**Study of the Hydroclimatic Information Needs of Rural Farmers in Aba Agricultural Zone of Abia State, Nigeria**

 **Abstract**

This research examined the hydroclimatic information requirements of farmers in the Aba Agricultural zone of Abia State, Nigeria. Using a multistage sampling method, data were gathered from 140 participants across three Local Government Areas in the zone via structured questionnaires. The collected data was analyzed through descriptive statistics, including mean, percentage, and frequency distribution tables. The study aimed to achieve several objectives: to pinpoint the sources of information regarding climate issues; to identify the hydroclimatic information necessities of the respondents; and to explore the perceived barriers to accessing hydroclimatic information. It was found that the respondents were aware of climate change, with radio, cooperative society, village meetings, fellow farmers, and extension agents being their primary sources of information. In contrast, the main climatic sign experienced by the farmers was an increase in temperature (62.9%)among others. The most significant hydroclimatic information needed in the study areas was related to the timing of rainfall (𝑥̅=3.36), along with the timing of high temperatures and guidance on when to plant. It was recommended that government agencies establish a hydroclimatic information system, provide training and capacity development, collaborate with extension services, and implement monitoring and evaluation practices.

**Keywords: Hydro-climate, agriculture, information, farmers,**

**Introduction**

“Climate change is a worldwide issue due to its extensive effects on the environment as well as socio-economic sectors such as water supplies, agriculture and food security, human health, terrestrial ecosystems, and biodiversity (United Nations Framework Convention on Climate Change” (UNFCCC).,2007) (Intergovernmental Panel on Climate Change (IPCC).,2007; IPCC, 2022). Alterations in rainfall patterns and increasing temperatures lead to changes in crop growing seasons and impact food security in economically disadvantaged and agriculture-dependent nations (Deressa, et al.,.,2011). Agriculture is a primary contributor to Nigeria's economy, accounting for approximately 52% of the Gross Domestic Product (GDP), employing 80% of the workforce, and generating over 85% of exports (Central Statistics Authority (CSA) (2005)). Despite its significant contribution to the national economy, this sector remains the most susceptible to climate variability and change (National Adaptation Programme of Action (NAPA).,2007).

The relationship between agriculture and climate is tightly interwoven. The agricultural sector is dependent on natural water cycles, which sustain the livelihoods of farmers and the overall welfare of rural communities (Hiremath & Shiyani.,2013). According to (Jotoafrika, 2013), smallholder farmers in the Aba Agricultural Zone of Abia State predominantly rely on rain-fed agriculture and adapt their planting schedules and farming calendars to align with the onset, duration, and conclusion of rainy seasons. However, the alterations in rainfall patterns caused by climate change mean that their planting schedules and farming calendars no longer correspond with seasonal rainfall patterns, often resulting in crop losses. Hence, seasonal rainfall forecasts are essential for providing early warning information that farmers can utilize (Jotoafrika,2013; Bryan et al.,2009) indicating that the accessibility and utility of weather information significantly influence a farmer’s capacity to adapt to climate change. Furthermore, research indicates that climate-related issues and information are among the primary considerations that farmers consider during their decision-making processes (Celia et al.,2009). This is termed Hydroclimatic Information.

Hydroclimatic information services play a crucial role in swiftly producing, translating, and providing data, information, and knowledge related to water, weather, and climate for decision-making in climate-sensitive sectors, particularly in agriculture and adaptation strategies on farms (Paparrizos et al., 2020). These services assist farmers in connecting their initiatives to increased earnings, decreased input costs, and minimized economic losses stemming from climate risks and uncertainties (Rahaman et al., 2020; Carr et al., 2020). However, the farming communities in the Aba Agricultural Zone largely rely on experiential and traditional knowledge for their agricultural practices and decision-making (Kumar et al., 2020). They lack access to localized and timely information services that could be beneficial (Kumar et al., 2020). The Aba Agricultural Zone in Abia State is among the regions most susceptible to climate change and rising sea levels. As indicated by (Huq et al., 2015), these farming communities experience high vulnerability to varying levels of climate impacts within this area of Abia State. Smallholder farmers in this zone predominantly depend on rainfed agriculture, facing ongoing hydroclimatic disasters such as cyclones, storm surges, tidal flooding, waterlogging, and saline intrusion into their fields (Kumar et al., 2020; Chen et al., 2018). These challenges have significant implications for food production systems and the insecurity of smallholder livelihoods (Huq et al., 2015; Lazar et al., 2015).

“At present, the hydroclimatic information services provided through government channels are insufficient to effectively address the frequent hydroclimatic disruptions in the Aba Agricultural Zone of Abia State. The services suffer from poor information quality due to reliance on traditional communication methods, short lead times, and a lack of user engagement. Forecast information is often communicated as a one-way transfer to farmers, which limits its practical application in agricultural decision-making. These issues are tied to the credibility (i.e., perceived quality), salience (i.e., perceived relevance), and legitimacy (i.e., user interest) of the existing information services that impact farmers' decision-making” (Hansen et al., 2011). (Inwood et al., 2019) noted that “creating a digital decision support tool necessitates proactive and continuous engagement with the intended end-users. Additionally, farmers struggle to comprehend and act upon the information services provided, which often arrive late and without adequate training” (Hansen et al., 2011; Tall et al., 2014a &b; Kumar et al., 2020; Sultan et al., 2020). Cultural beliefs, experiences with forecast inaccuracies, reliance on traditional methods, and local complexities regarding weather patterns are significant barriers that hinder farmers' uptake of information in the area studied (Islam et al., 2013).

To realize the objectives of climate services, it is crucial to comprehend the information requirements of farmers in order to customize hydroclimatic information services collaboratively (Tall et al., 2014; Swart et al., 2017; Naab et al., 2019). In this context, the forecast lead-time stands out as a significant factor in the customization of information. Forecast lead-time can be categorized into historical or past climate records, real-time or near real-time data, short-range weather forecasts (approximately one week), medium-range weather forecasts (around two weeks), and long-range weather forecasts and climate predictions that encompass monthly, seasonal, and interannual timeframes. Forecasts that fall within a month, including real-time or near real-time updates, as well as daily, weekly, and ten-day forecasts, are essential for informed agricultural decision-making. Therefore, the main objective of this study is to determine the hydroclimatic information needs of farmers in the Aba agricultural zone.

The specific objectives include to:

a). Identify the sources of information on climatic issues;

b). identify hydroclimatic information needs of respondents; and

c). examine perceived constraints to obtaining hydroclimatic information

**Methodology**

The study was conducted in the Aba Agricultural Zone (AAZ) of Abia State, Nigeria. Aba Agricultural Zone is made up of seven Local Government Areas namely: Osisioma, Aba North, Aba South, Obingwa, Ukwa East, Ukwa West, and Ugwunagbo. Aba has a total land mass of 810,160ha, with a population of 1,167,698 persons in 2025 projected from the 2006 census figure (NPC, 2006). The predominant soil of the area is sandy loam, while the natural vegetation is the tropical rainforest, characterized by two distinct seasons; the dry season and the wet season. The dry season lasts from November to March while the wet season lasts from April to October. Aba is a commercial and industrial town. But the main owners of the land are farmers. The farmers in the area are primarily involved in food crop production but they are also involved in livestock production including poultry, and so on. The major food crops cultivated include cassava, maize, yam, plantain, banana and vegetables. It is a major urban settlement and commercial center. As a result of that land is a scarce commodity in the area. It is important to state that Abia State has three (3) Agricultural Zones namely: Aba, Umuahia and Bende Agricultural Zones. For this study, Aba Agricultural Zone was selected because it is the most urbanized zone in Abia State. A multi-stage sampling procedure was used to sample the respondents**.** In the first stage, three (3) LGA’s were randomly drawn from Aba Agricultural Zone. The selected Local Government Areas are Aba North, Obingwa, and Ukwa East. In the Second Stage, two (2) communities were randomly drawn from each of the three (3) selected Local Government Areas in the Agricultural Zone. The selected communities are; Ogborhill communities and Ohanku Communities from Aba North Local Government Area, Umukalika Communities and Umuokwe Communities from Obingwa Local Government Area, Azumini Communities and Obehie Communities from Ukwa east Local Government Area. The third stage involves a proportionate selection of respondents from the list of registered farmers obtained from the Agricultural Development Programme (ADP). The list has a total of 1400 registered crop farmers and 10% was selected from each community, giving a total of 10 farmers. Data were collected using a structured questionnaire and complemented with an interview schedule. Descriptive tools such as mean, and percentage presented in frequency distribution tables were used to achieve all the objectives of the research. Mean was computed on a 4-point Likert scale of constraints of strongly agree (SA), Agree(A), Disagree(D), Strongly Disagree (SD), assigned scores of 4,3,2, and 1, added to give 10 divided by 4 to give a mean of 2.50. This was used to achieve objective 3.

This is mathematically expressed as SA + A + D + SD = 4 + 3 + 2 + 1 = 10

10 / 4 = 2.50. Any mean of 2.50 and above is regarded as a constraint to getting hydroclimatic information.

**Table 1: LGAs and Communities Sampled in the Study Zone**

|  |  |  |  |
| --- | --- | --- | --- |
| **Selected LGAs** | **Selected Communities** | **Numberof Registered Farmers** | **Number of Sampled Farmers** |
| **Aba North** | **Ogbor Hill** | **300** |  **30** |
|  | **Ohanku** | **280** |  **28** |
| **Obingwa** | **Umukalika**  | **300** |  **30** |
|  | **Umuokwe** | **190** |  **19** |
| **Ukwa East** | **Azumini**  | **230** |  **23** |
| **Total**  | **Obehie** | **100****1,400** |  **10** **140** |

 **Source: Field survey data, 2024**

**Result and Discussions**

**Sources of information.**

Table 2 shows the distribution of the respondents according to their source of information. The major sources of information on hydro-climate by the respondents were Radio (68.5%), extension agents (70%), social media (62.8%), fellow farmers (80%), churches (72.8%), television (15.3.%), cooperative society (78.5%), Town crier (68.5%), village meetings (60%), books/journal/pamphlets/fliers (31.4%), and Newspaper (31.4%). This indicates that sources through which farmers get hydro-climatic information differ and are varied depending the situation. The above agrees with Adetayo, et al., (2023) who said that climate change has become a significant issue globally. Nigerian undergraduates are aware of this and actively seek information about climate change from Google (86.9%), television (73.0%), friends (69.2%), family (67.9%), Facebook (55.5%), radio (54.8%), YouTube (53.9%), and Instagram (53.5%). These findings highlight the popularity of Google among students as a key resource for information retrieval. It is not surprising that undergraduates turn to Google for information on climate change, considering that such events are not frequently covered by local news outlets.

 **Table 2: Sources of Hydro-climatic Information**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|

|  |  |  |
| --- | --- | --- |
| Sources  | \*Frequency | Percentage |
| Television  | 23 | 15.3 |
| Radio Newspapers  | 9644 | 68.531.4 |
| Social mediaChurch es  | 88102 | 62.872.8 |
| Cooperative Society  | 110 | 78.5 |
| Books/journals/pamphlets/fliers Extension Staff  | 4498 | 31.470.0 |
| Fellow farmers in the community  | 112 | 80.0 |
| Town crierVillage meetings  | 9684 | 68.560.0 |

 |

 **\*Multiple response**

**Hydro – Climatic Signs Observed by farmers**

Table 3 shows the distribution of the respondents according to climate signs. The major climatic signs seen by the respondents are an increase in temperature (62.9%). This refers to a rise in the temperature of a substance or environment. This can occur due to various factors such as heat transfer, environmental changes, or human activities. The impacts of temperature increases can be significant and far-reaching, affecting both the environment and human health. Unpredicted heavy rainfall (42.1%). This refers to an unexpected and irregular pattern of precipitation that occur due to climate change. Heatwaves (40.7%). This refers to prolonged periods of abnormally high temperatures, often exceeding 90°F (32°C) for several days. They can have devastating impacts on agriculture, causing crop stress, reduced yields, and even death of crops. Reduced crop yield (39.3%). This means the decrease in the quantity and quality of crops due to various climate-related factors such as heatwaves, droughts, and floods. This can lead to food shortages and economic losses for farmers and communities. Death of crops (37.1%). This refers to the complete destruction of crops due to extreme weather events like heatwaves, floods, or droughts. Heavy winds (35.7%). This refers to strong and intense winds that can cause significant damage to crops, infrastructure, and buildings. They are often associated with extreme weather events like hurricanes and tornadoes. Floods (32.1%). This refers to the overflow of water that submerges land and can cause significant damage to crops, infrastructure, and communities. They are often linked to heavy rainfall and can have long-term impacts on agricultural productivity and food security. Droughts (26.4%). They are prolonged periods of abnormally low rainfall, leading to water scarcity and significant impacts on agriculture, ecosystems, and human health. They can cause crop failures, livestock deaths, and increased food prices. Extreme weather events (20.0%). This refers to the intense and unpredictable weather patterns that occur due to climate change. while Sea level rise (15.0%) refers to the gradual increase in the average level of the world's oceans due to climate change. This indicates that increase in temperature is the major climatic signs in the study area.

 **Table3: Hydro-climatic signs as seen by Respondents**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
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|  |  |  |
| --- | --- | --- |
| Hydro – Climatic Signs  | \*Frequency | Percentage |
| Extreme weather eventsSea Level riseDroughtsFloodsHeatwavesIncrease in temperatureUnpredicted heavy rainfallReduced Crop yieldHeavy windsDeath of crops | 28213745578859555052 |  20.015.026.432.140.762.942.139.335.737.1 |

 |

 **\*Multiple response**

**Hydroclimatic Information Needs of The Respondents.**

Table 4 illustrates that the primary hydroclimatic information requirements of the respondents include the timing of rainfall (𝑥̅ = 3.36); farmers seek reliable rainfall data to optimize their irrigation practices, reduce water waste, and effectively manage soil erosion. Understanding rain patterns is crucial for planning crop management, which entails forecasting when rain is expected, as this affects crop development, soil moisture, and nutrient availability. Information regarding disease management (𝑥̅=3.29); when vulnerability to diseases rises, farmers can enhance their crop management through hydroclimatic insights on disease control. This includes being knowledgeable about effective disease management strategies, such as pest control, crop rotation, and climate-resilient approaches; precise information on disease management helps farmers boost agricultural productivity, lessen crop losses, and allocate resources more efficiently. The timing of high temperature (𝑥̅= 3.13); this pertains to the occurrence of heatwaves, which can cause crop stress, diminish yields, and increase vulnerability to diseases. Hydroclimatic data on temperature trends aids farmers in managing their crops effectively during periods of excessive heat. Accurate temperature information also supports the development of strategies to alleviate crop stress, including providing shade, irrigation, and pest management. Flood information (𝑥̅= 3.13); farmers require hydroclimatic data related to floods to effectively manage their crops during times of heavy rainfall. This entails being informed about when floods might occur and their severity since such events can lead to crop damage, nitrogen depletion, and soil erosion. With reliable flood information, farmers can devise mitigation strategies, such as selecting flood-resistant crops, preserving soil, and implementing effective water management practices. Risk reduction strategies (𝑥̅= 3.12); farmers can utilize hydroclimatic data concerning risk mitigation to better manage their crops amid climate uncertainty. This involves knowing the most effective ways to minimize risk, like crop diversification, insurance, and climate-resilient practices. By having trustworthy information on risk reduction, farmers can enhance yields, decrease losses, and manage their resources more effectively.

Information about seasonal cropping practices (𝑥̅=3.11); utilizing hydroclimatic data on seasonal cropping methods allows farmers to enhance their crop management strategies in accordance with the specific climate conditions of their region. This encompasses understanding the optimal times to plant and harvest various crops, as these timings can change based on temperature, rainfall, and other climatic factors. Accountability for farm inputs (𝑥̅= 3.09); hydroclimatic data regarding agricultural inputs supports effective resource management. This means knowing how to best apply resources such as pesticides, fertilizers, and irrigation water in light of local climate conditions. When to plant (𝑥̅= 3.08); hydroclimatic information related to planting times is key for farmers to secure optimal growth for their crops. This involves grasping the right timing for planting different crops, influenced by temperature, rainfall, and other climatic aspects.

Having accurate information on planting times assists farmers in avoiding unfavorable weather, such as droughts or floods, and helps maximize crop yields, while plant timing (𝑥̅= 3.08); is crucial for ensuring the healthiest possible crop growth. This entails knowing when to cultivate specific crops considering temperature, precipitation, and other climate-related factors. An accurate understanding of planting dates helps farmers steer clear of adverse weather occurrences, such as floods or droughts, while optimizing production. Varieties of crops (𝑥̅= 2.94); hydroclimatic information on crop types aids farmers in selecting the most appropriate varieties for their local climate conditions. This involves being mindful of the best crop varieties suitable for different climate zones, influenced by factors like temperature, rainfall, and other climatic conditions. Having precise information on crop varieties enables farmers to enhance yields, decrease losses, and manage resources effectively. Information on planting dates (𝑥̅= 2.94); assists farmers in fine-tuning their crop management strategies in response to the distinct climate conditions of their area. This requires understanding the best times to plant certain crops based on climate variables such as rainfall and temperature. With accurate details on planting dates, farmers can maximize yields, minimize losses, and manage resources efficiently. Weeding time (𝑥̅= 2.93); allows farmers to optimize crop management during peak growth periods by using hydroclimatic data about weeding times. This includes knowing the ideal periods for weeding, which depend on various climate factors such as rainfall and temperature. Accurate insights on the best times to weed enable farmers to enhance crop yields, reduce weed competition, and allocate resources efficiently. Land cultivation timing (𝑥̅= 2.91); involves how farmers organize their crop planting and soil preparation based on their region’s climate conditions using hydroclimatic information on cultivation periods. This means understanding the optimal time for land preparation, which relies on factors such as temperature, precipitation, and other climate characteristics. Information related to labor (𝑥̅= 2.85); hydroclimatic insights on labor enable farmers to manage their resources effectively. This indicates that the primary hydroclimatic information requirement identified by respondents in the study area is rainfall timing (𝑥̅= 3.36); in order to determine the ideal moment for planting crops to achieve maximum productivity.

**Table 4 Hydro-climatic Information Needs of Respondents**

**Effects on Farm Families Mean Standard Deviation**

|  |  |  |
| --- | --- | --- |
| Time of rainfal | 3.36 | 0.96 |
| Time of high temperature Information on flood Information on seasonal crop practices | 3.133.133.11 | 0.880.980.97 |
| When to plantLand cultivation timeWeeding timePlanting rateCrop varieties to plantAccess to farm inputsPlanting date/monthInformation on risk reductionInformation on diseases managementInformation on labourFrequency of droughtsRainfall frequency and distribution | 3.082.912.933.052.943.092.943.123.292.852.783.09 | 0.920.950.960.780.820.840.971.020.970.760,740.82 |

 **Accepted mean= 2.50 and above**

**Perceived constraints to obtaining hydroclimatic information**

Table 5 presents the perceived obstacles to acquiring hydroclimatic information as reported by the respondents. The primary perceived obstacles to obtaining hydroclimatic information included insufficient funds/savings (𝑥̅= 3.32), indicating that there is not enough money to manage this work. Another constraint is the difficulty in understanding technical terminology (𝑥̅= 3.09), which implies that they face challenges in grasping the specialized vocabulary and jargon used. Limited data availability (𝑥̅= 3.07) signifies that data is inaccessible or unusable for reasons such as data compatibility issues, where data that functions on one platform may not work on another. Erratic power supply for charging phones (𝑥̅=3.06) indicates that there is an unstable power supply for charging their devices. Poor network connectivity (𝑥̅=3.05) refers to the inability of devices to communicate effectively over a network, leading to slow data transfer speeds and intermittent connection issues. Some respondents lack a smart/android phone (𝑥̅=2.97), meaning they do not possess such devices. Limited access to specialized tools or software (𝑥̅=2.92) indicates that they do not have the necessary resources, equipment, or software required to carry out specific tasks due to financial limitations. Additionally, a lack of ICT knowledge (𝑥̅=2.95) suggests that they do not have the essential skills, understanding, or familiarity with information and communication technology tools. Inconsistencies among various sources (𝑥̅=2.91) mean that multiple information sources provide conflicting or contradictory data. The high costs associated with accessing data or services (𝑥̅=2.89) refer to the financial challenges faced when seeking specific information. The time of delivery (𝑥̅=2.86) describes the duration between placing an order for agricultural products and the actual delivery to the customer. Lastly, a language barrier (𝑥̅=2.77) refers to the challenges in effectively communicating between individuals who speak different languages.

**Table 5: Perceived constraints to obtaining hydroclimatic information**

**Constraints Mean Standard Deviation**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|

|  |
| --- |
| Lack of adequate funds/savings  |

 Lack of ICT knowledge No smart/android phone

|  |
| --- |
| Poor network connectivity  |
| Language barrier  |  |
| Time of delivery  |

 | 3.322.952.973.052.772.86 | 0.970.890.950.941.060.90 |
|

|  |  |
| --- | --- |
| Erratic power supply to charge phone |   |
| Limited availability of data

|  |  |  |  |
| --- | --- | --- | --- |
| Lack of access to specialized tools or software  |   |   |  |
| Difficulty understanding technical terms |  |  |   |
| Inconsistencies among different sources |  |   |
| High cost associated with buying phoneHigh cost of phone repairs |

Theft/loss of phoneLong distance to repair shops |

 | 3.063.072.923.092.912.892.742.672.68 | 0.950.880.930.880.930.870.951.040.76 |

 **Accepted mean: 2.50 and above**

**Conclusion**

The findings indicate that farmers recognize climate change, with radio, cooperative societies, social media, village meetings, fellow farmers and extension agents as the primary sources of information. The main climatic sign reported by farmers is an increase in temperature (62.9%). The primary hydroclimatic information needed in the studied areas is the timing of rainfall (𝑥̅=3.36). Farmers in these regions require information about the timing of rainfall, periods of high temperature, and optimal planting times. The respondents demonstrated awareness of climate change, with radio and extension agents being the key sources of information. Furthermore, it can be deduced that understanding hydroclimatic information needs is essential for improving agricultural productivity, resilience, and sustainability. Farmers depend significantly on precise, timely, and location-specific hydroclimatic data to make informed decisions regarding planting, irrigation, pest control, and harvesting.

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**References**

Adetayo, A.J.,Oke, A.M, Babarinde, O.M. & Adeleke,.O.A. (2023) Information Sources and Climate Change Mitigation Support. Information Impact: Journal of Information and Knowledge Management, 14:1, 22-39, DOI https://dx.doi.org/10.4314/iijikm.v14i1.2

Bryan E, Deressa T, Gbetibouo GA, Ringler C (2009) Adaptation to climate change in Ethiopia and South Africa: options and constraints. Environ Sci Policy 12: 413-426.

Carr, E.R.; Goble, R.; Rosko, H.M.; Vaughan, C.; Hansen, J. Identifying climate information services users and their needs in Sub-Saharan Africa: A review and learning agenda. *Clim. Dev.* (2020),12,23-41. [CrossRef]

Celia M, Sonny R, Christian N.D, Mina D, Gonzales KG (2009) Climate Variability, Seasonal Climate Forecasts and Corn Farming in Isabela Philippines. Ashgate Publishing Limited Hampshire, England.

Central Statistics Authority (CSA) (2005) National Statistics Abstract. Addis Ababa, Ethiopia

Chen, J.; Mueller, V. Coastal climate change, soil salinity and human migration in Bangladesh. *Nat. Clim. Chang****.* (**2018). [CrossRef]

Deressa T, Hassan R, Ringler C (2011) Perception of and adaptation to climate change by farmers in the Nile basin of Ethiopia. J Agri Sci

Hansen, J.W.; Mason, S.J.; Sun, L.Q.; Tall, A. Review of seasonal climate forecasting for agriculture in sub-Saharan Africa. (Special Issue on assessing and addressing climate-induced risk in Sub-Saharan rainfed agriculture.). Esp. Agric. 2011,47,205-240. [CrossRef]

Hiremath, D.B. and Shiyani, R.L. 2013. Analysis of vulnerability indices in various agroclimatic zones of Gujarat. Indian Journal of Agricultural economy. 68(1): 122-137. DOI: 10.22004/ag.econ.206326

Huq, N.; Huge, J.; Boon, E.; Gain, A.K. (2015) Climate change impacts in agricultural communities in rural areas of coastal Bangladesh: A tale of many stories. *Sustainability* (2015),7,8437-8460. [CrossRef)

Intergovernmental Panel on Climate Change (IPCC) (2007) Climate Change 2007: Impacts, Adaptation and Vulnerabilities. Contribution of Working Group II to the 4th Assessment Report Cambridge University Press, Cambridge.

Inwood, S.E.E.; Dale, V.H. State of apps targeting management for sustainability of agricultural landscapes. *A review. Agron. Sustain. Dev.* 2019,39,8. [CrossRef]

IPCC, 2022: Annex II: Glossary [Möller, V., R. van Diemen, J.B.R. Matthews, C. Méndez, S. Semenov, J.S. Fuglestvedt, A. Reisinger (eds.)]. In: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [H.-O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, B. Rama (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA, pp. 2897–2930, doi:10.1017/9781009325844.029.

Jotoafrika (2013). Adapting to climate change in Africa. https://adaconsortium.org/publication/joto-afrika-issue-23

Islam, A.; Attwood, S.; Braun, M.; Kamp, K.; Aggarwal, P. Assessment of Capabilities, Needs of Communities, Opportunities and Limitations of Weather Forecasting for Coastal Regions of Bangladesh; WorldFish: Penang, Malaysia, 2013

Kumar, U.; Werners, S.; Roy, S.; Ashraf, S.; Hoang, L.P.; Kumar Datta, D.; Ludwig, F. Role of Information in Farmers’ Response to Weather and Water Related Stresses in the Lower Bengal Delta, Bangladesh. *Sustainability* (2020),12,6598. [CrossRef]

Lazar, A.N.; Clarke, D.; Adams, H.; Akanda, A.R.; Szabo, S.; Nicholls, R.J.; Matthews, Z.; Begum, D.; Saleh, A.F.M.; Abedin, M.A. Agricultural livelihoods in coastal Bangladesh under climate and environmental change-A model framework. Environ. Sci. Process. Impacts (2015),17,1018-1031. [CrossRef] [PubMed

Naab, F.Z.; Abubakari, Z.; Ahmed, A. The role of climate services in agricultural productivity in Ghana: The perspectives of farmers and institutions. Clim. Serv. 2019,13,24-32. [CrossRef

National Adaptation Programme of Action (NAPA) (2007) The Federal Democratic Republic of Ethiopia, Ministry of Water Resources and National Meteorological Agency. Addis Ababa, Ethiopia

Paparrizos, S.; Gbangou, T.; Kumar, U.; Sarku, R.; Merks, J.; Werners, S.; Dewulf, A.; Ludwig, F.; van Slobbe, E. WaterApps: Co-producing tailor-made water and weather information services with and for farmers for sustainable agriculture in peri-urban delta areas in Ghana and Bangladesh. In Proceedings of the EGU General Assembly Conference Abstracts, 4-8 May 2020; held online. p. 5712.

Rahaman, M.A.; Bijoy, M.R.; Chakraborty, T.R.; Kayes, A.I.; Leah Filho, W. Climate Information Services and Their Potential on Adaptation and Mitigation: Experiences from Flood Affected Regions in Bangladesh. In Handbook of Climate Services; Springler: Berlin/Heidelberg, Germany, 2020; pp. 481-501.

Sultan, B.; Lejeune, Q.; Menke, I., Maskell, G., Lee, k.; Noblet, M.; Sy, I.; Roudier, P. Current needs for climate services in West Africa: Results from two stakeholder surveys. Clim. Serv. 2020,18,100166. [CrossRef]

Swart, R.; de Bruin, K.; Dhenain, S.; Dubois, G.; Groot, A.; von der Forst, E. Developing climate information portals with users: Promises and pitfalls. Clim. Serv. 2017,6,12-22. [CrossRef].

Tall A, Kristjanson P, Chaudhury M, McKune S, Zougmore R.( 2014a). Who gets the information? Gender, power and equity considerations in the design of climate services for farmers. CCAFS Working Paper No. 89. Copenhagen: CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). Available at: <http://bit.ly/1YLZtzZ>

Tall A, Hansen J, Jay A, Campbell B, Kinyangi J, Aggarwal PK, Zougmoré R. (2014b). Scaling up climate services for farmers: Mission Possible. Learning from good practice in Africa and South Asia. CCAFS Report No. 13. Copenhagen: CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). Available at: http://bit.ly/1iYMs5X

United Nation Framework Convention on Climate Change (UNFCCC) (2007) Impacts, Vulnerabilities and Adaptation in Developing Countries: Martin-Luther-King-Strasse 853175 Bonn, Germany. P. 8