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The Capabilities of Interdisciplinary Approach to Strengthening Farmers' Resilience to Climate Variability and Change

Zuma-Netshiukhwi[1*], G and Mphandeli[2], S

[1]Agricultural Research Council, Institute for Soil, Climate and Water, Glen Agricultural Institute, Gielie Joubert Street, Glen, Bloemfontein, 9360, South Africa
[2]Water Research Commission, 4 Daventry Street, Lynnwood Manor, Pretoria 0081, South Africa

***Corresponding Author:** Zuma-Netshiukhwi, Agricultural Research Council, Institute for Soil, Climate and Water, Glen Agricultural Institute, Gielie Joubert Street, Glen, Bloemfontein, 9360, South Africa, Email:ZumaNetshiukhwiG@arc.agric.za*

ABSTRACT

Information and warnings about climate variability, intensification of weather extreme and climate change comes in a crucial sense of urgency which action is required. These warnings often comes wrapped in scenarios suggesting condescending strategy with technologies that assurance to deliver the farmers from the predicament of agricultural calamities. Such example, evolve around carbon sequestration and carbon storage resolutions. Such technologies promise to transform the so-called harmful carbon dioxide (CO2) infinite energy resource. Nevertheless, the process of photosynthesis has taught the importance of (CO2) in the agricultural value-chain. Farmers are faced with adversities subsequent from intensifying climate irregularities and extreme events. The consequences of climate variability, climate change, extreme weather events and unpreparedness of the farmers, has remarkable consequences resulting to minimisation of agricultural productivity, weakening of water-energy-food nexus and crops ecosystem and thus, threatens agricultural sustainability in the changing climate and environment. Therefore, strengthening of interdisciplinary approach and agro meteorological extension appropriate and afford the farmers the ability to consider other available adaptation strategies and better understanding factors fostering change of activities and embrace transformative technologies for enhanced decision making. The lack of agro meteorological training to extension agents challenged the efforts to equip farmers with new information and technologies to assist farmers. Based on the initiatives of institutionalizing an educational commitment and the development of local farm groups in South Africa, an interdisciplinary approach has proven to be effective and efficient means of providing climate services, and also forming part of provincial advisory forums such as Provincial Disaster Management Advisory Forum (PDMA) has proved to be effective. The paper scrutinizes the impact and the possibilities of adopting interdisciplinary approach between scientists and farmers and the significance of collaborative effectiveness.

Keywords: *Climate change, climate variability, weather extremes, agriculture and approaches*

INTRODUCTION

Climate Variability and Change, What is the Difference

Climate terms that are easily confused and misunderstood Climate variability and Climate Change. Both these terminologies refer to climate trends and patterns at a given period or simple space over time. Prior jumping to technical terminologies, let start with the basics and describe the blanket of air, where it all occurs, in the atmosphere. Atmosphere is the layer of air surrounding the earth globe, moving horizontally and vertically and thus causing inconsistencies in weather and climate. The most critical role-played by the atmosphere on agricultural productivity, it protects the earth from high-energy radiation from the sun. Two key words essential for describing atmospheric conditions, weather and climate. Weather refers to day-to-day state of atmospheric conditions in a short-term period from hours to about two weeks; it is a variation of climatologically parameters such as, rainfall, humidity, cloudiness and wind conditions. Climate refers to statistical information based on weather for locality averaged for at least 30 years; it is a quantification of weather deviation focusing on a specified area for an identified interval. For example, on average, Managing Metropolitan Municipality, Bloemfontein, Free State Province of South Africa is expected to be cold from 11 April, colder in June to July, rainy in December/January and hot in December but annual deviations are expected to occur. Furthermore, the 2015-2016 year in South Africa became the exceptionally warm summer season.

According to Intergovernmental Panel on Climate Change (IPCC), 2013; climate variability states to the climatic parameter of a region varying from its long-term mean. Thus simple means that variations in the mean state, standard deviations and the occurrence of extremes of the climate on spatial and temporal scales beyond that of individual weather events. For example, the average annual rainfall for Bloemfontein is 559 mm. Thus, not all years such amount may be received, but the actual rainfall varying from the prescribed mean could represent drought and flood conditions. Climate change attributes to the long-term fluctuations in rainfall, temperature, wind and all other climatological parameters. It refers to any change in climate over time, whether due to natural variability or anthropogenic forces. Therefore, it can be described as a change of climate, which attributed directly or indirectly to human activity, which modifies the composition of the global atmosphere and in addition to natural climate variability observed over comparable time and periods, an observed change in the average weather conditions. Therefore, climate change vulnerability refers to a degree to which a system is unable to cope with, the adverse effects of climate change, including climate variability and weather extreme events. Over the last decades, the scientific community was marked by the growing interest in climate change, climate smart technologies and its consequences to the agricultural sector and to the community at large. Climate change can be quantified merely by measuring changes of many elements of the climate system, but the most crucial climate parameters are the air temperature and rainfall (Stigter &Ofori, 2013; IPCC, 2014; Malinovic-Milicevic, Radovanovic, Stanojevic, & Milovanovic, 2016).In addition, itall starts with small changes in average conditions and these changes have big influence on extremes such as drought of floods, thus referred to as extreme weather. According to Simpson & Dyson (2018), Free State province received less than 50% of its average rainfall in 2016. These extreme weather events have noticeable effects on agricultural productivity(Iizumi&Ramankuty., 2015; Nhamo, etal. 2019).Such weather and climate events are sufficient to establish and develop approaches aimed at empowering farmers and extension agents towards understanding its impact to agriculture.

Climate Change: A Reality or not

A dilemma faced by most within the farming fraternity and has different school of thoughts. Is climate change a reality? Why does a different type of weeds thrive during prolonged dry spells in comparison to planted crops? Why has the rainfall times have changed? Why are we noticing the intensification of prolonged dry spell, which last for up to 28 days? Farmers in Managing Metro Municipality (MMM) in the Free State Province experienced exceptionally long spells ever in year 2018/2019, December 2018 and January 2019. The average rainfall received for December 2018 was 0.70 mm with the total rains of 21.59 mm and the highest being 13.71mm.Keeping in consideration that the maximum temperature ranged from 30ºC to 40ºC, thus indicates that evapotranspiration rate was very high. In January 2019, the first good rains experienced on 1 January with the amount of 25.40 mm followed by 5.33 mm on January 2, 2019. Thereafter, rains received on 29 January at the amount of 8.89 mm. However, the month of February 2019 a total amount of about 97.79 mm with rains occurring every 3 to 5 days. Given this knowledge, ―Has the planting seasons shifted? What are the best planting dates for this area? These are the questions asked by farmers and all within the agricultural community after experiencing severe drought in year 2015/2016 and 2018/2019, as examples. For the past decade, these are some of the questions asked by farmers. As a custom for farmers within MMM start planting maize, sunflower, sorghum and other cash crop late November, Mid-December and first week January. Since farmers thought that the rainy season was at hand, planting activities began. During prolonged dry spells or drought events in dry rain-fed fields,crop failure occurred, except in occasions where farmers would provide supplementary irrigation to increase soil water content. According to previous studies climate variability and change affects farming and food systems due to shift in season (Barnett, et al., 2005; Clement, et al., 2011). Unfortunately, farmers faced by such risk as it occurred in some other parts of Free State Province and South Africa at large, and are under the same unfamiliar significances of climate change. Such climate change, scenario occurrences require transparency, informative and educational platform to equip farmers. Regrettably, in most instances such abnormal scenarios occur when farmers are least expecting. For example, a false start of rain phenomenon occurred during 2018/2019; nonetheless, farmers were ill informed with appropriate anticipation capabilities to avoid planting earlier, as it is a tradition. Nevertheless, in most of the cases, risks experienced by farmers were due to their, inexperience, unwillingness to adapt and denial of future climate conditions.

This inexperience has persisted given the lack of agrometeorological training to extension agents, lack of localized early warning systems and climate services provided to farmers (Mapalla, 2018; Zuma-Netshiukhwi, 2013). It has also become evident that, farmers are left on their own without and exposure to scientific knowledge and highly dependent on indigenous knowledge on weather forecasting and climate prediction (Zuma-Netshiukhwi; Stigter &Walker 2013). Indigenous knowledge used by farmers accumulated by their observation of their environment and utilized such indicators to tell future climate predictions, agricultural activities, pest-disease management and many other agricultural and cultural related phenomenon. Indigenous knowledge is developed and improved to progressively changing environments and is intertwined with local and cultural values, which such knowledge addresses local problems and solutions that are context specific. Thus over years accumulated rich empirical knowledge through simple thorough observations and based on farmers historical experience (Dey & Sarkar, 2011; Winarto, 2018; Zuma-Netshiukhwi, 2013).

Many instances points out the intensification of weather extremes. For example, the storms that battered Gauteng and KwaZulu-Natal in 2017; drought episode in South Africa in 2015/2016; the floods recorded in the Free State and the outbreak of Rift Valley Fever; the outbreak of Spodopherafrugiperda (fall Armyworm) around South Africa in 2017 (Kusangaya, et al., 2014; du Plessis, et al., 2018; Patz, et al.,2003); the prolonged dry spells around the country at different agro climatologically zones in 2018/2019; the floods that shook many in the Free State in February 2019. Such extreme weather patterns and its impact have predicted the reality of climate change in South Africa, which threatens the well-being of farmers. In general, the extremes intensifying and the incidents of storm damages emanating such as, ripped off roofs, flooded roads, smashed windows, cars, uprooted trees, fallen bridges, and several people injured and/dead. Thus confirms that, the effect of climate variability and change and other external factors are causing a distress in the agricultural sector and minimizing its capability to strengthen food security for the growing population (Barnett. et al., 2005).Therefore, the impact of changes in temperature and rainfall patterns as recorded in previous studies, evidence indicates that in the southern Africa there is a rife of water scarcity, increased evaporation and evapotranspiration rate (Besada& Werner., 2015; Jury, 2013; Hinrichsen, et al., 2002). Given the above intriguing scenarios, farmers are entangled in between the past and the present knowledge systems. The reality faced by farmers are intensifying extremes, unusual risks, lack of knowledge in weather forecast application, unpreparedness, vagueness on opportunities on weather conditions and the comprehension of the relationship between weather conditions and climate change (Stigter & Winarto,2015).

Knowledge Dissemination to End- Users

How do you know that farmers at local ground receive weather forecast? Do the farmers understand the applications and the implications of weather forecast? How do you ensure that the weather forecast information and knowledge reach its rightful users? What are the reliability and the accuracy of weather forecast and climate prediction? These are once again many other questions raised by scientists to determine the status on knowledge transfer. Within the agricultural perspective, dissemination is reiterated around the interactive process of communicating knowledge to target the farming community at different levels. Knowledge dissemination is prescribed to lead to change or adaptation of new strategies during the changing climate (Ordonez & Serrat 2017; Zuma-Netshiukhwi, 2013).The production and generation of agricultural knowledge, much of which represents or should address the solution to the farmers 'problems. The value of generated or knowledge product is determined by the effective dissemination channels and methods to the targeted recipients, without efforts to knowledge transfer the scientist's efforts to develop knowledge are wasted. Thus, during the changing climate with evident shift in planting seasons, dissemination of scientifically developed.

Knowledge is a core responsibility of agricultural institutions to generate and create knowledge exchange platforms. It is worth emphasizing that, dissemination of knowledge is just as significant as its production (Fisher, et al., 2003; Willis& Hamilton-Attwell, 1998, Winarto &Stigter, 2013; Zuma-Netshiukhwi, 2013). Whether it is scientific knowledge or technology transfer, a managed process of conveying a body of knowledge from academic institutions or agricultural research centers to the prospective users is necessary. A body of knowledge or technology transfer such as climate smart technologies is a multi-stage process by which thoroughly researched weather patterns, trends, and its influence to agricultural productivity are transformed into a useable and user-friendly product. Thus, the transfer process involves the source and the receiver of knowledge. The source being the thinker, conceiver, developer, generator and the receiver being the end-user, adopter, implementer the call for well-developed and maintained solid, respectful, long-term relationships among stakeholders and an intact interaction for consultation and participation (Willis& Hamilton- Attwell, 1998, Zuma-Netshiukhwi, 2013).Therefore, there is a great need for the establishment of dissemination pathways and their appropriateness for the targeted end user. The usefulness and comprehensibility of its content determines its worth to the user. Therefore, a cyclical model or a re-iterative process of communication with prospective users Say well & Cotton (1999) brought some guidance on the importance of dissemination pathways for different platforms and end-users. The key to developing an understanding of the target end-user is to comprehend background, traditional knowledge and the impact of cultural aspects, which may operate as part of agricultural decision-making. However, as well as behavioral factors, perception of scientific knowledge, there are other resource-centered concerns. Considerations and identification of barrier to dissemination may lessen hindrances to knowledge transfer. Zuma- Netshiukhwi (2013) indicated that, vastamounts of scientific knowledge are never communicated beyond their immediate circles of interest and remain unused and decorate the library shelves or piled with dust collected in many years. Awareness and understanding on the probabilities of dry spells farmers may decide to wait until the true rainy season‘s onset, and thus may foster the interest in greater understanding that may in turn provide the basis for better decision making. The relationship of key components of dissemination leading to knowledge adoption and utilization revolves around the potential user the medium for knowledge transfer, the context entailed, the content and the source of knowledge and back to the targeted user. Without understanding these key elements, scientists and farmers would not understand the gaps that might exist within the community for service delivery. Therefore, many studies confirmed that institutionalized community based forums or leaner groups play a significant role, for example, within the agrometeorological learning, establishment of Science Field Shops confirms success to knowledge sharing and exchange. Science Field Shops are platforms, which allow multi-stakeholder participation, toward problem identification and to the development of solutions for the problem at hand. Farmers also learn new knowledge on agrometeorology to enrich their tactical and operational planning of farming in the context of climate change (Winarto and Stigter, 2013; Zuma-Netshiukhwi, 2013).Therefore, it is strongly advisable and recommended that the agricultural sector investigate the status of agrometeorological extension and applied agrometeorology to empower farmers with the best practices toward minimizing the risk of climate variability and change. Thus, during Science Field Shops, farmers are awarded the opportunity to learn new knowledge on agrometeorology to improve their tactical and operational decision on weather extremes such as the occurrence of drought. Furthermore, that agrometeorological learning is the integral part of every agricultural enterprise and provides assistance toward improved decision-making Stigter, 2016).

Facilitating Knowledge Transfer and Sharing "Scientist Vs Farmer"

In this paper, we try to acknowledge all knowledge from scientific and traditional perspectives and understanding the role of knowledge management in promoting a synergistic interaction between agrometeorological and local indigenous knowledge. Both scientific and local knowledge domains are perceived as strategic enablers of informed decision making toward improved agricultural productivity. According to Zuma-Netshiukhwi (2013), in pursuit to educate farmers on the application of weather forecasts and climate predictions discovered that most farmers entrusted on indigenous local knowledge for decision-making. Due to the difference in knowledge domains, it was found that commercial farmers, having more resources, performed better, compared to the resource poor farmers (Stigter, et al., 2013). Thus, leads to the acknowledgement of both school of knowledge for implementation of agricultural activities. The diversity of development across specific knowledge domains greatly intensify the potential for dissimilarity and enlarge the pool of knowledge that can be generated managed and utilized. However, both approaches, a combination of local innovations and scientific understanding must be taken into considerations within the establishment of field with farmers approach.

In then endeavors of Agrometeorologists addressing the weather and climate impact to agriculture, the extension agents and farmers could envisage the imminent season would have near-normal, above-normal and/or below-normal rainfall conditions. Sometimes the technical terminology would be at play and they received the warning of the El-Nino and La-Nina episodes described as weak or strong. With persistence in engaging with extension agents and farmers, they gained the skills to comprehend and apply the knowledge of seasonal activities, for example, on what, when and how to plant. Thus shows, within the South African context, the monthly discussions and engagement of agro meteorological knowledge in decision- making increase gradually. During the monthly meetings, seasonal climate scenarios are the pillar of the discussions on drawing and setting the seasonal boundaries and possible agricultural activities. The most critical and key weather and climate service furnished to farmers and extension agents are as follows:

- Interpretation of 0-6 hours, 1 week and 1 month weather forecasts;
- Interpretation of seasonal forecast and its implications and applications;
- Guidance on rainfall data collection and recording;
- Record keeping of yields and the impact of seasons on yields;
- Daily agro-ecological observations;
- Provision on the guidance on the establishment of field experiments, data collection, development of local best practices,
- Understanding traditional knowledge systems, its applications and its shortages
- Guidance on the climatic conditions that favour the outbreaks of pests-disease-weeds and controlling majors

The importance of organized study groups, which may be referred as Science Field Shops a rotational farm visits to encourage farmer- to-farmer knowledge transfer (Stigter, 2016).

During field excursions and farmer-to-farmer field visit sessions and observing farmers'fields agro ecosystems in detail, supplemented with insights on indigenous knowledge indicators and its application on agricultural operational decision making. As it is the platform for knowledge exchange between farmers and scientists, for farmers the organized groups called, Science Field Shops but for scientists it would be fair to name it, Indigenous Knowledge Field Shops. Toward acknowledging the imperativeness of both knowledge systems and knowledge exchange, the established field shops could be addressed as Knowledge Domains Field Shops (KDFS). Prior agricultural science became a discipline on its own; there was farming before 9000 BC (Hillman, 1996; National Geographic, 2016). Thus indicates the feasibility of local knowledge, based on cultural practices and the understanding of the local agro-ecosystems given the years of observations and experiences. In combination of daily rainfall readings and analysis, the agro-ecosystem record keeping provides a strong basis for advancing farmers understanding on the impacts caused by rainfall pattern on crop growth and animal husbandry, and most importantly on the field condition at large.

Exposure to such experience enables the farmer to relate the amount of rains received and the qualitative nature with their own agricultural perspective and understanding. The lexicons utilized by the scientist on seasonal conditions become understandable, as the farmers abilities increase to create seasonal boundaries and classify normal-above-below rainfall categories and its impact on crop and animal productivity. Understanding the application of seasonal rainfall categories farmers are grateful at knowing the wet and the dry season and decisions made to minimize losses. For example, season 2018/2019 farmers new about the high probability of prolonged dry spells and the best decision to make was not to plant at all alternatively, to plant drought tolerant crops or to consider soil water conservation tactics. In the long drought experienced on 2015/2016 under a severe ElN iño episode, farmer's experiences devastating losses on crop and animals, but farmers who were informed of the predicted conditions took measures to minimize losses such as not planting at all and selling some livestock. However, some crop producers planted drought resistant crops such as sorghum. The provision of agricultural meteorological knowledge plays the most significant part of climate services. In many studies relating to climate services across the globe, it has proved to be beneficial for farmers and the extension agents toward food security. Thus calls for structures to enforce engagements and commitments between farmers, extension agents and farmers at large.

Potentials and Challenges to Develop an Interdisciplinary Approach

The reality was that any intriguing new knowledge and technology given, required multi-year and seasonal-long engagement with the farmers, hence the development of study groups and later referred to as Knowledge Domains Field Shops. On the other hand, the South African state developed local farmer's cooperatives, for this study adopted as part of the study groups, and later formed part of Knowledge Domains Field Shops. Understanding the vast challenges experienced by farmers, other scientists recognized the need to involve other disciplines such as agronomists, soil scientist, agricultural economist and water management specialist. Mono-disciplinary scientist would have never been able to eradicate the problems faced by farmers at the field. Nevertheless, multi-stakeholder and multi- disciplinary collaborations furnish a strong base of farmer-problem solving, whether it was climate or agronomic or soil related. Climate change related challenges, could only be addressed and solved by agro meteorologists for farmers to improve resilience and adaptability to the changing climate the emphasize for successful agricultural problem solving would be to enforce interdisciplinary approaches, of which to eliminate escalating uncertainties and complexities of agro-ecological within the farmers vicinities.

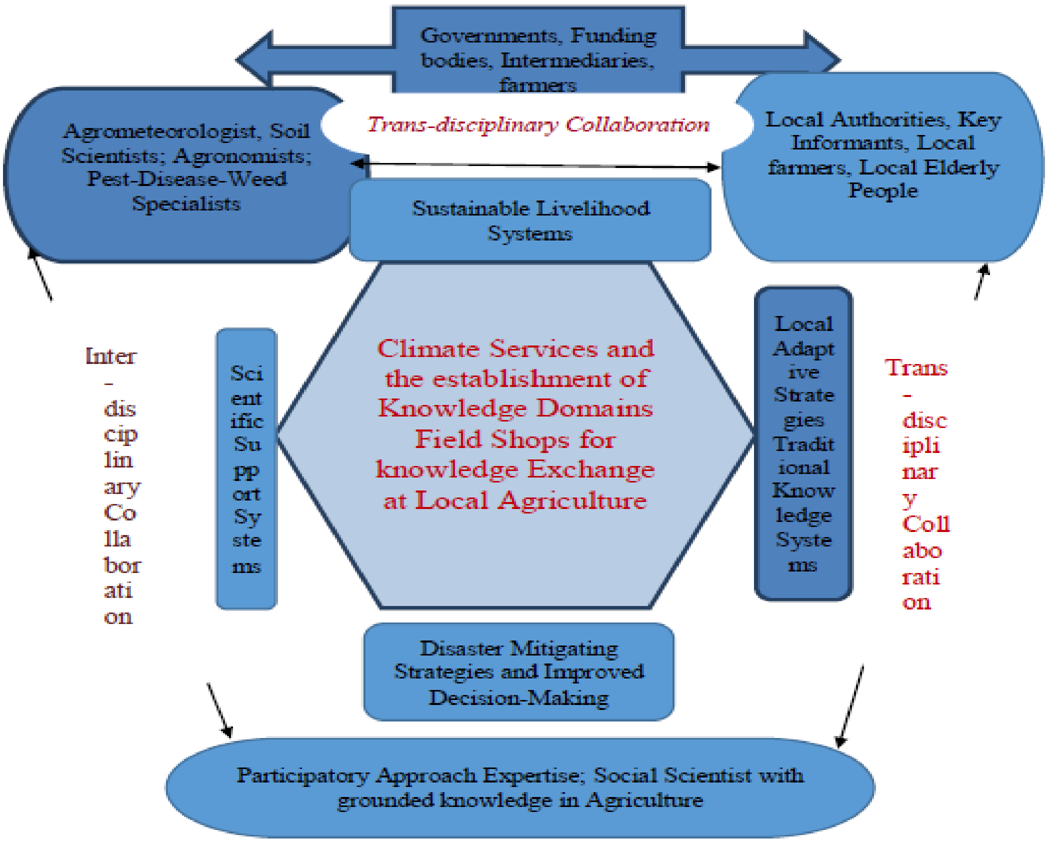

Figure1. *Research Approach: Collaboration and Methodology for the establishment of Knowledge Domains Field Shops (KDFSs)*

Figure1.exemplifies a visualization of strategy, collaborations and methodologies, which amalgamated multi-stakeholder, inter-disciplinary and trans-disciplinary approaches toward agricultural problem-solving strategy. In the past decade, agro meteorologists have taken initiatives to adopt and apply participatory tools and approaches toward educating and training farmers and intermediaries on the application of agro meteorological and agroclimatologically

concepts to benefit the farmers and minimize weather and climate related uncertainties and complexes (Stigter, 2010; Zuma-Netshiukhwi &Stigter, 2016, Zuma-Netshiukhwi, 2013).Such initiatives were implemented concerning, understanding on the challenges, impacts, problems and solutions. The priority intention to was understand the policies related to extreme meteorological events that cause farmers at district level, local governments and the adaptation to climate change strategies. Understanding difficulties faced by different types of farmers and difficulties in multiple cropping in comparison to mono-cropping by the farmers at the same categories the finding projected the fact that, within the South African contextualization challenges remain within the channels of communication. One other challenge was based to the lack of availability of tailor-made agro-advisories (Zuma- Netshiukhwi & Stigter ,2016) Thus, initiatives to enforce a multi-stakeholder, inter-disciplinary and trans-disciplinary approach became key to unraveling complexities faced by farmers.The establishment of Knowledge Domains Field Shops became a solution to multi-problems and as a platform for knowledge exchange. Thus served to acknowledge schools of thought and engineered the nature of educational commitments and knowledge sharing. Thus necessitated the ongoing transparency different perspectives and reflexivity between all stakeholders and disciplines involved toward community development, food security and sustainable livelihoods.

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