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AN EXTENSION APPROACH TO CLOSE THE GAP BETWEEN SUPPLIERS AND USERS OF AGROMETEOROLOGICAL SERVICES IN THE SOUTH-WESTERN FREE STATE OF SOUTH AFRICA.

Zuma-Netshiukhwi, G. N. C.[16] & Stigter, C. J.[17]

Correspondence Author: G. Zuma-Netshiukhwi - Email: ZumaNetshiukhwiG@arc.agric.za

ABSTRACT

Agrometeorological information, advisories and services remains one of the major hindrances toward productive agriculture. Well researched and scientifically proven information is inaccessible to most potential farmers whether commercial, resource poor or subsistence. A noticeable gap exists between information developers or suppliers and end-users such as farmers. This paper is aimed at discussing the existing gaps and practical solutions toward the enhancement of proper information dissemination. In workshops organised by the Agricultural Research Council in partnership with the University of the Free State on the training of extension agents the following was discovered: the interviewed extension agents indicated that 13% had good background on the application of agrometeorological information and 87% had no skill. About 80% followed the daily weather forecast. But 86% of the participants could not differentiate between short term forecast, seasonal and long-term predictions. The need for intensive training of extension agents on agrometeorological information, advisories and services was emphasised, since such information is the integral part of agricultural decision-making toward sustainable agricultural productivity and food security.

Keywords: Extension Approach, Agrometeorology, Advisories, south-western Free State

1. INTRODUCTION

Within the agricultural sector a number of stakeholders are involve such as research councils, academic institutions, department of agriculture and rural development, private sector but the central stakeholders are the end-users (farmers). Such role players necessitate critical roles toward the development of farmers. Different academic contributors are such as extension agents, agricultural researchers, advisors and educators forms integral part for improving agricultural information and educating farmers. South Africa is a land of contrast and dual economics in the agricultural sector subsists. This is comprised of well-established commercial farmers and poor resource farmers. Therefore, strengthening advisory service and intensifying training of extension agents and training of farmers and farmer to farmer information transfer, play a pivotal role toward food security and sustainable agricultural productivity.

The agricultural extension service in the Free State Province and South Africa at large, is predominantly about assisting farmers to be able to be hand-on and facilitates or coordinates resource utilisation and improving infrastructure on farms (Mutimba, 2014; Van Niekerk,

[16] Agricultural Research Council-Institute for Soil, Climate and Water, Glen Agricultural College, Glen, Republic of South Africa, 9360. Email: ZumaNetshiukhwiG@arc.agric.za Tel.: +27 (0)12 310 2500.
[17] Agromet Vision-Netherlands, Indonesia, Ghana, South Africa, Zambia, Zimbabwe, Groenestraat 13, Bruchem 5314 AJ, The Netherlands. Email: cjstigter@usa.net.

Stroebel, van Rooyen, Whitfield, & Swanepoel, 2009). The study area south-western Free State is comprised of well-established commercial farmers, up-coming commercial farmers and poor resource farmers. These dissimilarities are an indication of unequal level of agricultural productivity, access to information, farming skills, access to markets and many other factors. Agricultural extension service has to be designed in the manner that all types of famers obtain relevant information through extension agents to expedite sustainable agricultural productivity.

All types of farmers are faced by a variety of challenges ranging from environmental conditions, plant types, animal types and soil conditions. Extension models or approaches has to suit the type of a given farming situation considering local conditions. However, in the study area it is noticeable that a gap between information producers/suppliers and information users subsist. Therefore, the authors of this paper suggest that a peculiar extension approach to disseminate agrometeorological information is required. Such a model is to establish study groups that that are facilitated by extension agents and agrometeorologists in the study area toward sustainability and commercial viable. Thus to encourage famers to adapt as per given weather forecasts and climate predictions, and generate income from agricultural commodities for household consumption and to generate income.

Plants, animals and trees undergo life cycle changes as they encounter dissimilar weather conditions and are subjected to biotic and abiotic stresses (Davitt, *et al.*, 2011; Wahl, *et al.*, 2011). The most troublesome abiotic stressors occurring in the study area which are climate related are storm winds, extreme temperatures, drought, floods, hailstorm and wildfires, while biotic stressors include the living disturbances such as detrimental insects to agricultural production (Kanninena, *et al.*, 2013). After the development of sufficient and relevant agrometeorological information/advisories/services to counter those disasters and their consequences, training of extension intermediaries or extension agents/officers remains the most crucial part of information/advisories transfer and services establishment in farmers' fields (Zwane, *et al.*, 2015; Weiss, *et al.*, 2000; Stigter, 2010; Winarto & Stigter, 2011).

The implementation of this study made major changes in the availability of, and farmer's perceptions on agrometeorological information, advisories, services as well as the channels and methods of dissemination. Across the study area the use of Internet was only limited to a few commercial farmers. This is not just the case in the south-western Free State but it is true across the African continent. Currently, the most effective method of information dissemination differs from farmer to farmer and is predetermined by the farmer's capabilities; resource poor farmers in the study area mostly utilized the study groups and short message services. However, where people can assist to establish information, advisories, services, can be disseminated through to key communication outlets that are readily used by most people such as television, freely available local newspapers, local radio, bulletins, ward committees, extension forums and early warning committees. The agrometeorological details should entail relevant and tailor-made information/advisories/services that are directly useful to the farmers and the latter should be able to interact with the sources. For farmers in the south-western Free State to embrace the use of agrometeorological information/advisories/services would ideally require the interaction with extension agents to obtain the necessary knowledge.

2. DATA COLLECTION/ PROCEDURE

To discover the factors critical to the dissemination of agrometeorological information, extension service, suppliers and producers of such information and their perceived importance a number of 394 farmers and 30 extension agents were interviewed. The Farming Systems approach to Development (FSaD) was eventually complemented by the use of participatory tools (e.g. questionnaires, discussion in groups and with key informants, buzz questions) and techniques (e.g. a Participatory Rural Appraisal Approach). An action learning cycle was used in the FSaD where necessary, leading to the improved dissemination and application of weather/climate information and products/advisories in agrometeorological decision making for improved livelihoods. FSaD approach was used to understand current agrometeorological advisories and services (if any) and sources of weather/climate information, to identify and select appropriate channels for information communication/dissemination, and to derive rules for procedures, without scientists being involved each and every time, for enforcing extension potential, extension training and extension practice.

Action learning cycle also described as, plan-act-observe-reflect (Dick, 2002; McNiff, 2002; Tenge, 2005; Kramer 2007; Stringer, 2007; Serrat, 2008; Kelman, *et al.*, 2009) was neatly used to supplement the FSaD to interact with existing study groups, individual farmers and extension intermediaries to establish and describe the current farming systems. Subsequently, introduce agrometeorological information/products and then study the problems with and the impact of some relevant applications.

FSaD approach is comprised of four distinctive phases as follows: (a) Diagnosis or description of farmers' needs in relation to the agrometeorological information and advisories and services. (b) Design planning of the scenarios per agricultural enterprise through the use of participatory tools and techniques such as workshops, focus groups, key informants, formal and informal interviews, action planning, look and learn, role-play, learn by doing, observations and transect walks. (c) Testing and implementation through farmer-managed experiments according to planned interventions and activities. (d) Dissemination and impact assessment using dissemination methods as preferred by the farmers.

3. FINDINGS

3.1 Introduction

It was discovered through questionnaires that most extension agents in the south-western Free State area had no basic knowledge, understanding and training in agrometeorology and its applications to agriculture. Several gaps that were considered to hinder the process of information, advisories, and services flow from suppliers to users were:

- ✓ Lack of basic training on weather and climate knowledge and understanding
- ✓ Lack of training on basic operational agrometeorology
- ✓ Lack of communication between suppliers and users
- ✓ Lack of agrometeorological advisories/services available to farmers
- ✓ Lack of skills to interpret weather forecasts and climate predictions for agriculture
- ✓ Lack of information on the potential suppliers of agrometeorological information/advisories/services
- ✓ No clear channels of information dissemination
- ✓ Advisories available are too general, not understandable and not point specific
- ✓ No feedback from users to suppliers of agrometeorological information/advisories
- ✓ No availability of agrometeorological services
- ✓ Poor rainfall recording on farms

Therefore, training of extension agents in this study area became a priority since they are potentially the key people to close the gap between suppliers and users of agrometeorological knowledge and contributing toward sustainable agricultural development. Extension agents were involved in and facilitated the process of communicating agrometeorological information/advisories and assisting farmers in the development of decision-making for tactical and strategic operations and they ensured that the decisions were correctly executed. This means that training of trainers becomes the most important factor towards successful farming and to ensure that farmers get more self-reliant and independent.

The training of trainers exercise was to explore different approaches for the establishments of an extension agrometeorology (Stigter & Winarto, 2012) across the south-western Free State. The aim is that suitable intermediaries become well skilled to particularly articulate the needs of the farmers and of the farming community at large for agrometeorological information, advisories and services. The topics of interest that needed attention in the south-western Free State were in operational agrometeorology regarding agrometeorological services in relation to crop management, crop protection, monitoring and early warnings of natural disasters, and preparedness for other risks in weather and climate, making use of weather forecasts, climate predictions and other science-based information for agriculture.

3.2 Agricultural extension response to agrometeorological learning

During the diagnosis stage of this study, extension agents played a notable role to identify and access the farmers. They are familiar with practiced agricultural enterprises, challenges faced by the farmers and environmental conditions in the region of operation. The local study groups were identified with the assistance of the extension agents of the region, but other town study groups had to be established. Relating to the findings on the lack of agrometeorological services and advisories training of extension agents on weather forecasts, climate predictions and the application of it to agricultural decision making was conducted.

Trained extension agents consisted of animal nutritionists, animal health specialists, crop scientists, pasture & veld scientists and agronomists. The topics dealt with during the training were, among others, the interpretation of short-, medium- and long-range weather forecasts and climate predictions for agricultural purposes, crop type suitability, selection of crop cultivars, calculations of degree days (thermal time) for maize cultivar selection, maintenance and calibration of automatic weather stations. The institutions and organizations that were responsible for the development of agrometeorological advisories were listed to ensure that information suppliers were well known. The identified suppliers of agrometeorological information identified within the study area ranged from academic institutions, research councils, governmental departments and private sector service providers. The training focused on agrometeorological knowledge, concepts, principles and their application to agriculture training. Questionnaires were given to the extension officers prior to and after the training workshop to assess their level of agrometeorological understanding and to subsequently evaluate the training.

Facilitation of training of the trainers was structured in a very participative way. Under the main theme of operational agrometeorology, the crux of these workshops was based on the emerging practices in participatory poverty reduction and establishment of food security. Active agricultural enterprises and choices in different regions were discussed such as small and large stock production, vegetable production, grain and sunflower production. These were entry points in identifying the needs relating to weather and climatic conditions. The questionnaires were structured in a manner to evaluate extension agents' perceptions on weather forecasting and climate predictions and their understanding of and experience in agrometeorology as well as to discover whether extension agents could avail accessibility for guidance of daily agricultural activities to the farmers.

The findings on questionnaire analysis indicated that agrometeorological concepts are needed to be incorporated in agricultural training for improved decision making. Only 13% of the extension agents indicated that they had a good background and understanding of weather forecasting and climate prediction information and their application to agriculture, whereas 87% expressed to have very little knowledge on these subjects. Al least 20% of the extension agents did not often listen to weather forecasts nor did they receive climate predictions, while 80% listened to radio for daily weather forecasts and read climate information from the daily newspaper. About 56% of the extension agents did not personally receive directly any types of weather forecasts, 36% did receive rainfall and temperature forecasts and only 6% received all types of forecast personally. About 86% of the extension agents did not understood the differences between short term forecasts, seasonal and long-term predictions and 14% had a clear understanding of the usage of terminology. Only 16% of the extension agents indicated that their farmers did receive the weather forecast and climate predictions, but 84% indicated that farmers did not receive any type of weather forecasts or climate predictions. About 97% indicated that farmers should have access to agrometeorological information for decision making support towards improved agricultural productivity. About 70% of the extension agents had doubts on the reliability of weather forecasts and thought that the products were not user friendly and needs to be area specific.

At least, 90% of participants had good understanding of the meaning and the interpretation of normal, below normal and above normal rainfall from climate predictions while only 10% had no knowledge. About 79% of participants were able to explain the use of probabilities and make suitable recommendations. Participants were in the position to develop recommendations based on drought predictions. For examples, to minimize planting density, to plant drought tolerant crops, to reduce stock, provide fodder banks, to consider water conservation techniques, to allocate grazing camps accordingly and to buy supplementary feed/fodder, to plant under irrigation where possible. Although 27% of the extension agents mentioned that they could interpret the weather forecasts at their disposal, 93% requested thorough one-week training on agrometeorological information/advisories/services, as such information is the backbone of agricultural daily activities. Furthermore, the participants rated e-mail as the most preferred method of information dissemination.

According to participants trained during agrometeorology application workshop the received agro-meteorological advisories needs to be area specific and user friendly. The weather forecast should be point specific for effective information use. The extension agents in the south-western Free State recommended the development a regional early warning committee. Such committee require a collaborative effort from different stakeholders toward the development of local agro-advisories which are user friendly and point specific to minimise risks. Figure 1, displays the current flow of agrometeorological advisories within the south-western Free State. Such a flow of information and process provides no room for the feedback from the farmers to present suggestions, opinions and recommendations about the agro-advisory provided. The existing channels used for advisories and the manner in which it is developed and information entailed needs a thorough review toward betterment. In improved form it should address the specific recommendations for diverse groups of farmers, locally specific, user-friendly and the extension agents should be able to discuss information entailed within agro-advisories with the farmers and get feedback.

For the agrometeorology extension service to be effective in the south-western Free State a coordination centre for agrometeorology and agroclimatology information needs to be established. Such a centre should facilitate information relating to weather forecasts, climate prediction, climate change issues, precision agriculture, smart agriculture and all agricultural related information. Such a centre should have well-established and effective channels and methods of information dissemination peculiar to the needs of an individual or a group of farmers. Such a centre should facilitate the development of a localised decision support system.

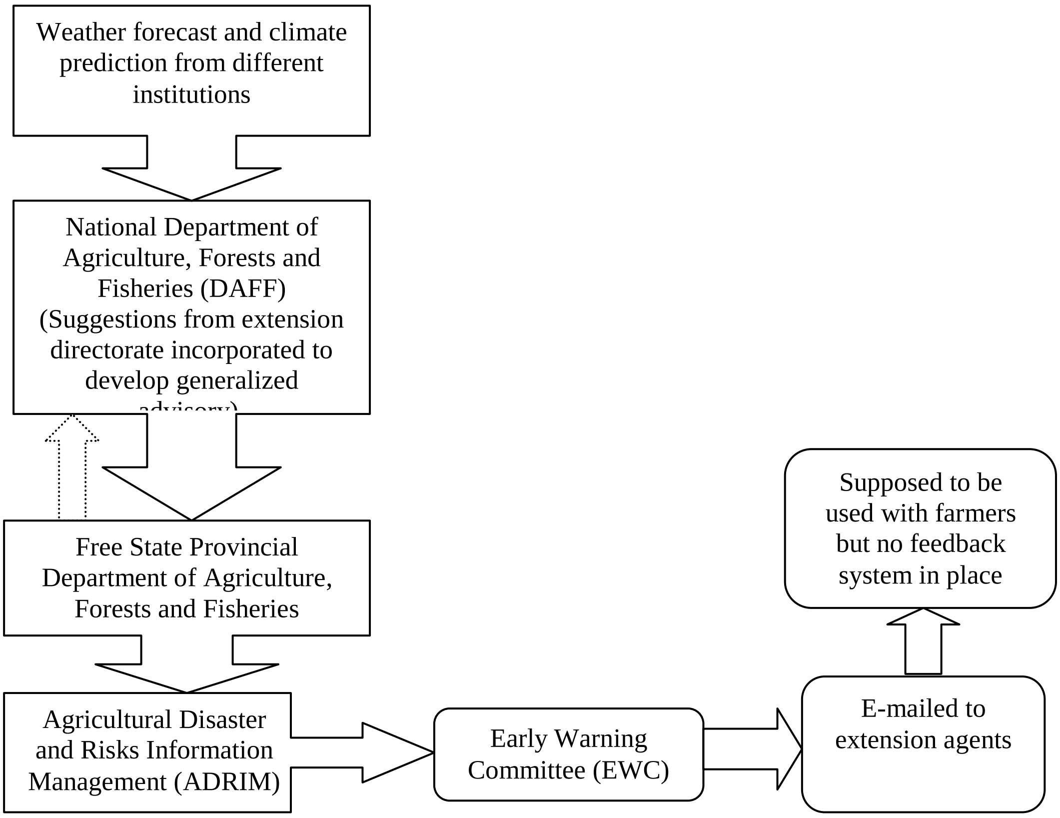

Figure 1: Current flow and development of agrometeorological advisories in the south-western Free State.

Therefore, for the improvement of agrometeorological information dissemination the listed ideas should be put into consideration. It is proposed that the Department of Agriculture and Rural Development and its entities should consider implementing the following thoughts:

i. to engage with a group of weather forecasters using different Global Circulation Models to request, downscaled climatic conditions per region at a high resolution,
ii. to employ a qualified team of agrometeorologists to develop tailor-made advisories per region and where possible per farm (see also Gommes *et al.*, 2010), this team has to develop and facilitate agrometeorological information, advisories and services and interact with the extension agents to address the needs of the farmers at grass root level,

iii. to encourage the development of tailor-made advisories which strengthen diverse farming methods and sustainable agricultural development,
iv. to implement conducive strategies of information dissemination as preferred and suitable for different farmers
v. delegation of weather forecasters/climate predictors and agrometeorologists to train extension agents during their monthly regional Extension Forums
vi. ensure dissemination of client friendly agrometeorological information/advisories/ services from intermediaries to farmers
vii. strategize and develop a two-way communication from farmers to intermediaries so that farmers' concerns can be sent back to advisories/services developers
viii. a two-way communication to give extension/feedback from farmer to farmer may positively influence the degree of application of agrometeorological information/advisories/services (as illustrated in Figure 2).

The most suitable manner of information dissemination discovered during the period of this study was the participation of intermediaries in the organized study groups per area. This platform encourages the interrogation and discussion of advisories for better clarity and good planning. The proposed strategy ensures open discussion and transparency from stages of information, advisories, services development to training of intermediaries and to the application of the ultimate results by the end-users. This strategy shall allow users from different levels of farming to be able to consider the relevance of agrometeorological information, advisories and services towards successful agricultural development. Ignoring the two-way communication may result in uncertainties and unnecessary information distortion. But with the provision of an open end situation, smooth flow and understanding of information, advisories and services may have outstanding results.

The agrometeorological information is very relevant to the changing climatic conditions which are dominated by more and more severe extreme meteorological and climatic events. The proposition from the farmers was the intensification of Agrometeorological Information days across the districts. The advisories were for the benefit of the intermediaries and the end-users to develop and make informed decision toward improved agricultural sustainability and productivity.

Advocacy in the implementation and expansion of the application of agrometeorological information, advisories and services should be possible by the support from the provincial ministry of Agriculture and Rural Development. This research study on extension agrometeorology focused on the Modder/Riet catchment in the south-western Free State. Promotion is only possible through the study partners' networks and the study anticipated contributing to developing a replicable model of study groups for sustainable agricultural productivity. With study groups in all identified towns of the study area, during the meetings the intermediaries and the farmers were empowered to be able to develop their own local weather and climate coping strategies.

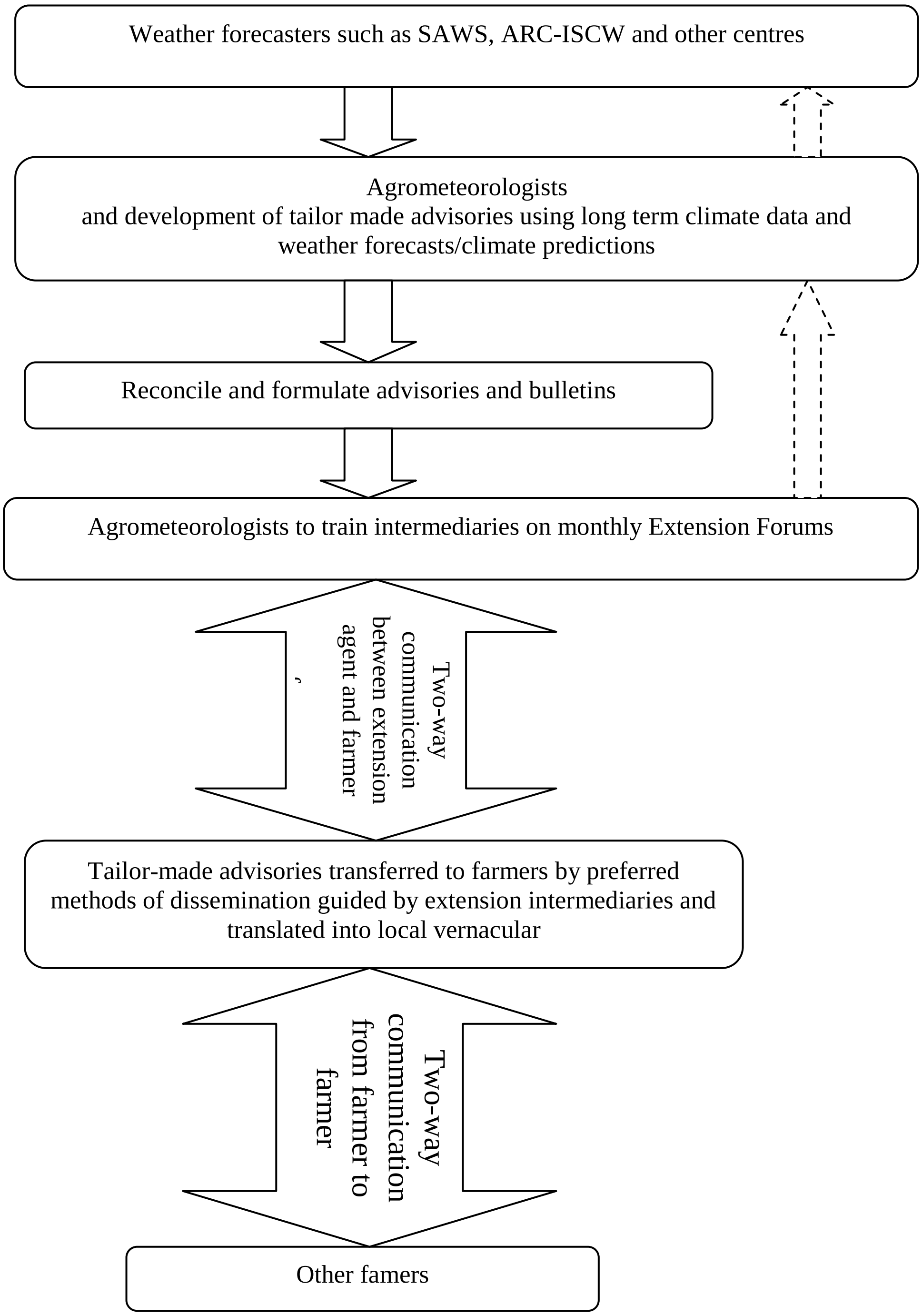

Figure 2: Recommended strategies for agrometeorological information/advisories/services development, transfer and sharing.

3.3 Farmers response to agrometeorological learning

Promoting science-based information to the farming community is a critical step toward successful farming. Scientific agricultural information evolves on yearly basis. Such information relate to change of cultivars, breeds, soil conservation technologies, planting technologies, pests and disease control measures, storage measures. During the engagement with the farmers, assessment and evaluation of the availability and the application of agrometeorological information, advisories and services in the study area and the farmers were monitored and evaluated from the inception to the last phase of the project. The purpose of this exercise was to determine the performance, production as to the final yield or outcome was used as an indicator.

The farmers were exposed to weather forecasts, climate predictions and other science-based information. Agrometeorological advisories were developed and sent to the extension agents and through them to farmers. Exposure to such type of information was gradually adopted by the farmers and the extension agents. The final workshop was conducted for all study groups to determine the experience of the farmers in agrometeorological learning. The guiding questions were prepared to probe for more information and ascertain the response from the farmers. During the final workshops farmers were divided into smaller groups of 3-5 participants per group. These sub-groups were given 5 minutes to discuss and write down the answers.

During the process of facilitating this exercise, observation of the behaviour of farmers and listening to arguments in groups were other tools used to combine the response from the farmers. Participatory approach contributed to building agreement and collective learning during farmer discussions. This assisted farmers to feel empowered in the process, which increased self-confidence in application of agrometeorological information, advisories and services and lead to substantial change. The focus was on exploring different farmers' stories and on-farm experiences. Adaptation of agrometeorological information was accumulated from season to season, although some farmers seemed not to be well equipped to handle and deal with new information and new challenges. But with proper monitoring and evaluation during on-farm visits, farmers developed confidence and determination towards adopting agrometeorological information, advisories and services and moved from the usage of indigenous observation technique. For example, the turn up at study group's workshops gradually increased and the enthusiasm to learn accumulated.

The study groups presented a very diverse situation in terms of experiences, challenges and needs that are related to their farming. The consequences of increasing climate variability needed greater emphasis as to farmer's ability to develop on-farm coping strategies and interventions. A successful farmer should understand the local trends in climate change and how agricultural outcomes are influenced. For example, the concept of response farming (Stigter, 2010) prepares the farmer to be aware of past and future climatic conditions and of the extent of increasing climate variability and related dangers and interventions to reduce vulnerabilities.

During the duration of the study, climate monitoring, record keeping and improved preparedness, pests and disease forecasting were the most emphasized issues during in-field training. Climate monitoring was emphasized with the use of rain gauges to measure rainfall and keep daily records. Record keeping played another new role for farmers to record all activities implemented on-farm against time (Winarto & Stigter, 2011). This allowed farmers to reflect on decisions taken and to make prompt adjustments where possible. But discussions on improved preparedness were the most crucial component of successful farming. These discussions were supported by timely provision of weather forecasts, climate predictions and other science-based information. For example:

- ✓ Swiss chard producers, raised concerns about the reduction of leaf development in winter season as it resulted in poor supply of bunch to the market. Continual supply is only satisfactory during summer season. These farmers were encouraged to invest into frost nets and to practise conservation agriculture as improved preparedness to allow continual and frequent market supply for winter and summer season.

- ✓ Farmers with access to water were encourages to give provision for supplementary irrigation and sequential planting was adopted. For example, in one farm: the 1st transplanting was conducted in the 2nd week of July when15000 plants/0.5ha of Swiss chard was transplanted. The 2nd transplanting took place in the 2nd week of September with again 15000 plants/0.5ha and the 3rd transplanting was in the last week of November, whereby 20000 plants/0.5ha were transplanted and the last transplanting was done in the last week of December with 35000 plants/ha. Continual supply was experienced and the income increased. Sufficient money was raised for expansion and crop diversification, when cabbage and onion seedling were planted 36000 plants/ha cabbage and 40000 plants/ha onions during winter season.
- ✓ Most farmers, who only chose to supply cabbage, were able to make adjustments and introduce different cabbage cultivars for winter and summer season (Table 1). Sequential cropping was also adapted by famers for continual supply to the market.

Table 1: An example of sequential cabbage planting adopted by farmers in the study area

Planting date	Cultivar	Number of hectare	Plant density	Harvest	Estimated income @ R3/head
15 October	Summer	1	36 000	35 000	105 000
15 November	Summer	1	36 000	35 000	105 000
30 November	Summer	1	36 000	35 500	106 500
15 December	Summer	1	36 000	35 000	105 000
March	Winter	1	36 000	35 500	106 500
April/June	Winter	0.5/1 (available field)	15 000	14500	43 500
Total					R 535 000

- ✓ Responding to tailor-made advisories developed some farmers negotiated with the Department of Agriculture through Extension Agents for plastic tunnels. The tunnels were erected for vegetable production under cover. This recommendation was prompted by very dry conditions in summer and very cold conditions in winter, some farmers had experienced the effect of cold spells whereby, for example some farmers had lost tomato plants of 0.5 ha when unexpected frosts were experienced.
- ✓ Beans and green beans producers across the study area raised a concern about experienced situations of water logging after above normal rainfall prediction that also actually occurred. The farmers were advised to select other types of crops such as maize and pumpkin which are more resistant to water logging.
- ✓ Livestock farmers appreciated the skill when above normal rainfall predictions since it gives hope for revitalized pasture growth for animal grazing. But worries came with the 2010 outbreak of Rift Valley Fever and other diseases related to above normal to above-normal rainfall conditions. For predicted drought conditions farmers prepare timely for supplementary feed, provision of water supply in drinking points and shelter for shade to minimize the possibilities of heat stress.
- ✓ Wheat producers in Koffiefontein and Thaba Nchu appreciated the provision of agrometeorological advisories since they were able to prepare their activities based on the short-term predictions for within the season activities and beyond harvesting. It was recorded that farmers had previously experienced heavy rains when wheat grains were just about a week before maturity. Such continuous rains that were not expected interfered with growth to full maturity as the grain seeds began to sprout prior to harvesting.

In partnership with the agronomy wing of the Agriculture ministry in the province, upon outbreak of diseases and pests, farmers were provided with prescribed chemicals. The role of the agrometeorologist was to ensure that spraying was conducted on dry days, with the benefit that the chemicals sprayed were not washed away by water, and that spraying was not done during windy days.

The most valued strengths of the project were the farmer's newly found agrometeorological skills for on-farm decision making and the better understanding of the roles of different stakeholders. During study group meetings information exchanged from farmer to farmer and from extension agents to farmer and vice-versa. Picture collected by agrometeorologist during farm visits and transect walk were utilised as the teaching aid to avoid the repetition on same challenges. Such pictures were used as examples and for further learning. The in-field training for farmers and organized special workshops for extension training were the successful tools for knowledge transfer. For example, during the on-farm installation of Automatic Weather Stations (AWS) in selected few farms in Sannaspos (2), towards Ladybrand (1) and Petrusburg (1) in-field training occurred, giving farmers knowledge and understanding of the importance of AWS.

3.4 Farmers response to agrometeorological learning

The concept of an extension agrometeorology approach (Stevens, *et al.*, 2006; Stigter & Winarto, 2012) holds great possibilities to train intermediaries and farmers on the application of science-based information. During the course of the study, farmers in the study area were trained by agrometeorologists, but training of extension agents was a priority and enforced for the proper training of the end-users. Agricultural success is established by the implementation of recommendations made on advisories and by the establishment of agrometeorological services leading to a significant decrease of losses and increase in production per farm. Despite the imbalances that transpired of the number of farmers per extension agent in the south-western Free State, training was emphasized for improved production.

Science-based knowledge and understanding as support for developing solutions for agricultural decision making is generated from universities, agricultural research organizations, meteorological services and other environmental services institutions. To clarify the process on agrometeorological information, advisories and services generation/development by intermediaries for farmers as end-users, Stigter's conceptual and diagnostic framework applies (Stigter, 2006) (Figure 3). This framework consists of three pertinent domains: the contemporary pools of knowledge, extension intermediaries (and their supporters) and end-users (the livelihood of farmers) which are known as C, B and A domain respectively.

This framework elaborates on two-way information exchange from basic scientists to extension intermediaries (and applied scientists supporting them), and from the latter to farmers and their livelihood systems. So the A-domain represents the livelihood of farmers into which agrometeorological services should be established. The B-domain represents the process of advisory/knowledge/services generation with the involvement of intermediaries to train the farmers. The C-domain represents a pool of science-based knowledge (Stigter *et al.*, 2000; Stigter, 2005; Stigter, 2006; Stigter, 2010).

This end to end model was indirectly witnessed for the duration of this study to be an appropriate model to close the existing gap between extension agents and farmers for improved livelihood. In the C-domain, different types of basic and derived knowledge such as long-term climatic data, soil characteristics, frost probabilities, climate bulletins, crop types and cultivars, crop suitability were used to run models and generate other knowledge in that C-domain. The results were used for the development of advisories and services (solution scenarios) in the B-domain. These advisories and services were contributed to and reviewed by intermediaries and applied scientists and were proposed to farmers and to the immediately related extension agents in the A-domain.

Research in this regard played different roles, purely supportive in the C-domain and applied, solution oriented, in the B-domain. The advantage of this picture of reality is that applied research is directly involved in understanding and solving the frustrations and challenges of the farmers. The disadvantage is that this is too big a load of work for only one portfolio. Therefore, training of extension agents becomes crucial to learn about the development of advisories and services and how to apply them with the farmers.

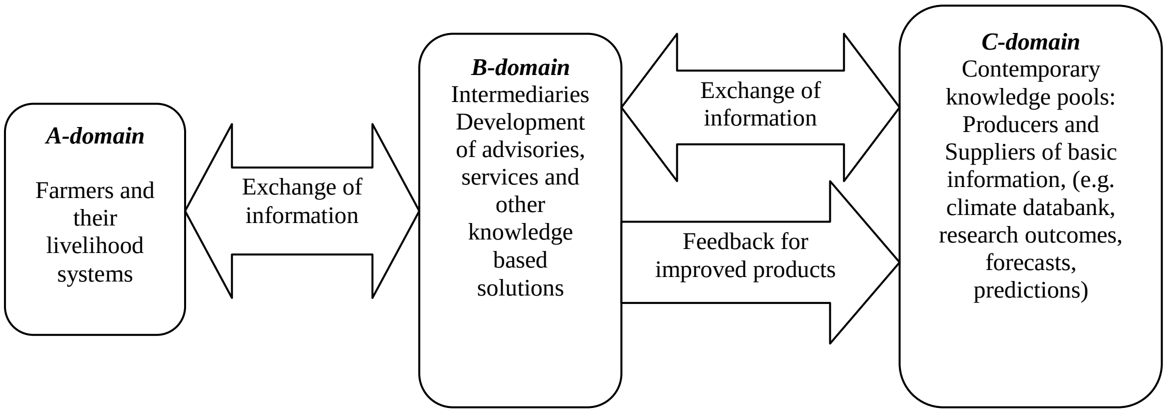

Figure 3: End to end information flow resulting in problem solving in the livelihood of farmers. In the B-domain extension intermediaries are involved in producing solutions that can be applied in the livelihood of farmers (Stigter, 2006; 2010).

Participatory tools were used and introduced to understand the livelihood systems and farming systems during training workshops with the farmers. In the previous discussions it was clear that farmers were not well-equipped for the interpretation of weather forecasts and climate predictions and for the application of other science-based information, while the same was the case with the extension agents. Therefore, more focus should be directed in the B-domain towards the training of extension agents. Such an intensification of training of intermediaries is the only solution to close the gap between the A-domain and the B-domain, finally using contents of the C-domain also to the benefit of resource-poor farmers.

An example from research diary whereby two farmers of which one was equipped with the application of agrometeorological information/advisories/services and the other was not. Ignoring the importance of training extension agents had a negative impact for the farmers of their concern. Good decision making supported by the application of agrometeorology awards farmers with better yields. During on-farm visits, it was identified that the crop status of resource poor farmers was below average and of low quality for the 2008/09 season compare, although it was a season of good rainfall, with above-normal rainfall predicted and experienced. Advisories were now developed prior to the onset of the season, to guide the farmers based on the seasonal condition for 2009/2010, where for the October-November-December (OND) and for the November-December-January (NDJ) periods the rainfall forecasts were below-normal, but for the January-February-March (JFM) period above-normal rainfall was expected. Advisories entailed recommendations on crop type selection, cultivar selection, planting date selection and basic management strategies. Late planting of a cultivar with a short maturing time in the last week of December 2009, with increased plant population, were the recommended options under these late above-normal conditions. However, not all farmers took attentiveness and delayed planting. For example, farmers who insisted and planted on 30 November 2009 harvested 1-2 ton/ha, while farmers who planted on 27 December 2009, three days before the actual onset of rainfall, and in July 2010 harvested 2-3 ton/ha.

Therefore, in the south-western Free State case study, it was discovered conducive to separately consider information producers, intermediaries and end-users. The system of extension approach of the Department of Agriculture can be effective by training extension agents to train the farmers. Extension agents, which we can safely call intermediaries, should focus on taking part in this new extension agrometeorology approach, and should focus on the following tasks:

- ✓ Training of farmers during on-farm visits and study groups;
- ✓ Where necessary and possible arranging with information producers to conduct in-field training for farmers with the extension agents being present (this method was baptized "Science Field Shops" by Stigter & Winarto (2012) in Indonesia and has been successfully applied there since 2008); and
- ✓ Giving feedback to the information producers for further improvements according to the needs of the farmers.

The above approach can be adopted on complementing and improving the extension approach which is now operational and already established. The most important factor is to equip extension agents to be able to transfer/establish agrometeorological information/advisories/services to/with farmers. The approach will build more confidence and strength the relationship amongst information producers, local extension agents and users.

4. CONCLUSION

The study examined an approach that is suitable for the delivery of agrometeorological information, advisories and services with south-western Free State. The study has highlighted the challenges faced by the farmers, by extension agents and agrometeorological information producers and suppliers. The main challenge encountered was the existing gap between the information suppliers and users. Therefore, end to end information flow from A-domain to B-domain and C-domain is suitable to understand the farmers and their livelihood and the development of tailor-made and user friendly agro-advisories. Intensive training of intermediaries is critical in enforcing the adoption of agrometeorological and agroclimatological information for improved decision making.

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