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INDIGENOUS KNOWLEDGE SYSTEMS: CHARACTERISTICS AND IMPORTANCE TO CLIMATIC UNCERTAINTY

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ABSTRACT

This paper details the importance of indigenous knowledge systems in developing countries around the world. Farmers, communities and households that live in risky environments, have developed intricate systems of diversification that help secure income and food consumption. An integral part of these systems are the knowledge systems that help households plan for future events and decrease uncertainty. Recently indigenous knowledge systems have been given more attention as their importance is addressed in development projects. Unfortunately acknowledgement and understanding of how knowledge systems are used is still not a basic part of all research. This is especially important in the recent advancement of climate and weather forecasting. Scientific advancements can aid poor countries only if knowledge systems are accessed and understood. Also forecast techniques will not improve welfare if they do not first address what households, farmers and communities need, want and lack.

INTRODUCTION

Due to risk and uncertainty that households may face in a single year a variety of complex production systems have been developed to provide for food and economic security. The production methods vary across regions, countries and continents but they all have been developed by the locally defined conditions and needs agriculturists face. An accumulated set of knowledge is commonly termed as indigenous knowledge systems (IKS). However, for poor households, especially in the developing countries, adaptation and coping strategies are closely linked to the adverse climates and resource poor areas in which they live. IKS for these communities are especially important because they provide farmers and households with the ability to survive and produce under risk due to, amongst others, climate, environmental constraints and incomplete market structure.

While numerous research efforts have been conducted on the importance of IKS and the need to incorporate it into development projects, there has been minimal investigation of the scope of climatic knowledge. The purpose of the paper is to add a new dimension of IKS in the area of climatic research. The structure and use of meteorology is changing and new focus has been placed on the use of climatic forecasting in agriculture. These could be beneficial, harmful or neutral to vulnerable households. This paper will attempt to illustrate the importance of the fusion of both modern technology and IKS in the hopes to provide certainty and the ability to plan for the future. Without acknowledging and respecting IKS, households will not be able to adapt or evaluate how modern climate forecasting systems can improve their livelihoods.

The paper is composed of three main sections. In the first section a workable definition of IKS is developed and the characteristics are discussed to understand how the system functions with the community and individual members. In the second section of the paper, involvement of IKS in research methods and development projects will be analyzed and possible avenues for current incorporation of IKS into evolving development models discussed. In the last section of the paper a discussion of the interactions of climate and human behavior will be examined, especially as it relates to developing countries which are affected by climatic anomalies, such as El Niño.

INDIGENOUS KNOWLEDGE SYSTEMS

Although there are a number of disagreements of how important IKS is in relation to Western Knowledge, there is a general consensus of IKS characteristics that can be identified in all societies (Agrawal, 1995). IKS serves many functions for a community, household and individuals by functioning as a base of knowledge to help process information, promote efficient allocation of resources, and aid in production method decisions.

CHARACTERISTICS

The first characteristic of IKS is that is composed of knowledge from previous generations. The knowledge set provides structure to explain relationships between particular events in the community. Bharara and Seeland (1994), in their study of the Rajasthan, have observed a number of indicators that exist to predict certain climatic events and its effect on agricultural practices. The development of these indicators was purely observational and provides a base for current generations to understand what is normal and what is an anomaly (Bharara and Seeland, 1994). The knowledge set is influenced by the previous' generations observations and experiment and provides an inherent connection to one's surroundings and environment (Woodley, 1991). The knowledge is characteristic of the local climate, flora and fauna, and cultural traits (Woodley, 1991). Therefore IKS is not transferable but provides relationships that connect people directly to their environments and the changes that occur within it.

While Woodley (1991) is attempting to make an ecological statement about IKS, defining IKS as a society's connection to their surroundings and environment, it can also be interpreted to be a person's connection to their culture and society. IKS is learned and identified by communities and people within a cultural context (Fields, 1991 and Bebbington, 1991). The knowledge base thus uses a specific language, sayings, and belief processes. This allows for cultural interaction and acceptance that is not identifiable in other situations or cultural contexts (Bebbington, 1991). Not only does the knowledge base identify the culture from others but also it provides for social interaction and acceptance (Bebbington, 1991).

DEFINITION

Consolidating all the important components of IKS a workable definition comes into view. First, knowledge is derived from experiences and observations, both from current and past generations. This knowledge base is transcribed and understood by participants through actions, such as production methods, verbally through sayings and myths, or by cultural events which are unique to the community and environment. The knowledge base provides cultural acceptance and identity and participants relate to all events and experiences from this worldview.

Therefore IKS can not just be defined by a certain tribe or ethnic background, but by its locality. Kloppenburg (1991) agrees that the knowledge base is local in the sense that it is produced from its surroundings, the economic and social activities, and the unique environment, both social and physical aspects. The use of indigenous is also misleading, since a community may possibly have a mix of ancestors and influences in their past and current history. For example in Latin America, there is a mix of agricultural practices that have developed because of the influence of Spain, since their conquest in 1531 (Fields, 1991; Gade, 1992). This socio-historical perspective provides the reader and researcher with an important clarification on how to understand knowledge systems.

Kloppenburg (1991) makes a clear distinction between scientific and local knowledge. Scientific knowledge is one in which the ideas, theories and concepts are "immutable mobiles." This implies that the knowledge is transferable, mobile and not tied to a singular locale, as opposed to local knowledge which is not mobile but is dynamic and thus mutable (Kloppenburg, 1991). This paper disagrees with the clear definition that is set between the two knowledge bases. With the advent of globalization many subsistence societies are fusing modern technologies with their traditional practices. Therefore knowledge systems in a locale are influenced by "immutable mobiles" and adapted. Many cultures adapt certain aspects of this knowledge base to the characteristics in the zone (Glade, 1992; Bebbington, 1991). This is once again an argument for a soico-historical perspective and not one that is delineated by origin of the knowledge, but instead in the use, adaptation and practical use of the knowledge in a certain locale. Therefore, IKS should be defined as local knowledge systems (LKS).

While this provides a workable definition of LKS it does not provide an understanding of particular aspects, characteristics and benefits to the users. Some argue (Agrawal, 1995) that LKS does not merit a separate classification. This idea has been supported give value and credit to the knowledge making it an essential part of the system and one that is found in all areas. This paper disagrees with this concept of LKS. LKS is unique because of the subject matter it possess, the contextual context, and the way in which it is used and interpreted. It is necessary that it is defined separately or else researchers, scientists and policy makers who work in development will not take extra care in incorporating it into current projects. Before a discussion of past development failures and areas to incorporate LKS an overview of distinct aspects and benefits of LKS will be discussed.

ASPECTS OF LOCAL KNOWLEDGE SYSTEMS

The use of LKS to provide rationalization and a decision process does not provide people with an individualistic view of themselves that is separate of their environment, since their daily decisions are based on interactions with their surroundings (Woodley, 1991; Biggelaar, 1991). Since all aspects of the community are intertwined in LKS it is hard to isolate agricultural knowledge, cultural events and climate forecasting from each other since each is an integral part of the other (Osunade, 1994). This is an important difference from western knowledge in that every function of society is incorporated into each other and people can not separate their individual decisions concerning agriculture from traditional social events. Rocheleau (1991) defines this as the science of survival where LKS combines social, economic, and ecological strategies to manage high-risk production patterns. By understanding how the components work together one understands how each aspect is dependent on the other and can not work separately. This can also be observed in the myths and folklore of certain societies that provide governance of agricultural planting times and decision practices (Woodley, 1991;

Rocheleau, 1991; Bharara and Seeland, 1994). Without these traditions people can not be included in the society.

Within a community or a system of knowledge, there are subsets of information that are possess and not held by all in the community. In all communities there will be one farmer who excels or one person that had skills in healing sickness. Also women have a unique knowledge base, which man do not have access to (Rocheleau, 1991 Bebbington, 1991, Biggelaar, 1991). It is important to note this aspect and understand how the different knowledge sets interacts within the community and the larger set of knoweldge. As mentioned previously, women in Africa, had exceptional skills in providing food during drought years. Women's role in many poor areas is to provide the food for the family and out of this has developed a knowledge that helps to forage and secure food during climatically uncertain or vunerable produciton seasons (Rocheleau, 1991).

Since LKS is formed by observations and experiences each person adds their perspectives, slightly altering and adapting the knowledge system to current needs and circumstances. This is especially important when dealing with climatic changes, such as drought or ENSO events, or the introduction of modern techniques, such as tractors or improved seed varieties. LKS is dynamic in three ways when confronted with unique observations and experiences or the introduction of alien technologies (Bebbington, 1991). The first is the replacement of prior ideas and values. LKS is constantly being revised by outside influences, especially market development. With the introduction of markets and the ability to sell crops, many traditional crops are no longer grown since monetary reasons prevail over subsistence needs. Second there could be a reinterpretation of prior ideas. Bebbington offers the example of the indigenous use of the "cuy", guinea pig, to diagnose internal illnesses in Ecuador. With the introduction of the X-ray machine, the cuy is compared to the x-ray, instead of being replaced by it. The final method of modifying LKS is with the incorporation of modern ideas into the existing knowledge system. For example Hess describes the efforts of a Peace Corps volunteer who tried to introduce new cuy production practices. When the farmer moved his cuy into a separate area outside of the kitchen, the volunteer was convinced his superior animal production practices had prevailed. Instead, the farmer had moved the cuy for personal reasons, which did not correlate with the volunteer's explanations. In other words modern practices may be incorporated into the daily practices but under the definitions and understanding of the local knowledge system (Hess, 1997).

BENEFITS OF LOCAL KNOWLEDGE SYSTEMS

The most important aspect of LKS is that it creates a moral economy. LKS identifies a person within a cultural context, therefore providing decision making processes or rules of thumb to be followed based on observed indicators or relationships within events (Bharara and Seeland 1994, Woodley 1991, and Biggelaar 1991). Members of communities act within these rules of thumb to maintain security and assurance, or risk isolation from their community. In an uncertain and biased world these rules of thumb provide people with a sense of community, belonging and stability.

The moral economy established by the knowledge set also decreases transactions costs. The need for the knowledge set is exemplified by the institutions and rules that are created within communities and regions (North, 1990). Institutions allow for a decrease in costs, by providing knowledge that all people can access and understand. It also provides ease of communication and ability for individuals to work together. The community aspect of local knowledge systems also helps in providing order and acceptance of local traditions (North, 1990). The knowledge base provides order and logic within a system and community, which is separate from other worldviews. While these rules of thumb aid individuals to work together it also provides the ability for communities to establish control and complete necessary social work that aids in the function of towns. Therefore a LKS plays an important role in cohesion in terms of households and communities.

Rules of thumb help to create order out of disorder and explain how events occur and how to survive within the environmental constraints and uncertainty. These indicators and decision-making processes thus provide mental reliance for farmers when faced with uncertainty and risk (Bharara and Seedland, 1994, Walker and Jodha, 1986). When faced with uncertainty a farmer may not know what the best option will be for his crop or animals. LKS provides standards and rules which all members in a community follow, giving the farmer assurance that he is doing all that is possible (Bharara and Seeland, 1994). These standards allow a process of communication or a forum in which farmers can discuss production options and decisions can be assessed using a collective decision process based on the knowledge of ancestors. If the decision does not provide the expected results it is added to the knowledge base and will aid farmers in future years.

Diverse production systems insure that risk is minimized and ensure the survival of the community or household (Biggelaar, 1991, Bebbington, 1991). To ensure food and economic security farmers may experiment with existing practices to adapt them to changing conditions or to improve yields. Therefore, farmers are by definition scientists, since they are constantly experimenting and attempting to improve current practices (Bebbington, 1991; Biggelaar, 1991). Kloppenburg (1991) also cites the important nature of experimentation to farmers as an essential tradition and characteristic of the knowledge base. A study of soil classifications by the Zuni in New Mexico showed similar methods of classifying and explaining soils types as soil scientists did. Other agricultural examples of experiments are the use of intercropping and staggered planting. Innis shows how intercropping produces different microclimates and how companion planting provides a higher yield and decreases risk related to climatic changes. Women also possess extensive knowledge of local plants that can be found during poor agricultural years to provide food security (Rocheleau, 1991). The knowledge and experimentation involved with identifying foraging plants is a unique set of knowledge that must be accessed during vulnerable years. These few examples show the ingenuity and ability of farmers to manipulate their environments and produce favorable results.

LKS has distinct characteristics and benefits to its users but unfortunately has not been an integral part of development projects. The next section will highlight failures, achievements and future possibilities for development projects, especially in the context of climate.

DEVELOPMENT AND LOCAL KNOWLEDGE SYSTEMS

Historically, development projects have been created, funded and managed by outside resources and introduced into poor communities with the hopes and promises of restoring food and economic security. Oftentimes culture was seen as an impediment for the success of the project, which created conflict and resulted in low participation and success rates (Woodley,1991, Bebbington,1991). By addressing problems of poverty and hunger as a lack of knowledge, created programs that increased the supply of scientific knowledge, such as improved seeds, advanced agricultural techniques, or medical information (Mansuri, 1999,). These programs soon failed since poverty, inequality and hunger were not problems caused by failures of the supply chain. Programs also failed because they refused to acknowledge that local traditions are a cultural framework and a form of science and knowledge to these communities but also because current systems were designed to ensure survival (Fields,1991, Bebbington, 1991, Woodley, 1991).

As a result of these failures, there was a growing interest in the incorporation of local knowledge and traditions to increase project participation rate and provide environmentally sound approaches to development (Bebbington, 1991, Woodley, 1991, Fields, 1991 and Norton et. al, 1998). Rural development programs were advocated, which were the first to recognize that rural life was complex and that various factors were included in poverty problems that could not be changed by addressing isolated problems (Carney, 1999). But due to bureaucratic problems the programs were questioned and emphasis moved to structural adjustments that would create more efficient market structures (Mansuri, 1999, Carney, 1999). However structural adjustments and changes in development programs did not bring the end to income inequality and poverty that was hoped.

A livelihoods approach was proposed that would address the local and national issues and the complex issues that the rural poor live with and survive in (Carnay, 1999). Acknowledgement that farmers are well equipped at understanding and solving problems which their community and farms face is the necessary step in the livelihoods approach (Bebbington, 1991, Biggelaar, 1991). Unfortunately we live in a dynamic and unstable world, where policies and economics play a complex role in the lives of communities and people that may not even know these exist. Therefore it is not also viable that farmers and communities be left alone, since there may not be a time nor a chance for a community to organize themselves on their own.

In order to combine both local knowledge systems with outside knowledge certain steps must be taken. The first step is acknowledgement that LKS has provided communities with the capability of dealing with pressures such as population growth, economic crises and wars. To enhance cooperation projects must show the importance of trust and local understanding of language structure. Projects must also encourage the highest level of local participation and must do so by analyzing the nature in which communities and households interact and share ideas. Fields (1991) believes that by recognizing the sovereignty of people allows them to develop the skills and practices necessary to forge their own path. Participation and equal status of participants are an important involvement in this model, which is necessary for empowerment and development (Biggleelaar, 1991).

Diversity of language, problems and household structure is another important aspect of development programs. Peasant households are often defined by their partial engagement in market economies (Ellis, 1993) thus creating different sets of goals and objectives for households. Subgroups of knowledge are also apparent in communities. Women possess many ideas and knowledge that could be vital to the success and development of many development projects (Rocheleau, 1991). In an agroforestry project conducted in Kenya, scientists learned hands on the importance of involving women in projects concerns. The project tried to introduce alley cropping in five villages, but soon the nursery established to grow the trees soon failed since women were not consulted and they were in charge of collecting water. This example provides an opportunity to analyze the diverse roles and jobs that are delegated in a community according to gender and may influence the success of a project if not all members are consulted. But the most important lesson learned during the project occurred when a drought developed in the region. Researchers noticed that women had extensive knowledge of plants and tubers that were used to sustain the families during the food insecure period. This knowledge was unique to the women and served as an important base to develop a project to propagate the species and then to introduce other trees and plants that could supply food for the family. A gap of knowledge between older and younger generations was also noted and the importance of securing the knowledge was deemed even more crucial (Rocheleau, 1991).

Increasing participation, assigning value to LKS, and recognizing diversity of knowledge within communities is an important step at creating development projects. But a way to foster and encourage local efforts and participation within projects can be done by exogenizing indigenous knowledge. By publicizing and creating recognition of the knowledge you give power to the indigenous people (Bebbigton,1991, Biggelaar, 1991). Studies of drought and famine has shown that susceptible communities rely on social networks to provide food and resources during vulnerable years (Rocheleau, 1991, Walker and Jodha, 1986). Often farmers cite their agricultural practices based on what an expert farmer in the neighborhood is practicing. (Bharara and Seedland, 1994, Osunade,1994). By capitalizing on these networks, developers can understand the communication and transmission of ideas and use this to encourage participation and development of projects (Rocheleau, 1991 Woodley, 1991, Biggleaar, 1991).

To generalize and conclude the discussion on development projects it is important to note that all authors encourage the development of LKS, but not as a substitute of outside knowledge. It is important that the two are complements and learn from each other (Bebbington, 1991; Kloppenburg, 1991). Government, agencies and private enterprises have an important role in the welfare of the rural poor, since they develop policies, affect research and provide resources (Mansuri, 1999). Therefore the solution is not to ignore one and focus on the other, but to work together to find viable solutions. The Conference on Hunger and Poverty states the purpose aptly : " Going one step further is the recognition that the poor are not so poor that they cannot even think about solutions. . . building bridges between people's knowledge systems and aspirations and the national and international research and extension systems."

LOCAL CLIMATE KNOWLEDGE AND CLIMATE FORECASTING

Climate is one of the main factors affecting people, nature, and economic activities around the world (Office of Global Programs (OGP)-NOAA, 1999). It is especially important in production decisions for farmers in developing countries (Valdivia and Jette, 1997). The predictive techniques employed in climate forecasting, such as General Circulation Models (GCMs), are improving in accuracy (Blench, 1999), especially for one of the world's strongest known climate patterns. The El Niño Southern Oscillation (ENSO) event, which warms and cools the waters of the equatorial Pacific Ocean (Stern and Easterling, 1999) affects economic and behavioral activities around the world. Being able to forecast these climatic anomalies is very important especially for vulnerable rural producers who live at a marginal level. Countries more reliant on local knowledge systems may be more vulnerable and less prepared for these weather conditions (Osunade,1994; Bharara and Seeland, 1994). While the vulnerability of these countries is greater, there exists a large body of local knowledge about climate and weather patterns.

The importance of climate in our daily lives is shown in the wealth of local knowledge based on predicting weather and climate. A study of weather knowledge in the village of Machache in Lesotho revealed the wealth of knowledge that farmers possessed. Pepin (1996) documented their knowledge into three basic categories. First there were truths that could be held around the world, since the beliefs were based on scientific principles. For example the correlation between halos around the moon and the likelihood of rain. Second beliefs that developed on correlation not causality. For example a local experience or observation that has developed into a belief without understanding the underlying link that causes the relationship between the two. Finally, the last types of knowledge are beliefs that are based on local knowledge and experiences and have no scientific basis. In studies of rural producers, the more reliant on subsistence living the more vulnerable the producer will be to outside shocks, such as climate events, to their production systems. This requires detailed knowledge and information systems of climate and weather in order to prepare for abnormal events **(IDS).** These farmers have developed intricate systems of "gathering, prediction, interpretation and decision-making in relation to weather" **(IDS, 41)**

Climate and weather can be gathered, predicted and interpreted by locally bound observations and experiences, shared, animals, stars, wind patterns, and social events. Bird cries in the Bolivian highlands is a predictor of abundant pasture, if the cry is not heard before August 30th. If the cry is heard earlier than it indicates a year of scarce pasture (Hatch, 1990). Animal behavior is also noted in Lesotho to predict rainfall such as pigs grunting or larks swarming (Pepin, 1996). Constellations are an important indicator of planting dates, harvest times and other decisions related to weather events. In Bolivia a clear, star filled night in May and June is a sign of frost (Hatch, 1990). The important concept here it that the vulnerability faced by poor producers creates a local climatic knowledge system that mitigates susceptibility and prepares producers for possible events (Maxwell, 1999; Carnay, 1999; Bharara and Seeland, 1994).

Language is also an important concept in climate knowledge, since it gives each community its own system of documenting and interpreting their surroundings. Local knowledge has many descriptions of weather patterns that are either overlooked or not essential to Western welfare. Normally many weather patterns are acknowledged and named, instead of the normal four that dominant Western cultures. Osunade (1994) in his study of the Yoruba people, noted that two generally seasons were named but within this large category numerous sub seasons were described. Also the definitions of seasons will depend on the prevailing characteristics of the season. Many different descriptions of famine show how it affects populations and people in qualitatively different way (**IDS**, Walker, 1995). In Darfur, Sudan there are more than 25 different names for famine, each describing different aspects of famine and hunger. While many people consider mountain climates to be harsh for growing crops, based on climate variability and marginal lands. Innis (1997), in his study of intercropping, noted that farmers did not characterize their land as being poor or their weather as unsuitable for crops. Farmers believed their land would support them and accepted their circumstances and knew how to manipulate to give results (Innis, 1997). These perceptions have implications for how locals react to aid and development programs and also how many development projects miss their objectives by not understanding language and vocabulary.

LKS also provides farmers with mental reliance and security in their production decisions. An example is the use of different positions on mountainsides to produce crops in the area close to Lake Titicaca in Bolivia, thus providing varying climates for the crops to grow in (Hatch, 1990). This allows a hedging strategy that characterizes many farmers strategy in decreasing risk associated with climate in the Altiplano of Bolivia (Hatch, 1990). The difference between science and local knowledge in interpretation, gathering and value of information associated with climate and weather is shown by the lack of statistically support of climatic interpretations (IDS, Bharara and Seeland, 1994). Bharara and Seeland (1994) compared folklore memory and actually rainfall data of past years. They found that folk memory provided an insight in how people perceived a past year and remembered traditional indicators to assist in future years. Actual rainfall data did not correspond to how the villagers remembered the production year. In statistically high rainfall years locals described those years as being drought times. The difference is attributed to the fact that locals defined drought by rainfall variability, locality and timing and not as the amount of rainfall received in a year. This shows how in rural areas different approaches and classifications are used. This holistic approach provides a more accurate account of how weather affects farmers and also how local indicators can help them prepare for the timing and distribution, while scientific forecasts can just prepare for the amount.

SCIENTIFIC CLIMATE FORECASTING:

Still dramatic weather events and climatic changes will occur and this will change the economic and household portfolio of rural communities, providing challenges and events which rural farmers are ill equipped to confront. Therefore preparing farmers for droughts, ENSO events and other uncertain climatic events could help farmers decrease risk. In developing countries climate predictions are left to government agencies or private organizations that prepare poor communities for climatic changes (Blench, 1999). Whereas in developed countries climate forecasting can be a lucrative enterprise, serving the needs of large multi-national corporations (Blench, 1999). If farmers could incorporate this information into their production strategies, they would be able to make more informed decisions (Blench, 1999; Stern and Easterling, 1999; Price, 1991). This bodes the question of whether it should be the domain of the public or private interests to invest in weather forecasting capabilities. This is a difficult question since public goods are usually not produced at market efficiency levels and technology is constantly evolving in this field **(Johnson and Holt,).** Also the cost of transferring the knowledge into different disciplines and communicating it to potential users also requires additional costs (**Johnson and Holt**).

The primary reason for providing forecasts is to increase economic security for a household. A rational person would opt, after reviewing the forecast information, a strategy that would maximize returns. But by taking into account risk aversion would change how to evaluate forecast information. A farmer may choose his production techniques to maximize yield, but instead to decrease risk. Therefore the value of information and research in the subject may be hard to evaluate and assign utility (Johnson and Holt).

Presently forecast information is of little use to farmers, due to the limited ability to change production methods, inability to interpret information, and generation of data that is not related to users' needs (Finan, 1999; Broad, 1999; OGP-NOAA, 1999). In order for forecast information to be useful to farmers, it must address current needs and problems, be expressed in the language of the users, and provide the communities with appropriate alternatives to current production methods (Price, 1991; Stricherz, 1999; Blench, 1999; Stern and Easterling, 1999). It also requires that trust and communication exist between users and providers of climate forecasts (Finan, 1999). Projects that attempt to address climatic variability and production decisions must first understand local problems and the resources farmers need to help survive abnormal weather events.

Another problem with climate forecasting is the collection of data. Climates, especially in mountain regions, are variable over time and within regions. Microclimates in mountain regions affect the accuracy of data collection and make it hard to forecast over a zone. Data collection is even more difficult in poor countries because of lack of infrastructure and resources (Price, 1991). When data is collected climate models have demonstrated a utility for strategic planning and tactical and site-specific management decisions and mitigation practices. But general climate models (GCMs) require a lot of improvement if they are to be considered reliable (**Kanemasu and Arkin,**). The ability to link GCMs with land models based on biological and physical variables is also a demand of farmers who need more than just the probabilities offered by GCMs.

Several agriculture models have been developed, such as CERES, IBSNAT, and DSSAT, which are computer-based decision support systems that attempted to address the possible impact of climate change on crop production (Hoogenboom et al., 1992). Mearns and Iglesisas (1992)used the CERES- wheat model to test its effectiveness on testing daily variability. This was an important concept that Mearns and Iglesisas (1992) tested, as it reflects how variability is important in crop production. Mearns and Iglesisas (1992) concluded that the experiments did not provide reliable results, but they did provide additional information on what aspects of climate change are most relevant for determining impacts on crop production. Mearns and Iglesisas (1992) also mentions the importance of creating a multidisciplinary approach to climate models so that details and variables essential to farmers will be analyzed. Muchna and Iglesisas (1992)studied the semi-intensive zone of Zimbabwe, which is very vulnerable to climate changes. Farmers in the regions rely on their production of maize, which makes them susceptible to any variations of weather that may harm the crop. They tried to determine what level of temperature was needed to produce a significant change in production. An important result of their work showed that increases in normal inputs, such as fertilizers and irrigation, would not increase production when temperature increased and precipitation decreased. This conclusion has repercussions for extension agents who attempt to address issues of climate change and find solutions for farmers' problems.

While the ability to interpret, disseminate and implement forecast information are essential problems, forecast providers also must take into account the value of their forecast information. Forecasts of low value can be produced and published at a minimal cost, but could not be accurate, beneficial nor applicable (Finan, 1999). Also a question of concern could be who benefits from the information. Finan (1999) cites that large fishing operations, who were able to access information financially benefited from forecasts, while smaller operations and workers were not able to. Consequently, private enterprises with access to information can profit from climate changes while poor farmers suffer. Therefore while the models and forecasting techniques may be accurate they were not accessible and available for rural producers.

The ENSO event is also interesting because it does not manifest the same characteristics. For example in Peru the onset of jellyfish in the El Nino of 1982-83 provided alternative means of income for fishing operations. This did not occur in the 1997-98 El Nino and therefore the degree of preparedness and understanding of the event was lower (Finan, 1999). This example also relates to mountain regions. Since the amount of precipitation varies spatially some regions may be prone to drought and other not. Calverias (1999) found in his study of Pervuian households that they understood the variation of rain. Although El Nino was predicted it did not manifest itself in the particular region where these households lived.

The above examples illustrated how far away scientists and researchers are from accurately forecasting climate change, but methods are improving and the available information must be shared.