judgments. The items were finally reduced to 16 items for farmers and 24 items for extensionists by statistical analysis using Mokken's Scaling Analysis. Loevinger's coefficient was calculated for item H (Hi); item pair H (Hij) and for the overall scale (Hs). By this means, and based on the mean scores on items by individuals, a set of items were selected. Items which had Hs>0.4 were selected. These scales can be used by various stakeholders for designing interventions for climate and nutrition smart agriculture. There is a need for agri-nutri education for consumers and farmers, especially the women in India which has a triple burden of malnutrition. Synergies of the climate and nutrition agendas need to be built for human and planet health. The implications are huge. Climate change and agriculture needs to be seen through a nutrition and gender lens for convergence to ensure food and nutritional security.

Keywords: Climate change, Food systems, Nutrition, Nutritional security, Perception, Extensionists, Farmers and Mokken scale analysis

INTRODUCTION

Climate change is hitting us where it counts the most: the stomach and hunger. While climate change is ravaging out planet, it's our nutritional health which is going to be hit even harder. Food is going to be more expensive, less nutritious and scarcer. A number of recent studies point out that climate change will reduce nutrients in many crops. There is strong evidence that climate change will affect food quality (diversity, nutrient density and safety) and food prices (Global Panel on Agriculture and Food Systems for Nutrition, 2015; Vermeulen *et al.,* 2012).

Climate, agriculture, nutrition and gender are intrinsically linked, Climate change impacts are already being felt which is supported by a strong research base. There is a growing area of research, painting a rather grim and alarming picture, where climate change is severely going

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to impact nutrition of crops, which in turn is going to affect the most vulnerable - the poor, the women and children. There is certainly a need to develop better understanding of the pathways linking climate change to agriculture, nutrition outcomes and women for developing strategies for climate smart, nutrition smart and gender sensitive food system.

The reduced nutritional quality of important crops could mark the beginning of a looming nutritional health crisis. Serious questions are being raised over the future of nutritional security since studies are revealing how climate change is not only reducing yields but also what is again a serious issue, is that it is also sucking nutrients from our meals. These studies are eye-openers for us to realize that we need to bridge this gap to ensure sufficient nutrition and safe food till the end of this century.

Myers *et al.* (2016) reported that wheat grown in high CO_2 levels had 9 per cent less zinc and 5 per cent less iron, as well as 6 per cent less protein, while rice had 3 per cent less iron, 5 percent less iron and 8 per cent less protein. Maize saw similar falls while soybeans lost similar levels of zinc and iron. By 2050, the Vitamin B content of rice is expected to drop 17 to 30 per cent upping the risk of deficiencies in folate (B_9), thiamine (B_1) and riboflavin (B_2) for tens of millions of people, especially in regions dependent on rice. All these vitamins are crucial for normal and healthy development. According to Smith and Myers (2018), Atmospheric CO_2 is on pace to surpass 550 ppm in the next 30-80 years. Many food crops grown under 550 ppm have protein, iron and zinc contents that are reduced by 3-17 per cent compared with current conditions. They analyzed the impact of elevated CO_2 concentrations on the sufficiency of dietary intake of iron, zinc and protein for the populations of 151 countries using a model of per capita food availability stratified by age and sex, assuming constant diets and excluding other climate impacts on food production. They estimated that elevated CO_2 could cause an additional 175 million people to be zinc deficient and an additional 122 million people to be protein deficient. For iron, 1.4 billion women of child bearing age and children under 5 are in countries with greater than 20 per cent anemia prevalence and would lose more than 4 per cent of dietary iron. Regions at highest risk-South and South East Asia, Africa and the Middle East- require extra precautions to sustain an already tenuous advance towards improved public health. Ebi's research (2018) focused on health risks associated with climate variability and change. The results showed that rice grown at the concentrations of atmospheric carbon dioxide scientists expect the world to reach by 2100, has lower levels of four key vitamins. Higher carbon concentrations in plants reduce nitrogen amounts in plant tissue, which is critical to the formation of B vitamins. Vitamins B are required for regulatory key functions in the body. Folate, B vitamin, reduces the risk of birth defects consumed by pregnant women. By 2050, levels of protein available per head could fall by 19.5 per cent and of iron and zinc by 14.4 per cent and 14.6 per cent respectively. That is a fall of - for all three vital elements of survival, almost one fifth (Cole & Desphande-Lancet Planetary Health, 2019). Besides the impact of climate change on the levels of zinc, iron and vitamins in crops, a recent study has projected that as a result of climate change 66 per cent of croplands will lose 8.7 per cent of their selenium. Selenium boosts immune systems and prevents cognitive decline. It is also known to inhibit proper growth of bones in children.

Dietary intake is the number one source of zinc, whose deficiency can lead to diarrhea, poor vision, mouth and stomach ulcers, and even psychological and cognitive disorders. The most common iron deficiency can result in fatigue, hair loss and weakened immune function. In general people in low- and middle-income countries receive a larger portion of their nutrients from plant-based sources, which tend to have lower bioavailability than animal based sources. Nutritional deficiencies and malnutrition continue to take a heavy toll. The impact on individual crops can have disproportionate effects on diets and health. Significant nutrient losses in wheat and rice have especially widespread implications since majority of our population depends on these affordable cereals. Whitmee *et al.* (2015) reports that the hardest hit areas would be India, whereby 2050 the less nutritious food could lead to 50 million more people zinc deficient, 38 million more protein deficient and 502 million women and children facing iron deficiency. The Earth has already reached the point of diminishing returns. Millions could be added to the billions of people who do not get enough nutrition.

Little is known about farmer's perception on climate change impacts on nutrition and their effects on adaptation decisions. This information is a pre-requisite for adaptation strategies. It is crucial to understand their views and perceptions while formulating adaptation plans and policies, Understanding farmers including women farmers perceptions on climate change and nutrition are essential for designing and implementing extension strategies for climate and nutrition smart agriculture.

Hence, there is a need to study the perceptions of farmers and extensionists regarding the impact of climate change on nutrition. The objective of the study was to develop and standardize a scale to study these perceptions by designing, testing and refining a set of items to assess perceptions in relation to impact of climate change on nutrition in crops. These scales need to be used to generate data for designing development communication strategies and interventions. This will also be helpful for Extension in the face of climate change challenges.

MATERIALS AND METHODS

As science advances and novel research questions arise it becomes essential to develop new scales. Scales are a manifestation of latent constructs used to capture an attitude, perception or behavior which cannot be accessed and encapsulated directly in a single variable or item. The development and validation of scales is of paramount importance in behavioral issues and outcomes. However this is not a straight forward endeavor since it involves a number of stages and steps.

The locale selected for the study was from States of Uttar Pradesh (UP) and Odisha due to their nutritional vulnerability status. The sample size constituted of 100 farmers from these villages and extensionists from Krishi Vigyan Kendras and line departments of the state who were selected by random sampling technique.

Mokken Scale Analysis was employed to reduce the number of items (Shenkin *et al.*, 2014; Van Der Ark, 2007). This a non-parametric approach. The main purpose of the Mokken scale is to validate an ordinal measure of a latest variable (Hemker *et al.,* 1997; Sijitsma and Molenaar, 2002).

The principle preferred standpoint of Mokken scale analysis as compared to factor analysis is that it can deal with less number of data and it does not require prior assumptions of the data generating process. Mokken scaling works by seeking unidimensional sets of items on the basis of Loevinger's coefficient (H) which is based on the extent to which pairs of items, as scored by respondents, conform to Guttmann criteria. In a Guttmann scale which is deterministic in nature any pair of items should be scored relative to one another consistently; in other words, of two items item i and item j, if item j represents more of the latent trait then item i (i.e. it is more 'difficult' in psychometric terms) then item i should always be more readily endorsed than item j. Where item pairs are not endorsed in the expected direction (i.e. where an individual endorses item j more readily than item i) then that is a Guttmann error. In this sense, 'difficulty' means the ease with which an item is endorsed or agreed with by respondents and is indicated by the mean score of the item: more 'difficult' items have lower mean scores. In addition, the present study employed Genetic Algorithm Approach to estimate the Loevinger's coefficient (H). The 'Mokken' package in R was used for the analysis.

We adopted the following steps under the three Stages based on Boateng *et al.* (2018).

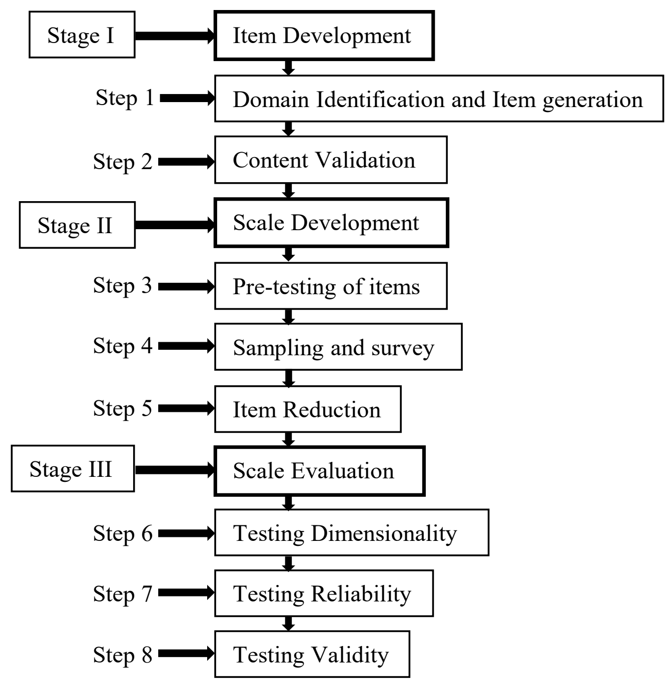

Figure 1: Stages and steps for development and validation of perception scale

Stage I: Item Development (2 steps)

Step 1: Domain Identification and Item generation:

Here the purpose is to first of all identify the domain and identify and generate appropriate items to fit the domain. The domain identified was perceptions of farmers and extensionists regarding the impact of climate change on nutrition. The dictionary meaning of 'perception' is a particular way of looking at or understanding something, an opinion. Cambridge dictionary defines it as a belief or opinion often held by many people and based on how things seem. It is the way something is regarded, understood or interpreted on insight. They may include appreciations and apprehensions, assimilations, comprehensions. In psychology it is seen as the process of recognizing and interpreting sensory stimuli a process of acquiring and processing of information. Perception is very important in understanding human behavior because every person perceives the world and approaches life problems in a different manner. People behave and take action on the basis of their perceptions.

Understanding public perceptions of climate change impacts is critical for developing and implementing effective strategies for mitigation and adaptation and reduce human vulnerability to these impacts especially in terms of nutrition. In this study we aim to develop perception scales which can be used to address the questions of whether farmers and extensionists have the capacity to perceive links between climate change and nutrition in crops that indicates sensitivity to climatic conditions and nutritional security. This will enable researchers to collect data and policy makers to understand farmers and extensionists perceptions and behavior and make evidence based decisions on what issues to focus on and how do this effectively when communicating with farmers.

Through review of literature it was revealed that there is no such existing instrument on this emerging area of importance. Hence fresh items were generated. Deductive and inductive methods were used for item generation. Since no scale was found in this domain the research studies on impact of climate change were reviewed to frame the items. This deductive approach provided the theoretical basis for defining the domain. Focus group discussions and interviews with farmers (men and women) and extensionists in ICAR institutes and Krishi Vigyan Kendras were used as the inductive methods to make pragmatic decisions about the domain and move from an abstract point to its manifest form.

Step 2: Content validation

Content validity is vital to ensure that items measure what they are presumed to measure. The purpose here is to validate each item constituting the domain for the relevance, adequacy representativeness and technical quality of content by experts. Here 30 experts were chosen from the field. Formalised scaling and statistical procedures were followed. For content validation the authors consulted experts in the field of agriculture, climate change, and nutrition and extension education. The items were then subjected to content analysis using expert judges to select items that were accurate, relevant and interpretable. Items were then accepted, rejected or modified based on majority opinion. Cognitive interviewing entails the administration of draft questions to target populations and then asking the respondents to verbalize the mental process entailed in providing such answers (Beatly *et al.*, 2007). Cognitive interviews allowed for items to be modified, clarified, or augmented to fit the objective of our study. This helped to ensure that farmers and extensionists (our respondents) understood items as we intended and they were able to respond in a manner which reflects their experience. This was done on a sample outside of study population. Cohen's kappa measures agreement between two raters only. For a similar measure of agreement Fleiss' kappa is used since there are more than two raters, (Fleiss, 1981). Hence as we had 30 experts, Fleiss' kappa was utilized to check the validity. The Fleiss' Kappa value for m raters was 0.8995 and z= 16.5 while p value=0. The interpretation of the magnitude of Fleiss kappa is like that of the classical Cohen's kappa (Fleiss, 2003). For most purposes, values greater than 0.75 or so may be taken to represent excellent agreement beyond chance, Values below 0.40 or so may be taken to represent poor agreement beyond chance, and values between 0.40 and 0.75 may be taken to represent fair to good agreement beyond chance.

The initial bank contained 69 items we developed since we agreed with Kline (1993) and Schinka *et al.* (2012) that the number of items should be at least twice as long as the desired scale. The statements were kept simple, straight forward and followed contentions of normal conversation as suggested by Krosnik (2018). We developed items afresh and tested their clarity in rounds of qualitative interviews and focus group discussion. The 43 items selected from the 69 items after content validation are presented in Table 1.

Stage II: Scale Development

Step 3: Pre-testing of items to ensure meaningfulness of questions and answers.

The purpose in this step was assessment of the extent to which our domain was reflected by the questions and that valid measurements were produced by the answers. This was done by means of cognitive interviews wherein draft questions were administered to 30 interviewees in three rounds. This allowed the respondents to verbalise the mental process entailed in providing answers.

Table 1: Items selected after content validity screening on perceptions of farmers and extensionists on impact of climate change on nutrition

S.No.	Statements
1.	Climate Change strips nutrients from food crops (vegetables, legumes, peanuts, cereals etc.)
2.	Environmental changes (such as water scarcity, increase in temperatures and greater concentration of carbon dioxide could impact nutritional quality of crops vital to our everyday nutrition)
3.	Climate change is sucking the nutrients from our vegetables
4.	Climate change is sucking the nutrients from our legumes
5.	Climate change is affecting nutritious foods that are more important to a healthy diet.
6.	Farmers, especially women in rural areas, will be most affected by climate change effect on nutrition
7.	Important micro nutrients for our health (eg. Iron) will be reduced in bones due to climate change
8.	Anti-nutritional compounds (phytic acid and lead) will be increased due to climate change
9.	Climate change variability and extremes are the key force behind rise in hunger and malnutrition.
10.	Climate change stresses will most heavily impact the most nutritional vulnerable/insecure people
11.	Climate change will lead to lower levels of essential nutrients such as protein, iron and zinc in our diets
12.	Loss of dietary nutrients in foods will aggravate nutritional deficiencies/malnutrition
13.	Climate change will make rice less nutritious
14.	Some vitamins (eg. Vitamin E) may increase in rice due to climate change effects (eg. rising CO_2)
15.	A drop in nutritiousness of rice as result of climate change could have profound health effects
16.	Potatoes may be impacted by climate change in terms of nutritional quality
17.	Climate change will impact nutrition through decreased food quantity and access
18.	Climate change will impact nutrition through decreased dietary diversity
19.	Climate change will result in decreased food nutritional content
20.	'Double duty' actions that address climate adaptation and nutrition are required
21.	Climate change is reducing yields and impacting food security
22.	Global warming may cause our crops to be less nutritious
23.	Farmers especially women in rural areas will be most affected by climate change effect on nutrition
24.	It is troubling to see climate change impacting nutritional content of our crops
25.	Rising temperatures may actually improve nutrition but decrease yields (eg. In soybean)
26.	Crop yields may increase at the cost of nutrition due to climate change
27.	Bio availability of micro nutrients (esp. iron & zinc) may be impacted by climate change (increasing CO_2)
28.	Climate change can potentially intensify the problem of malnutrition
29.	Effects of climate change may be positive or negative on nutrition and health.
30.	Climate change in future will translate into increasing prevalence of malnutrition
31.	Climate change will reduce the nutritional quality of diets.
32.	Climate change will result in more human and animal diseases
33.	Unless food is stored properly it can increase risk of spoilage and contamination and result in more food-borne diseases especially in extreme weather conditions
34.	Heat wave will make livestock less fertile and more vulnerable to diseases
35.	Climate change will impact meat production and nutrition
36.	Livestock farmers may use more chemicals and medicines which might enter food chain
37.	Milk production could decline due to climate change affecting dairy cows
38.	Climate change will enable more weeds, pests and fungi to survive and result in more unsafe and injudicious use of pesticides
39.	A warmer and more acidic ocean will affect seafood impacted by climate change.
40.	Climate change may lead to increased food prices making food more expensive and scarce.
41.	Climate change has implications for food safety and quality
42.	Levels of vitamins (eg. B, B2, B5 and B9) may drop in rice due to climate change effects (eg. rising CO_2)
43.	Rising temperature may safeguard crop nutrition as climate changes

Step 4: Administration of survey and sampling in order to get sufficient data from the right people

The purpose here is ensuring enough data availability with minimum measurement errors for scale development and validation. The potential scale items were administered on a recommended sample size of 100 farmers and extensionists each. The respondents were farmers (men and women) drawn by simple random sampling technique from the purposively selected states (UP and Odhisa) and districts due to their nutritional vulnerability. The extensionists were selected by simple random sampling technique from the Krishi Vigyan Kendras and Agriculture Department of the two states. Personal interviews were conducted for data collection.

Step 5: Item reduction for ensuring that the scale is parsimonious (optimum)

The purpose of this step is to determine the probability of a particular respondent correctly answering a given item (Item Response Theory) According to Thurstone (1947) in scale development item reduction analysis is conducted to ensure that only parsimonious, functional and internally consistent items are ultimately included. Items which are not or are the least related to the domain under study are identified for deletion of modification. These items are correlated with each other, discriminate between individual cases, underscore single or multi-dimensional domain and contribute significantly to the construct (Boateng *et al.*, 2018). As per Fan (1998) two theories, Classical Test Theory (CTT) and the Item Response Theory (IRT) underpin scale development. Between the two, the IRT approach to scale development has the advantage of allowing the researcher to determine the effect of adding or deleting a given item or set of items by examining the item information and standard error functions for the item pool (Harvey and Hammer, 1999).

To determine the correlations between scale items, as well as the correlations between each item and sum score of scale items, the item total correlations were computed for each items. Values for an item-total correlation (point-biserial) between 0 and 0.19 may indicate that the item is not discriminating well, values between 0.2 and 0.39 indicate good discrimination, and values 0.4 and above indicate very good discrimination (Table 2).

Table 2 shows the item- total correlations which shows the relationship between each item vs the total score of scale items. Hence only functional items were obtained

Table 2: Item total correlation of the items

S.No	Variable	Item Total	Range
1	C54	0.22	(0.2-0.39) Good discrimination
2	C32	0.22	
3	C28	0.24	
4	C3	0.25	
5	C2	0.28	
6	C51	0.39	
7	C41	0.39	
8	C63	0.40	(0.4 and above) Very Good discrimination
9	C53	0.46	
10	C45	0.46	
11	C34	0.46	
12	C17	0.48	
13	C56	0.52	
14	C25	0.53	
15	C18	0.56	
16	C27	0.56	
17	C57	0.57	
18	C61	0.57	
19	C33	0.60	
20	C26	0.63	
21	C10	0.64	
22	C19	0.64	
23	C9	0.65	
24	C30	0.65	
25	C16	0.66	
26	C37	0.66	
27	C15	0.68	
28	C50	0.68	
29	C62	0.70	
30	C12	0.72	
31	C59	0.73	
32	C46	0.73	
33	C35	0.74	
34	C5	0.74	
35	C21	0.74	
36	C39	0.76	
37	C42	0.76	
38	C13	0.76	
39	C22	0.80	
40	C24	0.81	
41	C6	0.83	
42	C60	0.84	
43	C38	0.86	

which were correlated with each other, discriminated between individual cases, underscored a single domain and contributed significantly to our construct (Boating *et al.,* 2018). Figure one depicts the inter item correlations. These inter-item correlations examine the extent to which scores on one item relate to scores on all other scale items and the extent to which the main content is being assessed by the items. As per the interpretation given in Figure 1, the items with very low correlations are less desirable and are considered for potential deletion from the tentative scale. Smaller size denotes lesser correlation which means greater discrimination.

Further to ensure the availability of complete cases for scale development mean imputation method was used for imputing missing cases. With regard to missing cases imputing individual items before scale development is a preferred approach to imputing newly developed scales (Ggottschall *et al.,* 2012) and have shown to produce more efficient estimates over scale – level imputation. Mokken's method of scaling assists in the determination of the dimensionality of tests and scales, and enables consideration of reliability, without reliance on cronbach's alpha (Stochts *et al.*,)

Stage III: Scale Evaluation

Step 6: Testing Dimensionality: The purpose here is to address the underlying relationships and latent structure of scale items. Unidimensionality was tested by MSA (Given as values of binary one in Table 3).

Step 7: Testing reliability to establish if responses are consistent on repetition and are dependable. The purpose is to assess the internal consistency of the scale which is the degree to which the scale items co-vary, relative to their sum score. MSA was used here.

Step 8: Testing validity to ensure that we measure the dimension we intended. Validity and reliability are the yardsticks against which adequacy and accuracy of our scales are evaluated.

Table 3: Selected sixteen items on perceptions scale for farmers for impact of climate change on nutrition (based on MSA)

S. No.	Statements	Binary	H Value (Loevinger's coefficient)	Standard error
1.	Climate Change strips nutrients from food crops (vegetables, legumes, peanuts, cereals *etc.*)	1	0.846	(0.036)
2.	Climate change is reducing yields and impacting food security	1	0.562	(0.072)
3.	Environmental changes (such as water scarcity, increase in temperatures and greater concentration of carbon dioxide) could impact nutritional quality of crops vital to our everyday nutrition.	1	0.797	(0.052)
4.	Climate change is affecting nutritious foods that are more important to a healthy diet.	1	0.819	(0.046)
5.	Farmers, especially women in rural areas, will be most affected by climate change effect on nutrition	1	0.780	(0.059)
6.	Climate change will reduce the nutritional quality of diets.	1	0.828	(0.044)
7.	Climate change will impact nutrition through decreased dietary diversity	1	0.841	(0.040)
8.	Climate change will result in more human and animal diseases	1	0.847	(0.025)
9.	Climate change will impact meat production and nutrition	1	0.645	(0.077)
10.	Unless food is stored properly it can increase risk of spoilage and contamination and result in more food-borne diseases especially in extreme weather conditions	1	0.719	(0.062)
11.	Heat wave will make livestock less fertile and more vulnerable to diseases	1	0.780	(0.039)
12.	Milk production could decline due to climate change affecting dairy cows	1	0.786	(0.052)
13.	Livestock farmers may use more chemicals and medicines which might enter food chain	1	0.872	(0.026)
14.	Climate change will enable more weeds, pests and fungi to survive and result in more unsafe and injudicious use of pesticides	1	0.891	(0.017)
15.	A warmer and more acidic ocean will affect seafood impacted by climate change.	1	0.859	(0.023)
16.	Climate change has implications for food safety and quality	1	0.537	(0.056)

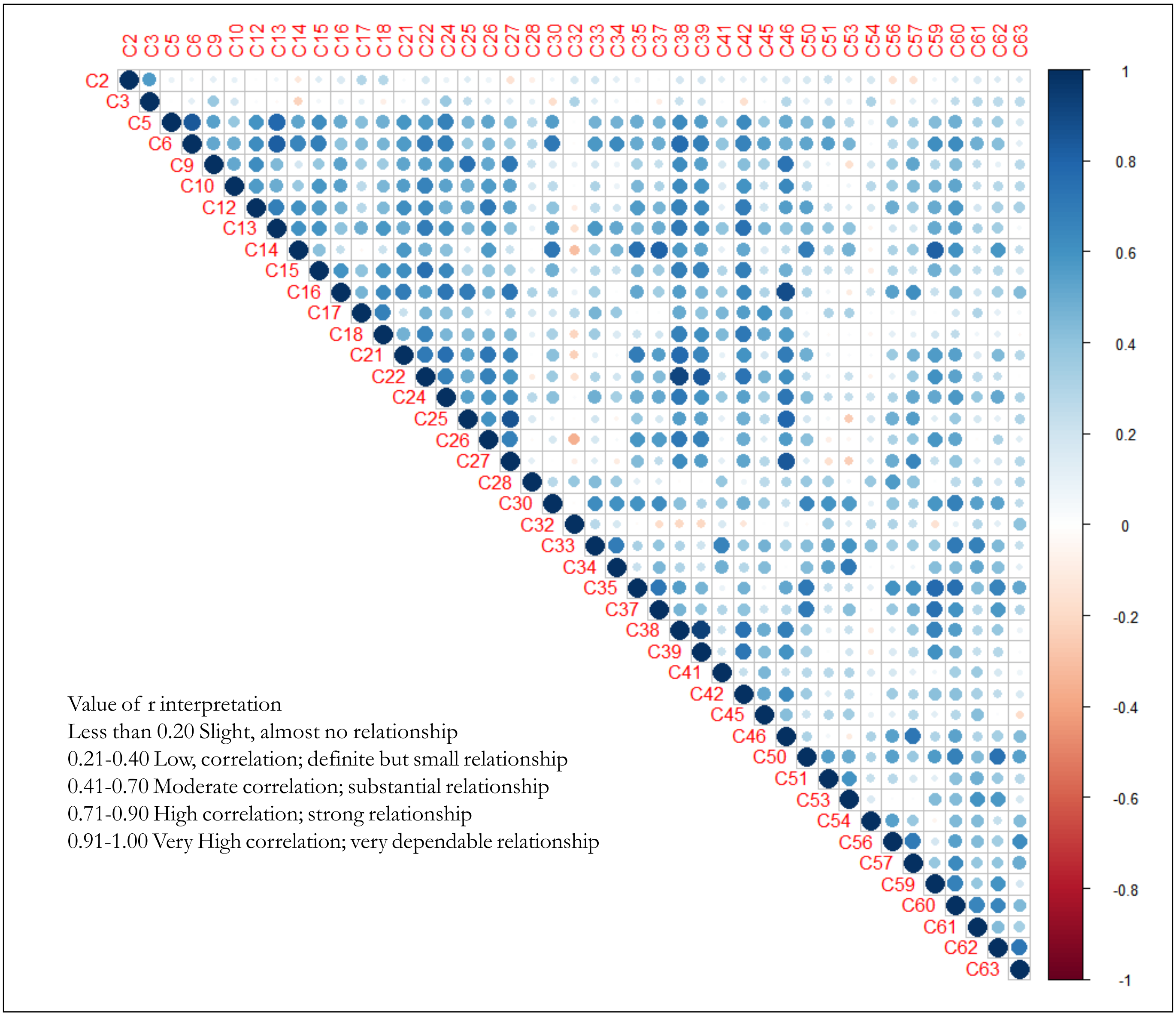

Figure 2: Inter Item correlation plot between the items

Pearson Product moment coefficient was used to suggest support for validity

Lesser the correlation greater is the dicrimination and the items discriminate well among each other suggesting better results for scale items.The circles in the Figure 2 indicates the correlation (inter-item) lessser the size of circle,lesser is the correlation.

RESULTS AND DISCUSSION

On the basis of Mokken scale analysis 16 out of 43 statements were retained for the final scale for farmers. Loevinger's coefficient is calculated for item H (Hi); item pair H (Hij) and for the overall scale (Hs). By this means, and based on the mean scores on items by individuals, a set of items can be selected. In this study, the items which are having Hs>0.4 are selected for men and women farmers.

As a rule of thumb in practical interpretations items with H<0.3 are not considered as unidimensional. Item sets with coefficient higher than 0.3 and lower than 0.4 are indicative of weak scales: unidimensional but not strong in any scaling sense. When H ranges between 0.4 &< 0.5 the scale is considered of medium strength and only when H >0.5 the scale is seen strong. which implies that the items discriminate better among different values of (Seefeld and Linder, 2007) All items can be considered to measure a single underlying construct threshold value , 0.3 level is worthy of retaining the time. A perusal of Table 3 clearly

Table 4: Selected twenty four items on Perception scale for extensionists for Impact of climate change on nutrition (based on MSA)

S. No.	Statements	Binary	H Value (Loevinger's coefficient)	Standard error
1.	Climate change is affecting the nutrients of our vegetables	1	0.579	0.059
2.	Climate change is affecting the nutrients of our legumes crop	1	0.613	0.048
3.	Climate change is affecting nutritious foods that are more important to a healthy diet.	1	0.507	0.095
4.	Farmers, especially women in rural areas, will be most affected by climate change effect on nutrition	1	0.452	0.085
5.	Important micro nutrients for our health (eg. Iron) will be reduced in bones due to climate change	1	0.461	0.087
6.	Anti-nutritional compounds (phytic acid & lead) will be increased due to climate change	1	0.543	0.068
7.	Climate change variability and extremes are the key force behind rise in hunger and malnutrition.	1	0.539	0.060
8.	Climate change stresses will most heavily impact the most nutritional vulnerable/ insecure people	1	0.488	0.104
9.	Climate change will lead to lower levels of essential nutrients such as protein, iron and zinc in our diets	1	0.488	0.092
10.	Climate change will make rice less nutritious	1	0.429	0.090
11.	Some vitamins (eg. Vitamin E) may increase in rice due to climate change effects (eg. rising CO_2)	1	0.469	0.074
12.	A drop in nutritiousness of rice as result of climate change could have profound health effects	1	0.427	0.092
13.	Potatoes may be impacted by climate change in terms of nutritional quality	1	0.473	0.085
14.	Climate change will impact nutrition through decreased food quantity and access	1	0.415	0.132
15.	Climate change will impact nutrition through decreased dietary diversity	1	0.410	0.101
16.	Climate change will result in decreased food nutritional content	1	0.543	0.083
17.	'Double duty' actions that address climate adaptation and nutrition are required	1	0.420	0.097
18.	Rising temperatures may actually improve nutrition but decrease yields (eg. in soybean)	1	0.542	0.065
19.	Crop yields may increase at the cost of nutrition due to climate change	1	0.502	0.071
20.	Rising temperature may safeguard crop nutrition as climate changes	1	0.486	0.072
21.	Bio availability of micro nutrients (esp.. iron & zinc) may be impacted by climate change (increasing CO_2)	1	0.421	0.135
22.	Climate change can potentially intensify the problem of malnutrition	1	0.531	0.112
23.	Effects of climate change may be positive or negative on nutrition and health.	1	0.429	0.114
24.	Climate sensitive crops such as rice, vegetables, cereals, and spices will be affected nutritionally	1	0.500	0.107

depicts that the items have H values above 0.5 indicating a strong scale.

Furthermore it is also important to understand the perceptions of extension personnel with regard to the impact of climate change on nutrition. Hence again, out of 43 items, on the basis of Mokken scale analysis, 24 items having Hs>0.4 were retained. These selected 24 items are given in Table 4.

Unidimensionality refers to measuring a single ability, attribute or construct. Thus this scale measures only perception in context of impact of climate change on nutrition. Even though perception is a psychological concept with many layers of complexity that can be different for different situations, unidimensional data will maximize Cronbach's alpha. Primary values of 1 for all 16 statements (farmer scale) and 24 statements (extensionists scale) confirm unidimensionality of the scale implying that this scale has only one dimension. The small standard error values indicates that the sample mean is a more actual population mean. It is an estimate of the reliability of our observed sample mean. As per Table 4, twenty four statements have H >0.4 were selected and retained for the final scale for extensionists. Here we note that there are 15 Items in the range of 0.4 to 0.5 (medium strength) and 9 items of H values above 0.5 (strong).

CONCLUSION

The set of items framed has the benefit of being evidence based, policy relevant and readily understood. The next pandemic can be entered with a plan for how to measure farmer perceptions. A better understanding of how farmers (including women farmers) and extensionists perceive the impact of climate change on nutrition is important for policy makers who aim to strengthen links between climate, agriculture and nutrition. On the basis of Mokkan Scale Analysis, two scales were developed for farmers and extensionists for understanding their perceptions regarding impact of climate change on nutrition. These instruments can be used by researchers. Also Climate change and agriculture needs to be seen through a nutrition and gender lens. Urgent policy action is needed to link food system resilience with higher quality diets and nutrition along with a gender sensitive approach. Climate change and nutrition education and communication strategies need to be planned in accordance with these perceptions. Extension programmes need to build on the adaptive capacity of the vulnerable and promote Nutrition Sensitive Agriculture. They may be intertwined with relevant modern and traditional agri-nutri technologies. Based on data and findings generated by using these scales recommendations for effective climate change and nutritional security communication policies can be outlined. We need agriculture to be climate smart and also nutrition and gender smart to meet the needs of communities and nations in these shifting climates with a pro nutrition lens where food production systems are diverse, efficient and resilient. It is a complex and multifaceted connection between climate change and nutrition. More voice and power is needed for food systems with dietary diversity, safe food and less food wastage.

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