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Article

Moving towards a Global Agricultural Competitiveness Index (GACI): A conceptual model

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Abstract: Considering increasing concerns about climate change and its implications for global agricultural competitiveness and food security, a small text has assessed the sensitivity of agriculture competitiveness employing a composite scale to the climate change impacts. The world's food production and supply chains have been jeopardized strain as the world struggles to cope with the far-reaching consequences of climate change, which are worsened by a series of natural disasters, the Ukraine-Russia war, and the continuous fight against infectious diseases like COVID-19. Natural disasters and armed conflicts are overstretching people's capabilities to acquire nutritive foods at economical/reasonable prices, risking local and global food security and agricultural market competitiveness. The study develops a framework for global agricultural competitiveness assessment by conducting a Delphi Expert survey. The framework has served as a global benchmark for assessing and comparing the national and international agriculture landscape. Its implementation will significantly contribute to the development of policies that promote inclusive and sustainable agricultural practices. Through this action, it guarantees to substantially enhance worldwide food security, thereby effectively tackling the urgent issues that impact communities across the globe.

Keywords: climate change; agriculture; competitiveness; Pillars; Delphi Expert Survey

1. Introduction

The agriculture sector, which contributes to food security, poverty alleviation, and economic growth, is facing significant risks (Alam et al., 2022). The excessive use of land and water for farming has not yet reached a crisis point, but the evidence suggests a decline in agricultural productivity, depletion of resources, and environmental harm (FAO, 2022). The threat of climate change, warfare, pests, and the spread of infectious diseases on food production is undeniable. This could lead to supply chain disruptions and hinder the availability of nutritious foods at reasonable prices, posing a risk to both local and global competitiveness in the agricultural sector (Malik et al., 2022). Nevertheless, it is unfortunate that there is currently no comprehensive measure or composite index to assess global competitiveness within the agriculture sector (Bobitan et al., 2023; Nugroho et al., 2023). Most measures presently in use only consider specific competitiveness measures in isolation and do not consider the impact of climate change on agricultural market competitiveness (Latruffe, 2010). It is imperative to address the existing gap in the study. Our objective is to formulate a comprehensive evaluation index that encompasses various dimensions of global agricultural competitiveness. Through this, the study can

effectively assess and evaluate the competitiveness of agriculture.

The Global Competitiveness Report indicates that competitiveness is determined; by a combination of institutions, policies, and factors that affect a country's productivity level (Schwab and Sala-i-Martin, 2014). By embracing competitiveness, individuals, companies, and the entire country can increase their productivity, setting them apart from the rest of the world. This increased productivity can provide a way for impoverished individuals to escape the economic trap of low productivity. Measuring competitiveness can be complex and involves various indicators, including productivity, cost measures, and revenue measures. Some indicators; can be; used individually, while others are combined to form indices. Competitiveness; can be measured at the local, national, or regional level and specific to certain sectors (Latruffe, 2010; Lei, 2023; Zia et al., 2022).

In today's global world, countries are analysed based on their competitiveness. Agricultural and food market competitiveness is becoming increasingly important, not just in developing countries but also in developed ones (Kym and Ponnusamy, 2023). It can; have a significant impact on the functioning of these markets, affecting pricing stability, price transmission, product accessibility, and availability. Lack of competition in these sectors can directly affect farmers and food consumers. Without healthy competition, government initiatives aimed at these markets may not succeed. The impacts on farmers may differ depending on the food security measurement tools used (FAO, 2015). For example, Australia has a well-developed agricultural sector and invests a large sum of money in promoting agriculture's competitiveness. The Agricultural Competitiveness White Paper (2015) outlines the Australian government's aim to expand agriculture and invest 4 billion Australian dollars in Australian farmers. The white paper highlights that "stronger farmers" lead to "a stronger Australian economy" (Agricultural Government, 2015).

Farmers can benefit from increased competitiveness in agriculture; as it leads to higher farm-gate returns, improved farm infrastructure security, better preparedness for disasters, and increased foreign trade, for the country (Nugroho, 2021). Moreover, competitive markets can enhance the quality of goods and lower prices, benefiting consumers. Various indicators can be employed to evaluate sector-specific progress, growth, and sustainability. However, there is no global index available for measuring agricultural market competitiveness. While individual measures exist (Latruffe, 2010), no global composite index is created specifically for this purpose (OECD, 2008). A composite index can provide a more accurate estimate of an industry's competitiveness (Nardo et al., 2008). Therefore, we suggest constructing an agricultural market competitiveness index to analyse the problem; empirically (Zia et al., 2022). It is essential to include climate change in this index as it has; a significant impact on agriculture (Nowak, 2022; Tagwi, 2022). Ignoring climate change would provide a skewed view of agricultural market competitiveness. By including climate change in our proposed index, we can establish climate policies that are more favourable to agriculture markets and maximize growth potential in the industry in the long run.

The construction of an agricultural market competitiveness index is proposed to be an appropriate measure for analysing the problem empirically. Moreover, Schwab and Sala-i-Martin acknowledge that climate change is a consequential phenomenon

that needs to be incorporated into the existing competitiveness indices (Schwab and Sala-i-Martin, 2011). Since climate change has considerable effects on agriculture, an index that does not take climate change into account is taking a skewed view of agricultural market competitiveness. Because of this, we are going to include climate change in the index for measuring the competitiveness of agricultural markets. As a result, it will be easier to establish agricultural market-friendly climate policies and secure long-term growth in the industry by maximizing the potential of agricultural markets.

The main objective of this study is to design a global measure for agricultural competitiveness evaluation. Initially, a detailed literature review was conducted by Zia et al. (2022) to explore the potential constructs of the Global Agricultural Competitiveness Index (GACI). The literature review provided a comprehensive list of the competitiveness measures used locally and globally in agricultural and non-agricultural sectors. This review also provided a list of the proposed strategies for agricultural competitiveness improvement. The World Economic Forum's (WEF) Global Competitiveness Index (GCI) was found to be the most comprehensive measure of global competitiveness. Therefore, a list of the twelve pillars of the GCI was given in the survey while asking for their applicability to the agricultural sector. However, the GCI was lacking in two things. The first was the agricultural-specific competitiveness measures, which were the most significant for agricultural competitiveness assessment. The second was the climate change impacts, particularly on agriculture, which is a compelling determinant of agri-competitiveness in the present global world/scenario. Therefore, the pillars of GCI, along with choices for the agricultural-specific competitiveness assessment and climate impact assessment, were used from the literature review to design the Delphi Expert Survey. The survey results endorsed the applicability of the pillars of GCI for the agricultural competitiveness assessment. A conceptual model for a GACI is designed on the basis of the Delphi Expert Survey and detailed literature review. The framework will serve as a global benchmark for assessing and comparing the national and global agricultural standing, and help in policymaking for sustainable and inclusive agriculture, thus increasing the global food security.

2. Literature review/gap

Several studies have explored the link between climate change and agricultural competitiveness, identifying key success factors, export priorities, and assessment methods. They advocate an interdisciplinary approach but have not proposed a unified metric for evaluating global agricultural competitiveness. Dwi et al. (2023) examined the relationship between climate change and agricultural competitiveness in 71 developing countries and 24 developed countries from 1990 to 2020. The study found that agriculture's competitiveness increased temperature in developing countries and decreased it in developed ones, reducing agricultural competitiveness in both. However, developed countries were more sensitive to temperature changes. Application of technology in agricultural business management and improving agricultural labour productivity can help increase agriculture's competitiveness and manage the rise in temperatures. Temperature change, agricultural comparative

advantage, industry (including construction), value-added (annual % growth), population, consumption of renewable energy, total natural resources rents, net forest conversion, consumer price index, official exchange rate, economic globalization index, land area equipped for irrigation, mobile cellular subscriptions, employment in agriculture, forestry and fishing, and human capital index were used to compare climate change impact on agricultural competitiveness.

Lei (2023) evaluated global agricultural market competitiveness using the analytical hierarchy process. By analysing factors affecting competitiveness using stakeholder interviews and literature reviews, the study determined critical success criteria, export priorities, and competitiveness methodologies for these markets. Furthermore, applying the proposed approach to real-firm performance cases revealed that agricultural production is profitable from a financial and economic perspective, given an optimal competitiveness strategy applied. The study employed several indicators like 'investment in formal education for farm managers, public and private investment in market infrastructure, technical innovations, information transfer, and facilitating access to agricultural advice, to evaluate the competitiveness of global agricultural markets.

Nowak and Kasztelan (2022) proposed a comprehensive interdisciplinary approach that incorporates both economic and environmental aspects of agriculture to address the issue of agricultural competitiveness. Measuring the competitiveness of agriculture is a complex task that poses methodological challenges. To address these challenges, the authors leveraged synthetic measures that utilized several partial indicators, which allowed for a comparison of competitiveness across economic and environmental aspects. Through the analysis of synthetic-specific indicators, Nowak and Kasztelan (2022) identified the strengths and weaknesses of the competitiveness of agriculture in respective countries. An essential aspect of this study was to determine the extent to which the results of economic competitiveness outcomes for respective countries coincided with their ranks for green competitiveness. Disparities between the values of both indices in respective member states were identified. The indices were based on 16 indicators, including labour productivity, agricultural income, and land productivity, which were used to analyse economic competitiveness. (Nowak and Kasztelan, 2022)

Previous studies have focused on specific aspects of global agricultural competitiveness and have not put forward a comprehensive approach or measure for assessing global agriculture competitiveness. In contrast, this study introduces a framework for finding global agricultural competitiveness based on a holistic approach.

The expert consultation method is a well-known approach and is used in many fields. These include research on climate change adaptation, agriculture-related studies and vulnerability analysis. The most common application of the Delphi method is found in environmental and natural resource studies. Delphi Expert Survey is used with index construction and extension in several studies. Recent research based on Delphi Expert Surveys comprises designing a system for monitoring sustainable tourism development performance in the wetland areas (Ghoochani et al., 2020); development of an index about flood vulnerability, coping capacity and exposure indicators through a Delphi survey (Nguemeleu et al., 2020). construction of an

entrepreneurship index using the Delphi method (Rezaei-Moghaddam and Izadi, 2019). formulation of the components of farmer's satisfaction with extension services and determination of factors affecting their satisfaction using Delphi with 42 experts (Zare et al., 2020); establishment of a quality assessment index framework for public health using 30 experts Delphi study (Zhao et al., 2015); development of an index with 17 nutrition and food experts (Valerino-Perea et al., 2021); construction of an evaluation Scale for Inter-Country Tourism Industry Competitiveness using Delphi surveys on a group of 20 international researchers (Oh et al., 2013); and an extension of an index by Delphi with 15 experts consulted (Eden et al., 2021). A number of studies, while analysing the previous literature, de Loë et al. (2016); Zartha Sossa et al. (2019) have provided the highest propensity of the experts ranging from 10 to 20, 20 to 30, and 30 to 40 experts in the Delphi studies.

3. Materials and methods

3.1. Theoretical foundations

A theoretical framework is developed to lay out the foundation for selecting and combining single indicators into a relevant index/composite indicator while observing the fitness for purpose principle. Stakeholders' and experts' engagement is expected during this phase of the index construction. It is developed for providing a comprehension of the multifaceted/compound/complex phenomenon to be quantified. Further to frame the different sub-categorizations required for the phenomenon under study; and to formulate the principles for selecting the variables such as a process, input, or output.

The current study is designed to formulate a composite index for global agricultural competitiveness assessment. Competitiveness refers to the traits and features of an economy that facilitate more efficient utilization of the factors of production.

The current study has foundations in the growth accounting theory. Growth accounting is a method used to analyse the sources of economic growth. It aims to quantify the contributions of different factors, such as labour, capital, and productivity, to overall economic growth. One of the key components of growth accounting is productivity, which refers to the efficiency with which inputs are used to produce outputs. Under this theory growth is the combination of growth in production factors and growth in the total factor productivity. The production factors consist of labour and capital, whereas, the total factor productivity accounts for the components not considered by labour, capital, or other inputs. The total factor productivity is a component of productivity that is not accounted for in the growth of the factors of production. It represents the portion of output growth that cannot be attributed to increases in input quantities. The total factor productivity (TFP) shows the efficiency with which the factors of production operate and is representative of long-term economic growth. It is simply the measure of how smartly the labour and capital are combined for output generation. TFP growth is often considered a measure of innovation, technological advancements, and overall efficiency improvements in an economy. The drivers of TFP growth include technological advancements, research and development (R&D), human capital development, infrastructure development,

access to finance, and market competition. Competitiveness, on the other hand, refers to the ability of a country or industry to compete effectively in the global marketplace. It encompasses various factors, including productivity, innovation, infrastructure, institutions, and market conditions. A competitive environment can foster productivity growth and drive TFP improvements, leading to enhanced economic performance.

The study is based on the factors determining the total factor productivity as a measure of competitiveness (**Figure 1**).

Figure 1. Theoretical framework.

3.2. Study design

The study was undertaken between December 2020 and October 2021. The study utilized a short expert-targeted survey as per the Delphi requirements. Participants were first recruited through a compiled contact list of experts that were found relevant to the study. The request to participate in the survey was first sent to the experts (n = 100). The study employed a multi-stakeholder approach along with purposive sampling. The nature of the study desired the engagement of field experts from varied geographical and professional backgrounds. However, on one hand, due to the experts' presence in different countries, it was expensive and non-climate-friendly to have all the experts gathered in one location. On the other hand, due to the outbreak of COVID-19 and the immense COVID restrictions, it was highly risky and challenging to gather all the experts in one place to get a consensus on the global agricultural competitiveness index indicators. Therefore, a Delphi Expert Survey provided the best alternative for conducting this study. The study purposely sought experts from the Academia, World Bank (WB), WEF and government organizations. The experts' panel was planned and manned in a meticulous way in order to guarantee multi-stakeholder involvement and also to increase the pillars' validity and reliability. The purposive sampling necessitated identifying and choosing experts who were competent and knowledgeable about climate change, competitiveness and agriculture (Palinkas et al., 2015). Hence, ten out of the twelve experts that were 83.33% of the total experts, engaged in the study, had a PhD degree. They were highly active researchers in the field of climate change, agriculture, competitiveness or any two of the three target areas. The study employed the Delphi method for exploring the expert

opinion regarding the potential indicators/selection of the indicators for the GACI about climate change. Delphi Method had the advantage that there was no consensus on the required number of participants (Roy et al., 2014) and therefore was more helpful during the COVID scenario. The Delphi Expert sample of the related studies ranged from 8 experts up to 30 experts and even above. Moreover, a literature review of Rowe and Wright (1999), provides the possible range of Delphi experts to be from 3–98. Therefore, we had the liberty to choose the number of experts according to our study objectives and needs. The statistical sample of the study included a total of 12 experts surveyed. A snowball sampling approach was adopted, based on Roy et al. (2014) criteria, in which three conditions were necessitated for expert selection. These were; i) Experts with a minimum of a decade's professional experience (ii) People who were at first hand involved in agricultural research, agricultural markets, climate change and competitiveness. Thirdly, people that were on board or consulted for a minimum of a consecutive ten years in agricultural/climate/competitiveness policy-making by the private or government sector. Lastly, the survey was disseminated through LinkedIn and professional email accounts.

3.3. Survey development

A three-item survey featured structured (n = 1) questions examining the suitability of pillars/nominations for agricultural competitiveness assessment and open-ended (n = 2) questions examining potential choices and suggestions for agricultural competitiveness indicators and climate change impact incorporation (Appendix A: Questionnaire).

A tick and cross selection were used to shortlist the pillars for GACI, where a tick indicated the suitability of the pillar for inclusion in GACI and a cross reflected the non-suitability of the pillar in GACI. Open-ended questions allowed the experts to expand on the use of the agricultural-specific pillar of GACI and the climate change impacts incorporation pillar of GACI. The survey was pretested with local experts.

The structured question was developed by the researcher based on a well-reputed globally published, peer-reviewed, and globally applicable Global Competitiveness Index of the World Economic Forum. Whereas the non-structured questions were based on the literature. Given the novelty of the GACI when the survey was undertaken, no such survey was available for the agriculture sector. However, the questionnaire was pilot-tested with 3 local experts to evaluate the scope, feasibility, and relevance of the questions and was approved by them. The survey was designed in English language and all the experts were able to comprehend and respond in the same. Therefore, no translations were done in any other language.

3.4. Data analysis

Qualitative software of 34r. Structured (tick and cross) responses were analysed using quantitative analysis (mean, frequency, and percentage of consensus). Qualitative free-text responses were carefully coded in QUIRKOS. Content analysis of the qualitative free-text responses identified convergent themes in QUIRKOS. The software has a specialty in generating visual themes, in the form of bubbles, from the qualitative free text data and provides bigger bubbles for convergent themes.

4. Results

There are different methods to analyse the Delphi Expert Survey (Beiderbeck et al., 2021). These methods include scenario analysis, sentiment analysis, dissent analysis, and descriptive analysis. Descriptive analysis; was used to analyse the current Delphi expert survey. STATA 17 was used to analyse the structured part of the survey, while QUIRKOS, and MS Excel, were used to analyse the non-structured part of the survey questionnaire.

4.1. Descriptive statistics

Out of 72 Delphi Expert Survey participants, only 12 completed the questionnaire due to time constraints or not responding to emails. The response rate was 17%, but this falls within the suggested range. The 12 experts were from various academic institutions/universities, global organizations, and government organizations, with one expert respondent from each organization except for WEF, which had two. Some experts; were unable to participate due to time constraints, while others did not respond to the survey request emails. Therefore, the response rate was not very high. However, this number of expert participants falls within the range suggested by the Delphi Survey literature. The expert respondents came from various academic institutions/universities, global organizations, and government organizations such as The Agriculture University of Peshawar, The University of Agriculture Multan, Comsat University Vehari Islamabad, the University of Swat, East West University of Bangladesh, Hunan University of Science and Technology, China, The University of Sydney, World Bank, World Economic Forum, Centre for Agro-food Economics and Development, and Competition Commission of Pakistan. The descriptive statistics for the Delphi Survey datasets are usually bifurcated into quantitative and qualitative analyses.

4.2. Quantitative analysis in Delphi

When analysing Delphi datasets, the most commonly used tools for quantitative analysis are mean, mode, percentages, interquartile range, and standard deviation (Zartha Sossa et al., 2019). These same tools were utilized; in the initial section analysis of the current Delphi survey (**Table 1**). To analyse the structured part; quantitatively, we calculated the arithmetic mean, frequency, and percentages of consensus among experts. Additionally, we visually assessed histograms to gain insight into the consensus among experts. This section determines; whether to include or exclude the GCI's twelve pillars in the GACI.

Table 1. Delphi expert survey pillar response.

Pillar No	Pillar Name	Respondent 1	Respondent 2	Respondent 3	Respondent 4	Respondent 5	Respondent 6	Respondent 7	Respondent 8	Respondent 9	Respondent 10	Respondent 11	Respondent 12
1	Institutions	✔	✔	✔	✔	✔	✔	✔	✔	X	✔	✔	✔
2	Infrastructure	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
3	ICT Adoption	X	✔	✔	X	✔	X	✔	✔	X	✔	✔	✔
4	Macroeconomic Stability	✔	✔	X	✔	✔	✔	X	✔	✔	✔	✔	✔
5	Health	✔	✔	X	✔	✔	X	X	✔	✔	✔	✔	✔
6	Skills	✔	✔	✔	X	✔	✔	✔	✔	✔	✔	✔	✔
7	Product Market	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
8	Labour Market	X	✔	✔	✔	✔	✔	X	✔	✔	✔	✔	✔
9	Financial System	✔	✔	✔	✔	✔	✔	✔	✔	X	✔	✔	✔
10	Market Size	X	✔	X	X	✔	✔	X	✔	✔	✔	✔	✔
11	Business Dynamism	✔	✔	X	X	✔	✔	X	✔	✔	✔	✔	✔
12	Innovation Capability	✔	✔	X	✔	✔	✔	X	✔	✔	✔	✔	✔

A survey of twelve experts; from around the world; found that all twelve pillars of the GCI are vital for assessing global agricultural competitiveness, but their suitability for inclusion in the GACI varies. The survey had two sections, with the first focusing on experts' opinions about the usefulness of each pillar towards the GACI.

Overall, the survey results show that the majority of experts consider all twelve pillars to be vital for the assessment; of global agricultural competitiveness, with varying; levels of suitability for inclusion in GACI (**Table 2**).

Table 2. Delphi expert survey pillar response results.

Pillar No	Pillar Name	Frequency	Percentage
1	Institutions	11	91.67
2	Infrastructure	12	100
3	ICT Adoption	8	66.67
4	Macroeconomic Stability	10	83.33
5	Health	9	75
6	Skills	11	91.67
7	Product Market	12	100
8	Labour Market	10	83.33
9	Financial System	11	91.67
10	Market Size	8	66.67
11	Business Dynamism	9	75
12	Innovation Capability	10	83.33

Note: The frequency and percentages are shown for the "Yes" option.

Experts agree that institutions (92%), infrastructure (100), ICT adoption (67%), macroeconomic stability (83%), and skills (92%) are necessary for inclusion in the GACI. Health and ICT adoption are also deemed suitable. Further, experts also agreed on including the product market (100%), labour market (83%), financial system (92%), market size (67%), business dynamism (75%), and innovation capability (83%) pillars in the GACI. The financial system and innovation capability pillars were deemed vital by 92% and 83% of experts, respectively. All pillars meet the criteria for inclusion in GACI. The yes response frequency is consistently above 50%. Each has a yes response rate higher than 66%, meeting the necessary criteria.

4.3. Qualitative analysis in Delphi

Qualitative analysis is usually focused on expert opinions/viewpoints and comments on the issue. In most cases, it can be very insightful, especially with respect to the Delphi questions' mutual interactions and relationships; and therefore, should not be ignored (Beiderbeck et al., 2021). The questions asked in sections A and B were provided with three possible choices and a fourth choice was left open for the expert suggestions. Content analysis is among the most commonly used and highly recommended methods for qualitative analysis in Delphi datasets. Therefore, the qualitative analysis was carried out by making use of the content analysis. The content analysis was done by using a qualitative data analysis software, named as QUIRKOS.

1) Agricultural Performance Positioning.

In the qualitative section, the first question revolved around the agricultural sector competitiveness. Participants were given four options, each with a tick or cross if they supported or rejected the choice. The first option asked if the agricultural sector competitiveness should be a 13th pillar in the GACI. The second option inquired about replacing the Business Dynamism in the GCI with the agricultural sector competitiveness pillar. The third option was to incorporate agricultural competitiveness into the business dynamism pillar. Finally, the fourth open-ended question requested suggestions from the experts regarding finding agricultural sector competitiveness while using the pillars from the GCI of the WEF. It's worth noting that a detailed literature search conducted by Zia et al. (2022) had already found that the GCI is the most comprehensive measure to determine country competitiveness positions and comparisons. Delphi expert survey aimed to ascertain the relevance of GCI pillars in constructing GACI. The survey also guided the positioning of agricultural-specific measures of competitiveness and the impact of climate change on competitiveness in the GACI. Seven experts chose to add a separate 13th pillar of agricultural competitiveness, which received the highest response rate (**Table 3**). Therefore, we designed the 13th pillar. Option (iv) allowed experts to add their suggestions, either in combination with one of the first three choices or alone. Only one expert did not select an option from the first three choices and provided suggestions only (**Table 3**).

Table 3. Agricultural performance positioning results.

Questions	Frequency	Percent of responses	Percent of cases
i.	7	46.67	58.33
ii.	3	20	25
iii.	1	6.67	8.33
iv.	4	26.67	33.33
Total	15	100	125

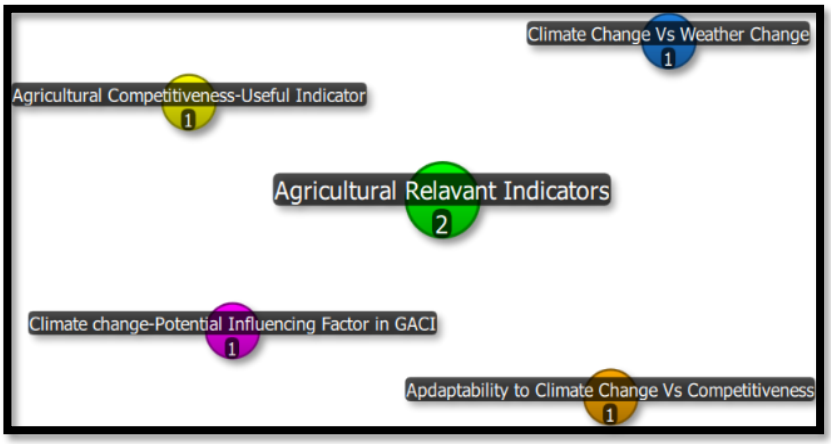

Figure 2. Agricultural performance positioning coding map.

In order to analyse part iv, a content analysis was used. Content analysis is among the most commonly used and highly recommended methods for qualitative analysis in Delphi datasets. Therefore, the qualitative analysis was carried out by making use of

the content analysis. This software has a specialty of generating visual themes from/out of the qualitative text data, that help in understanding the survey findings easily. The codes and themes emerge as bubbles, with the dominant themes emerging as bubbles with bigger sizes (**Figure 2**). To analyse the content, careful coding was done. Coded themes, their description and coding coverage identified in the content analysis are summarized in **Table 4**.

Table 4. Agricultural performance positioning code themes and description.

No	Codes	Description
1	Agricultural Relevant Indicators	Agricultural-specific factors should be focused on (along the others). While calculating the GACI, the cross-cutting pillars should be kept as they are, but the pillars more relevant to agriculture should be kept in more depth.
2	Adaptability to Climate Change vs. Competitiveness	Competitiveness needs to be considered in contrast with the adaptability to climate change.
3	Climate Change vs. Weather Change	The climate change and the index duration must also be matched. The index may be more sensitive to weather changes instead of long-term climatic changes.
4	Climate Change-Potential Influencing Factor in GACI	Climate change is the potential influential factor of variation in the GACI. It should not be included as a component of this index.
5	Agricultural Competitiveness-Useful Indicator	Agricultural competitiveness can be a useful indicator along with environment-related factors such as changes in temperature, level of precipitation and availability of water, etc.

An important suggestion was to include the agricultural relevant indicators in detail within the pillars. However, this was not possible due to the data deficiency in the agriculture sector. Overall, the suggestions provided very good future directions for the research. However, only four experts provided the suggestions and the consensus level is not very high to contribute towards the global agricultural competitiveness index construction.

2) Climate change impact positioning.

The main question asked in the second section is regarding the climate change impact positioning in the GACI. The pattern is the same as was for section A, with four tick/cross choices. The first choice has asked about the inclusion of climate change impact as a separate 14th pillar in GACI. The second choice inquired about the replacement of indicator 1.26 (Pillar 1) of GCI used in GACI construction; with the climate change impact upon agriculture. The third choice sought to find about the possibility of inclusion of the climate change impact on agriculture, in indicator 1.26 (Pillar 1) of the GCI used in GACI construction. While the final question provided an open space to the expert for providing suggestions regarding the positioning of the climate change impact in the GACI. The frequencies, percent of responses and percent of cases were calculated for the section responses (**Table 5**). The frequencies show that seven experts opted for the first option of adding a separate 14th pillar of climate change while GACI construction. The percent of responses and the percent of cases is also highest for the first choice of adding a 14th pillar of climate change. Therefore a 14th pillar of climate change impact was designed. However, the frequency for option iv is also the same as that for the first option. However, due to the difference in opinions and suggestions, they are not capable of being directly incorporated in the GACI construction. However, they provide significant future directions to the research.

Table 5. Climate change impact positioning results.

Questions	Frequency	Percent of Responses	Percent of Cases
i	7	43.75	58.33
ii	2	12.5	16.67
iii	0	0	0
iv	7	43.75	58.33
Total	16	100	133.33
Valid cases	12		
Missing cases	0		

A qualitative content analysis is used for analyzing option iv. The QUIRKOS software is used (**Figure 3**). The coding themes, descriptions and coding coverage are provided in **Table 6**.

Table 6. Section B code themes and description.

No	Coding Theme	Description
1	Agriculture Sustainability Indicators	GACI Potential Indicators: It is also better to focus more on the agriculture sustainability indicators for including in the GC
2	Water	Water (water overuse) is currently the most significant determinant of agricultural competitiveness. It would be better to include the water variables in the construction of this index.
3	Climate Change: A Composite Measure	The climate change by itself is a mixture of too many variables.
4	Climate Change: A Significant Indicator of GACI	It is very important to consider climate change in competitiveness and will be a very important dimension of competitiveness in the future For the construction of a Global Agricultural Competitiveness Index, climate change could be a useful indicator
5	Pesticide Use	Pesticide use can be a component of the ad hoc pillar of climate change
6	Chemical Pollution	Chemical Pollution from agriculture, industry, etc., can be a component of the ad hoc pillar of climate change
7	CO_2 Emission	CO_2 emission from agriculture, industry, etc., can be a Component of ad hoc pillar
8	Capacity to Adapt	Use the capacity to adapt to measure climate change.
9	Climate change impact	Use the climate change impact to measure the climate change.
10	Climate change: An overlapping indicator	Climate change is a cross-cutting factor that intersects with all other indicators, rather than an independent indicator on its own.
11	Climate Change Impact Agriculture & Industry	Climate change will impact both agriculture and industry, not just agriculture.
12	Disaster	Instead of looking at agriculture alone, if we look at agriculture and industry both, then disaster will be a good measure of climate change.
13	Separate Climate Change & Competitiveness	Climate change and competitiveness are separate issues.
14	Ad hoc Pillar of Climate Change	An ad hoc pillar with indicators about the use of pesticides, water overuse, chemical pollution, CO_2 emission from agriculture, industry, etc., (Sector-wise) should be created.

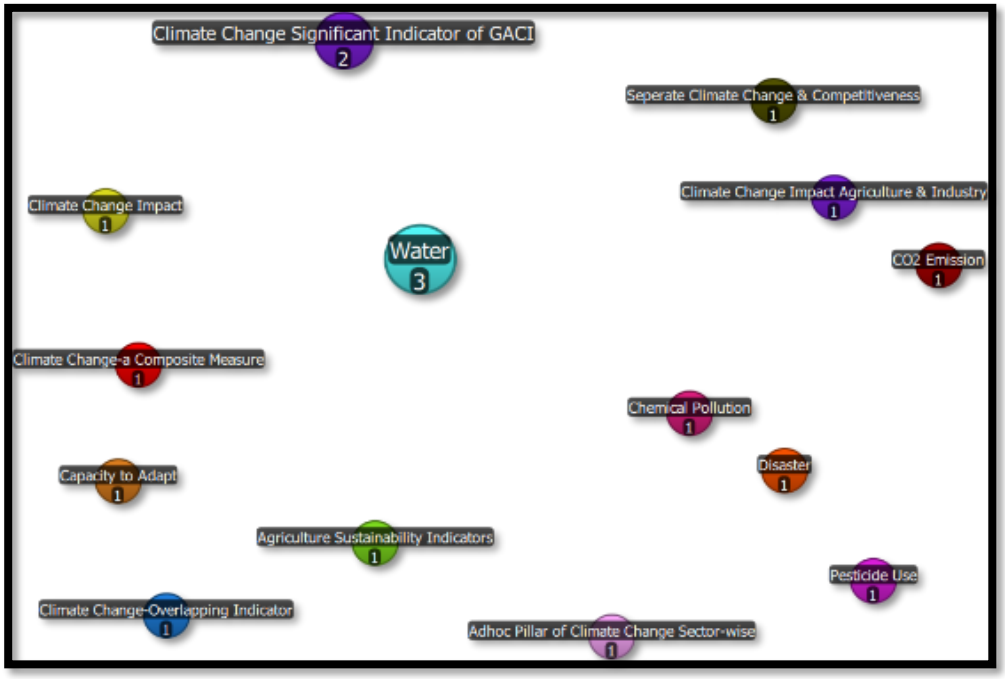

Figure 3. Climate change impact positioning coding map.

4) Global Agricultural Competitiveness Index (GACI) Framework.

The above methodology results in the construction of a GACI framework. The GACI consists of a total of fourteen pillars. The first twelve pillars are used from the already developed GCI of the WEF. These twelve pillars are used with the belief that all these pillars are equally applicable to the agricultural sector markets, like any other sector of the economy. Moreover, the use of these twelve pillars in the GACI is backed up by a Delphi Expert survey, which was conducted globally. Whereas, the thirteenth and fourteenth pillars are added up as a result of a systematic literature review and a Delphi Expert Survey conducted globally. The systematic literature review provided the constructs for the thirteenth and fourteenth pillars while the Delphi Expert survey approved the inclusion of these pillars with some suggestions for the future direction of the study.

The Global Agricultural Competitiveness Index comprises fourteen pillars (**Figure 4**). The first twelve pillars are acquired from the Global Competitiveness Index of the World Economic Forum, with support from a Delphi Expert survey. Whereas, the thirteenth and fourteenth pillars are constructed on the basis of the literature.

To ensure the reliability and validity of the survey findings, effective management of data biases and outliers in an expert survey involves several crucial steps. The pre-survey planning of the study included designing the survey tool meticulously, selecting experts, and setting clear criteria for data collection. We rigorously selected experts based on their unparalleled expertise, extensive experience, and diverse perspectives to eliminate bias. We carefully monitored the responses for potential biases or outliers throughout the data collection process. The collected data underwent a thorough review to identify and address any biases or outliers. This process included removing duplicate entries, correcting errors, and excluding outliers.

Appropriate statistical techniques, such as descriptive statistics and content analysis, were used to analyse the survey data, considering identified biases or outliers.

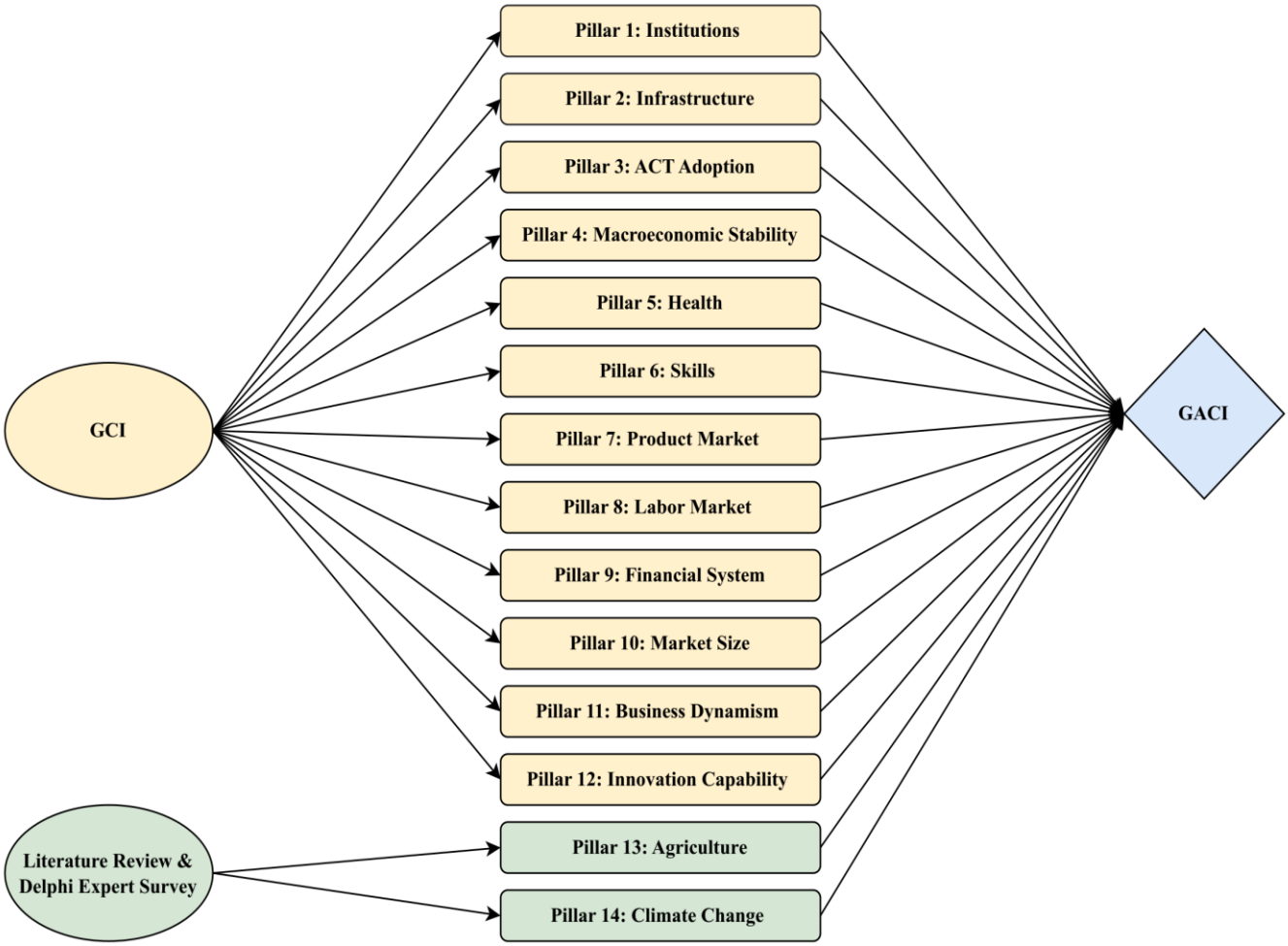

Figure 4. Framework of Global Agricultural Competitiveness Index (GACI) developed.

5. Discussion

5.1. Institutions

The first pillar of Institutions is of immense significance in all sectors of the economy, including agriculture. It plays a pivotal role in strengthening national agricultural competitiveness by providing the required framework, policies, and regulations (Gitz et al., 2015). According to the survey experts, the institution's pillar with all sub-indicators of this pillar is crucial for the agriculture sector, including social capital, security, checks and balances, public sector performance, transparency, property rights, corporate governance, and the future orientation of governments. A Delphi expert has proposed an additional sub-indicator, "regulation of agriculture," but the unavailability of data for this indicator is acknowledged. Some core agricultural institutions considered imperative for agricultural competitiveness are government agencies, agricultural extension services, research organizations, and trade associations (Gitz et al., 2015).

5.2. Infrastructure

Experts consider the infrastructure pillar, which is the second pillar, to be equally important in the field of agriculture (Calzadilla et al., 2013). It plays a crucial role in boosting national agricultural competitiveness by providing necessary support and facilities for Agri-specific products (Bojnec and Ferto, 2017) and activities, increasing productivity, lowering costs, and enabling efficient movement of agrarian products (Babu and Shishodia, 2017). Transportation, irrigation (Ren et al., 2022), storage, and cold chain infrastructure are critical for agriculture (Babu and Shishodia, 2017).

5.3. ICT adoption

The information and communication technology (ICT) adoption in the agriculture sector is crucial to bolster national agricultural competitiveness. ICT tools and applications available today can help farmers access real-time information and improve their decision-making, productivity, and ability to connect with markets (Neglo et al., 2021). In particular, Agri-specific indicators such as access to market information (Qiang et al., 2011), agricultural extension services (Kariuki et al., 2019), weather monitoring and early warning systems (Kassie et al., 2017), financial services (Aker and Mbiti, 2010), and supply chain management (Fetai et al., 2016) can be highly relevant in this regard (Neglo et al., 2021; Nugroho et al.,2021). Additionally, a recent study by the Food and Agriculture Organization (FAO) in 2019 highlighted the potential of blockchain technology in enhancing agricultural competitiveness and sustainability (FAO, 2019). Blockchain technology has the potential to revolutionize the agricultural sector by enhancing competitiveness and sustainability. It can create transparent and secure supply chains, enable traceability and accountability, prevent fraud, reduce food waste, ensure authenticity and quality of agricultural products, streamline transactions, reduce paperwork, improve efficiency, automate agreements, track environmental impact data, and promote sustainable practices. Overall, it can enhance competitiveness and sustainability in agriculture by improving transparency, efficiency, and accountability throughout the supply chain.

5.4. Macroeconomic stability

The stability of macroeconomic conditions plays a crucial role in boosting national agricultural competitiveness. Access to credit, sound fiscal policies, controlled inflation, stable exchange rates, and a favourable investment climate are essential factors that contribute to stable macroeconomic conditions (Abbas, 2022; Resnick et al., 2020). Agricultural enterprises face several risks in the product market, including price volatility, market uncertainties, and fluctuations in commodity prices and exchange rates (Abbas, 2022; Kargbo, 2006; Sarker and Ratnasena, 2014). However, skilled agribusiness managers and farmers can manage these risks using risk management strategies like diversification, hedging, and forward contracting. Market risk management not only ensures the profitability of agricultural enterprises but also enhances their competitiveness. Therefore, agribusiness managers and farmers must adopt effective risk management strategies to ensure the success of their agricultural enterprises (Duong et al., 2019).

5.5. Health

Healthy labour is essential for a productive economy. Women in developing countries are more susceptible to diseases, which affects the agriculture sector as they perform most of the farm work. Reduced labour supply, higher healthcare costs, and declining assets are outcomes. Prioritizing healthcare for the agricultural workforce is crucial for long-term growth, social well-being, and competitiveness (Babu, 2017; Ruel, 2006).

5.6. Skills

Skills are integral to the agricultural sector, ensuring its efficiency, productivity, and competitiveness in domestic and international markets. They include knowledge of precision farming, the use of digital tools, data analysis, and implementation of sustainable farming techniques. Skilled farmers can make informed decisions and optimize resource allocation, thus improving productivity and competitiveness. Skillful farmers can optimize resource allocation, leading to improved productivity. Innovative techniques and products developed by skilled researchers enable farmers to remain competitive (Cosby et al., 2022). Adept professionals in logistics, marketing, and quality assurance lead to efficient value chain management and contribute to overall competitiveness (Manning et al., 2022). Skilled entrepreneurs, marketers, agribusiness managers, and market intelligence systems provide farmers with up-to-date information on market trends, prices, and consumer preferences, enabling them to align their production and marketing strategies with market demands (Cosby et al., 2022). Skilled farmers can implement sustainable practices such as organic farming, agroforestry, water management, and integrated pest management, which reduce production costs and appeal to consumers seeking sustainable agricultural products (Sørensen et al., 2021).

5.7. Product market

In today's global economy, a nation's agricultural competitiveness is paramount to its economic growth and prosperity. The key to achieving this success is a robust product market. A vibrant product market provides farmers access to diverse buyers who can offer competitive prices (Nugroho, 2021), thus incentivizing them to increase production and improve the quality of their products. Furthermore, a competitive market creates opportunities for innovation and adoption of new technologies, which ultimately leads to enhanced efficiency and cost savings. In light of this, it is evident that a thriving product market is indispensable to realizing the full potential of the agricultural sector and ensuring long-term sustainability and prosperity. It encompasses domestic and international markets where agricultural products are sold and bought. There are several critical factors that farmers must consider to achieve competitiveness. These factors include market access and trade, consumer preferences and demand, market information, price volatility and market risk, and value addition and differentiation. Farmers must adapt to changing consumer demands, market trends, and preferences (FAO, 2018; Nugroho, 2021). Hence, it is crucial to have a sound understanding of these factors. For agricultural competitiveness, access to both domestic and international markets is imperative. The ability of farmers to reach

consumers and compete with other producers depends on efficient supply chains, trade agreements, and market access policies. The marketing, logistics, and international trade professionals along with the regulatory bodies are vital in facilitating market access and ensuring regulatory compliance. By doing so, farmers can compete effectively and emerge as winners in the market (Borsellino et al., 2020).

5.8. Labour market

The labour market plays a pivotal role in enhancing the national agricultural competitiveness. It is the marketplace where the supply and demand of agrarian labour meet. The skilled workforce, labour availability, and flexibility, labour costs and efficiency, labour regulations and policies, and labour migration and agricultural workforce are the key aspects that have a substantial impact on the agriculture-specific labour market (Tocco and Davidova, 2012).

5.9. Financial system

Access to affordable and timely financing is essential for agriculture to maintain its competitiveness in the market. The financial setup comprising banks, microfinance institutions, and agricultural credit programs is significant in providing access to capital and funding agrarian investment. By offering risk management tools like insurance, derivatives, and hedging mechanisms, the financial system helps mitigate risks faced by agriculture and banks, such as price and weather volatility. These tools reduce uncertainty, protect against losses, and enable farms and agribusinesses to maintain competitiveness. (Lorant and Farkas, 2015; The International Bank for Reconstruction and Development, 2005). Microfinance institutions and agricultural credit programs provide access to capital and support investment. In addition, innovative financial products such as index insurance, warehouse receipt financing, and contract farming can boost competitiveness. These products lower costs, improve access to finance and enhance market integration (International Finance Corporation, 2014; The International Bank for Reconstruction and Development, 2005). Investment in agricultural financial literacy, education, and research and development (R&D) can also contribute significantly to measuring and enhancing agrarian competitiveness. Therefore, it is crucial to continue investing in these areas (Heisey and Paul, 2018; Nin-Pratt and Stads, 2023; World Bank, 2012). Thus, an indispensable and constructive role in enhancing national agricultural market competitiveness belongs to the financial institutions. By providing farmers and agribusinesses with access to capital, risk management tools, and financial services indispensable for investment, growth, innovation, and thus competitiveness, the financial system helps build a more sustainable and prosperous agricultural sector.

5.10. Market size

Recognizing the significance of market size in enhancing the competitiveness of national agricultural markets is crucial (Babu and Shishodia, 2017; Casaburi and Reed, 2017). Market size denotes the overall demand and supply for Agri-specific products in a particular market, whether it is domestic or international, and has a profound impact on various aspects of agricultural market competitiveness (Borsellino et al.,

2020). These aspects include economies of scale, diversification, specialization, increased market opportunities, expansion, market integration, investment, and innovation (Emran and Shilpi, 2012). A larger market size results in greater competitiveness in the agricultural market (Melitz and Ottaviano, 2008).

5.11. Business dynamism

Business dynamism refers to the ability of agricultural businesses to innovate, adapt, and respond to changing market conditions. It promotes the adoption of new technologies and encourages entrepreneurship and market orientation (Chen et al., 2016; FAO, 2017b). It also facilitates business expansion and diversification (Ahmed et al., 2021), as well as efficient supply chain management through collaboration (Chen et al., 2016). Lastly, it emphasizes the importance of knowledge sharing and networking to foster growth and development in the agricultural industry (Clark, 2009; FAO, 2019).

5.12. Innovation capability

Innovation is critical for a country's agricultural sector. It refers to developing and adopting new technologies, techniques, and practices that significantly increase yields, reduce costs, and improve efficiency. It is necessary to ensure food security and mitigate the impact of climate change. Sustainable agriculture practices, innovative solutions, and technology can create employment opportunities, improve farmers' income, reduce rural-urban migration, and bring diversity to agrarian markets. By continuously improving agricultural practices, countries can produce high-quality products at competitive prices, enabling them to capture a larger share of the international market and increase agricultural exports (OECD, 2013).

5.13. Agriculture (performance)

Assessing the performance and efficiency of agricultural systems is crucial to measuring their competitiveness (Bachev and Koteva, 2021; FAO, 2017; Latruffe, 2010). It is essential to use several indicators to gain insights into various aspects of agricultural production, trade, sustainability, and adaptability (Bachev and Koteva, 2021). Commonly used indicators for assessing agricultural competitiveness are total factor productivity, export competitiveness, trade balance in agriculture, agricultural value added, environmental sustainability, and climate change adaptability. TFP reflects the overall productivity and technological progress. It measures the efficiency with which inputs (land, labour, and capital) transform into outputs. Export Competitiveness examines a country's ability to compete in international markets by assessing its share in global agricultural exports, export prices, and market access conditions. Trade Balance in agriculture measures the difference between a country's agricultural exports and imports. A positive trade balance indicates competitiveness in the global market (Latruffe, 2010).

5.14. Climate change (impact)

Climate change has a significant impact on agricultural competitiveness. Extreme weather conditions such as droughts, floods, and heat waves are causing reduced crop

yields, loss of livestock, and increased production costs (IPCC, 2014; IPCC, 2020; FAO, 2021). The unpredictability of weather conditions poses a substantial challenge for farmers, making difficult the planning and management of agricultural activities. This uncertainty disrupts supply chains, leading to price fluctuations and decreased market competitiveness (Chauhan and Debnath, 2018; Sazvar et al., 2018). Climate change also has a significant impact on water resources, which are vital for agriculture (Hatfield and Takle, 2014). Irregular precipitation and evaporation patterns lead to reduced crop productivity and water scarcity. Furthermore, pests and diseases that harm crops and livestock are affected by climate change (Hallegatte et al., 2016). Warmer temperatures and altered rainfall patterns can result in increased crop losses and the need for additional pest control measures (Zovko and Paja˘, 2021). To compete with climate change, farmers must adopt sustainable practices, including precision farming and water-efficient irrigation systems (FAO, 2020). Diversifying crops and investing in climate-resilient varieties can also help mitigate the effects on agricultural market competitiveness (Birthal and Hazrana, 2019; Mortensen and Smith, 2020; Waha et al., 2018). To keep the agrarian markets competitive, proactive measures for long-term sustainability are required in the face of climate change impacts on agriculture (Darjee and Neupane, 2023; Hallegatte et al.,2020). Extreme weather conditions can disrupt production processes, decrease market competitiveness, and shifting crop-growing areas can disrupt supply chains (Gitz et al., 2015). Therefore, it is essential to monitor the climate change impact on agricultural competitiveness and then to implement sustainable practices and adapt to the changing climate to ensure the long-term viability of agricultural production systems.

6. Conclusion

6.1. Main findings

The agriculture sector is crucial in today's world and has the potential to overcome the current crisis. To evaluate the state of the nation's economy and agricultural sector it's essential to measure the competitiveness of this sector. A comprehensive and diverse set of pillars contribute to the success and competitiveness of agriculture. Therefore, constructing a global agricultural competitiveness index is necessary to monitor, judge, and enhance this sector's performance. By comparing countries' agriculture sectors using a uniform benchmark, each country can identify which pillar(s) they fall behind and find ways to improve. Although data deficiency is a concern, efforts are underway to make agricultural data available. The Delphi expert survey has provided valuable insights into constructing the GACI. The study has identified all twelve pillars of the GCI as relevant to GACI and proposed a framework based on a systematic literature review. The study has also suggested agriculture-specific measures of competitiveness in each pillar based on literature and expert opinions.

Although there is a shortage of data, the study's findings provide a direction for future research to collect and incorporate the necessary data into the GACI framework. The study's results will aid policymakers, researchers, and stakeholders in improving agricultural competitiveness worldwide.

6.2. Future implications

Policy guidance and benchmarking: The GACI will serve as a benchmarking tool that will help policymakers assess their country's agricultural competitiveness relative to other nations. It will provide valuable insights into the strengths and weaknesses of the agricultural sector, enabling policymakers to formulate evidence-based policies and strategies for improvement.

Investment attraction and trade promotion: A higher ranking in the GACI will indicate a country's ability to compete in global agricultural markets. This can attract foreign direct investment, stimulate export growth, and enhance trade opportunities. Policymakers can leverage the index to identify areas where investment and trade promotion efforts should be focused.

Economic growth and job creation: A competitive agricultural sector will contribute to overall economic growth and job creation, particularly in rural areas. For improving competitiveness countries can enhance productivity, increase agricultural output, and generate employment opportunities.

Sustainable development and resource management: The GACI considers the sustainability aspect, such as climate change impact. By incorporating sustainability into competitiveness assessments, the index encourages countries to adopt environmentally friendly and resource-efficient agricultural practices, contributing to long-term sustainability.

Knowledge sharing and learning: The GACI facilitates knowledge sharing and learning among countries by highlighting best practices and successful strategies. It will allow policymakers to identify countries with high competitiveness and learn from their experiences, fostering international collaboration and knowledge exchange.

6.3. Future direction

The GACI can adapt to future challenges in global agriculture by incorporating new indicators, methodologies, and data sources that reflect emerging trends and priorities in the agricultural sector. To tackle future challenges such as anthropogenic climate change, resource scarcity, and technological advancements, the GACI should consider integrating sustainability metrics, incorporating digital technologies, focusing on resilience and adaptation, and collaborating while sharing knowledge.

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Appendix A: Questionnaire

Name: _____

(Your name will be kept confidential)

Delphi study on construction of a global agricultural competitiveness index while incorporating the phenomenon of climate change

Round I

Over the past few years, climate change (especially with respect to the perennial changes in average temperature and normal precipitation levels) has become recognized as an incremental factor alongside traditional pressures, remarkably impacting agricultural productivity, yields, costs, revenues, etc. These climate variations exert extra pressure on the agricultural sector by causing productivity and costs to change unprecedently. Such changes in agricultural inputs and outputs directly impact the prices and market share of crops in different ways. As a result, the market competitiveness of the country's agricultural sector can be enhanced or reduced. However, an improvement in the competitiveness of the agricultural sector due to better anticipation and adaptation to climate change can empower the masses engaged in agriculture, improve the country's food security, and flourish the agricultural sector nationally as well as internationally. This can not only improve the competitive position of a country globally but also enable the country to fully exploit its potential natural resources. A decline in agricultural competitiveness will lead to reverse outcomes.

A number of indicators, such as productivity, yield, revenues, and costs, are used for measuring agricultural competitiveness. There are also some indices used, such as the Balassa Index, which mainly target the trade aspects of competitiveness. However, there is a deficiency of a comprehensive global agricultural market competitiveness index where the most important factor of climate change is also given due consideration. Therefore, the current study aims to develop a comprehensive global agricultural competitiveness index that incorporates climate change as an indicator/factor/contributor. In addition, for the same we need your response in the given survey.

I. The global competitiveness index

The global competitiveness index (GCI) is a comprehensive competitiveness measure comprising 4 broad categories (Enabling Environment, Human Capital, Markets, Innovation Ecosystem) based on 12 pillars. The pillars include Institutions, Infrastructure, ICT Adoption, Macroeconomic Stability, Health, Skills, Product Market, Labour Market, Financial System, Market Size, Business Dynamism, and Innovation Capability. Each of the 12 pillars is a subindex and is composed of multiple indicators. The indicators are aggregated to construct the subindex, which is further aggregated to construct each pillar, and finally, the pillars are aggregated for the construction of the GCI. A simple arithmetic mean with equal weights is used during the aggregations.

Framework of the global competitiveness index:

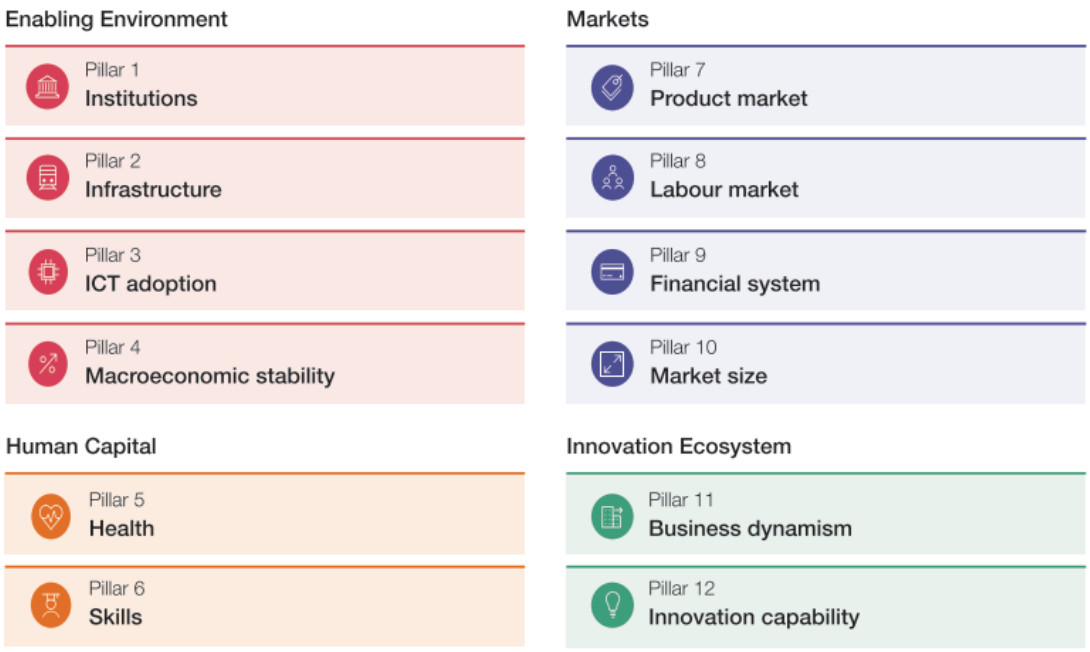

Figure A1. Framework of the global competitiveness index.

II. Possibilities for construction of a comprehensive global agricultural competitiveness index (GACI) while incorporating climate change

Q. Which indicators of the Global Competitiveness Index do you consider appropriate for inclusion in the Global Agricultural Competitiveness Index (GACI)? (Each pillar detail is provided in the Appendix B)

Pillars		**✔/X**
Enabling Environment (not used in calculation)		
Pillar 1	Institutions	
Pillar 2	Infrastructure	
Pillar 3	ICT Adoption	
Pillar 4	Macroeconomic Stability	
Human Capital (not used in calculation)		
Pillar 5	Health	
Pillar 6	Skills	
Markets (not used in calculation)		
Pillar 7	Product Market	
Pillar 8	Labour Market	
Pillar 9	Financial System	
Pillar 10	Market Size	
Innovation Ecosystem (not used in calculation)		
Pillar 11	Business Dynamism	
Pillar 12	Innovation Capability	

Section A

Q. Which choice do you consider appropriate to be included in a comprehensive global agricultural competitiveness index? (✔ or X)

i. Should agricultural sector competitiveness/dynamism be added to the GCI as a new, separate, 13th pillar? ( )

ii. Should agricultural sector competitiveness/dynamism be added as a replacement for the Pillar 11 (Business Dynamism) of the GCI? ( )

iii. Should agricultural sector competitiveness/dynamism be added to the already existing Pillar 11 (Business Dynamism) of the GCI? ( )

iv. Give your suggestions for incorporating the agricultural dynamism/competitiveness variable/indicator/pillar in the GCI for the construction of the Global Agricultural Competitiveness Index with climate change as a factor/indicator. ( )

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Section B

Q. Which choice do you consider appropriate to be included in a comprehensive global agricultural competitiveness index? (✔ or X)

i. Should climate change be added to the index as a new, separate, 14th pillar in the GCI? ( )

ii. Should climate change be added as a replacement for indicator 1.26 (environment-related treaties in force given in the appendix) in Pillar 1 of the GCI? ( )

iii. Should climate change be added to the existing indicator 1.26 (environment-related treaties in force given in the appendix) in Pillar 1 of the GCI? ( )

iv. Give your suggestions for incorporation of the climate change variable in the GCI for construction of the Global Agricultural competitiveness Index with Climate Change as a factor/indicator. ( )

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Note: We base our study on the GCI definition of competitiveness.

Note: Climate change will be measured using temperature and precipitation.

Appendix B

Enabling Environment (not used in calculation)		
PILLAR 1 Institutions	A. Security	1.01 Organized crime 1.02 Homicide rate 1.03 Terrorism incidence 1.04 Reliability of police services
	B. Social Capital	1.05 Social capital
	C. Checks & Balances	1.06 Budget transparency 1.07 Judicial independence 1.08 Efficiency of legal framework in challenging regulations 1.09 Freedom of the press
	D. Public Sector Performance	1.10 Burden of government regulation 1.11 Efficiency of legal framework in settling disputes 1.12 E-Participation
	E. Transparency	1.13 Incidence of corruption
	F. Property Rights	1.14 Property rights 1.15 Intellectual property protection 1.16 Quality of land administration
	G. Corporate Governance	1.17 Strength of auditing and accounting standards 1.18 Conflict of interest regulation 1.19 Shareholder governance
	H. Future Orientation of the Governments	I. Government adaptability 1.20 Government ensuring policy stability 1.21 Government's responsiveness to change 1.22 Legal framework's adaptability to digital business models 1.23 Government long-term vision II. Commitment to sustainability 1.24 Energy efficiency regulation 1.25 Renewable energy regulation 1.26 Environment-related treaties in force
PILLAR 2 Infrastructure	A. Transport Infrastructure	I. Road 2.01 Road connectivity 2.02 Quality of road infrastructure II. Railroad 2.03 Railroad density 2.04 Efficiency of train services III. Air 2.05 Airport connectivity 2.06 Efficiency of air transport services IV. Sea 2.07 Liner shipping connectivity3 2.08 Efficiency of seaport services
	B. Utility Infrastructure	I. Electricity 2.09 Electricity access 2.10 Electricity supply quality II. Water 2.11 Exposure to unsafe drinking water 2.12 Reliability of water supply
PILLAR 3 ICT Adoption		3.01 Mobile-cellular telephone subscriptions 3.02 Mobile-broadband subscriptions 3.03 Fixed-broadband internet subscriptions 3.04 Fiber internet subscriptions 3.05 Internet users
PILLAR 4 Macroeconomic Stability		4.01 Inflation 4.02 Debt dynamics

Human Capital (not used in calculation)		
PILLAR 5 Health		5.01 Healthy life expectancy
PILLAR 6 Skills	A. Current Workforce	I. Education of current workforce 6.01 Mean years of schooling II. Skills of current workforce 6.02 Extent of staff training 6.03 Quality of vocational training 6.04 Skillset of graduates 6.05 Digital skills among active population 6.06 Ease of finding skilled employees
	B. Future Workforce	I. Education of future workforce 6.07 School life expectancy II. Skills of future workforce 6.08 Critical thinking in teaching 6.09 Pupil-to-teacher ratio in primary education
Markets (not used in calculation)		
PILLAR 7 Product Market	A. Domestic Market Competition	7.01 Distortive effect of taxes and subsidies on competition 7.02 Extent of market dominance 7.03 Competition in services
	B. Trade Openness	7.04 Prevalence of nontariff barriers 7.05 Trade tariffs 7.06 Complexity of tariffs 7.07 Border clearance efficiency
PILLAR 8 Labour Market	A. Flexibility	8.01 Redundancy costs 8.02 Hiring and firing practices 8.03 Cooperation in labour-employer relations 8.04 Flexibility of wage determination 8.05 Active labour market policies 8.06 Workers' rights 8.07 Ease of hiring foreign labour 8.08 Internal labour mobility
	B. Meritocracy and Incentivization	8.09 Reliance on professional management 8.10 Pay and productivity 8.11 Ratio of wage and salaried female workers to male workers 8.12 Labour tax rate
PILLAR 9 Financial System	A. Depth	9.01 Domestic credit to private sector 9.02 Financing of SMEs 9.03 Venture capital availability 9.04 Market capitalization 9.05 Insurance premium
	B. Stability	9.06 Soundness of banks 9.07 nonperforming loans 9.08 Credit gap 9.09 Banks' regulatory capital ratio
PILLAR 10 Market Size		10.01 Gross domestic product 10.02 Imports of goods and services

Innovation Ecosystem (not used in calculation)		
PILLAR 11 Business Dynamism	A. Administrative Requirements	11.01 Cost of starting a business 11.02 Time to start a business 11.03 Insolvency recovery rate 11.04 Insolvency regulatory framework
	B. Entrepreneurial culture	11.05 Attitudes toward entrepreneurial risk 11.06 Willingness to delegate authority 11.07 Growth of innovative companies 11.08 Companies embracing disruptive ideas
PILLAR 12 Innovation Capability	A. Diversity and collaboration	12.01 Diversity of workforce 12.02 State of cluster development 12.03 International conventions 12.04 Multistakeholder collaboration
	B. Research and development	12.05 Scientific publications 12.06 Patent applications 12.07 R&D expenditures 12.08 Research institutions prominence index
	C. Commercialization	12.09 Buyer sophistication 12.10 Trademark applications