III.3.5.(β) Developing Scales and Tools for Weather and Climate Related Risk Quantifications: Multiple Cropping

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The discussion of scales and tools development for risk quantifications must be significant for delineating areas for (coping with) weather risks rather than multiple cropping, as the former is suitable to the latter too. FORECASTERS are for example weather-pest forecast models which are tools for weather related risks in farming. Insect pest growth is thermally influenced whereas pathogens depend on minimum temperature, relative humidity, wetness duration, sunshine duration etc. (Venkatesh 2008). So again we have generic examples and indicate particularities where applicable to multiple cropping such as in pest epidemics (Patel and Shekh 2006).

Communities that are most exposed to these risks are those with limited access to technological resources and with limited development of infrastructure. Currently there are opportunities that can assist in coping effectively with agrometeorological risks and uncertainties (Meinke and Stone 2005; Stone and Meinke 2005). We have shown this throughout this book but it is also clear that for multiple cropping relatively fewer existing tools and scales have been applied.

There are generic examples galore. A climate risk screening tool has for example been developed for climate risk assessment by the World Bank (2006). To consider requirements for any level of prescribed risk for irrigation demands, as a scale a gamma probability density function (PDF) was developed by Green et al. (1999). Saha (2006) assessed the rainwater deficit of West Bengal, India, through incomplete gamma distribution analysis of water deficits accumulated over three crop growth stages. Though the total rainfall was sufficient to grow rainfed rice, due to skewed distributions the crop faces stress. More examples are in Box III.3.19 (specifically for drought) and below.

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Box III.3.19 (Contributed by Kulasekaran Ramesh)

Chopra (2006) delineated drought risk areas of Gujarat, India, using temporal images from the NOAA-AVHRR (8 km) based Normalized Difference Vegetation Index (NDVI) and the meteorologically based Standard Precipitation Index (SPI). They also used the Palmer Drought Severity Index (PDSI), Vegetation Condition Index (VCI), Standard Water Supply Index (SWSI), a crop moisture index and a temperature condition index for quantification of the drought. The hazard and risk assessment context of this work can be understood from ADPC/ITC/UB (2007).

Newhall Simulation Model (NSM) for quantification of agricultural drought revealed that more than 5% of the area of the Czech Republic would be faced with relatively frequent arid or xeric events, accompanied also with higher probability of less severe drought spells (Kapler et al. 2006).

Nkemdirim (2007) quantified risk as potential loss of farm income due to a higher frequency of severe droughts. Spatial distribution of drought intensity in the time window is derived via downscaling in a GIS-Statistical environment based on comparable data from the major drought events of the 1930s and 1980s. Exposure is the product of probability of a drought and the time window 2050–2080, both obtained from projections made by the Canadian climate centre coupled AOGCM.

A climate risk index based on suitability models was established combining the mean suitability level and the influence of climate change (Huaisui et al. 2006). It was found that the value of the Normalized Difference Vegetation Index (NDVI) was lower in high drought risk areas (Prathumchai et al. 2001), so it could be used for risk quantification (Elhag 2006, see also Box III.3.20). Prasad and Rana (2006) simply quantified climatic risk through analysis of maximum temperature during a particular month over 3 years, to study the impact of increased temperature on rabi crops in Himachal Pradesh, India. So indeed generic examples galore.

Box III.3.20 (Contributed by Sue Walker)

The requirements for climate risk quantification are good detailed long term climate data sets and good data bases of the crop requirements. The modifications of crop requirements under multiple cropping would also need to be available, to compare the reduced risk due to adopting a multiple cropping system in place of a mono- or sole cropping system. Then the risk can be quantified using the climate data to formulate a hazard index. The farmer's ability to cope with such a hazard or his/her failure to cope must then be quantified as the vulnerability of these farming systems to this specific hazard. Therefore in such cases a risk index should be computed using the weather forecast and the knowledge of the local farming system(s).

A risk assessment on an operational level, using daily weather data, was developed to give a warning of the risk of infection of grape vines downy mildew (Haasbroek 2006). As the vineyards are often grown together with a pasture or cover crop, or adjacent to fruit tree orchards, these can also be considered to be multiple cropping systems. The downy mildew infections are triggered by different weather conditions. Therefore, each day the automatic weather station data are downloaded and run through a model, to predict the risk of infection that has occurred over the last 2 weeks. This information is then sent via e-mail or mobile phone text message service to the growers each day (Walker and Haasbroek 2007).

This type of risk quantification and those of Box III.3.19 can also be performed across a whole country or an extended part of a country, so as to be also of use to decision makers at the highest national government level. Here are such examples from Africa:

- The central Rift Valley of Ethiopia is a major agricultural area, yet suffers from frequent drought. Walker and Mamo (2007) developed a tool that simply qualifies the rainfall probabilities across the central Rift Valley. This information is integrated with the long term simulation of sorghum production at different planting dates, with varieties with different lengths of the growing season and at different fertility levels (Diga 2005). The tool works in such a way that the 3 months seasonal rainfall predictions from at least three providers are used as input and compared with the long term rainfall probabilities and simulated yields, so as to be able to make recommendations. These recommendations include when to plant, which varieties (as to length of the growing season) to plant or whether to refrain from planting until sufficient rainfall or a more favorable forecast is recurred (Diga 2005; Walker and Mamo 2007).
- As NDVI is an index of the vegetative cover, it represents an integrated index of multiple cropping systems for combined cropping and pastoral systems. In the Butana area east of the Blue Nile river, satellite data were used together with aerial maps and community groups to quantify the effect of desert encroachment (Elhag 2006). Then the long term rainfall data of the region were compared with the land cover trend from the portion of the effect attributed to human influence (Elhag and Walker 2009). These studies were consolidated into a simple discussion support tool (TASHUR) to be used at a national level to assess the effects of changing land use and shifts between cropping and pastoral systems (Elhag and Walker 2007).

Singh et al. (1990) developed an index that has been evolved for identifying a year as hydrological flood/drought year in different parts of India, based on the total seasonal rainfall of June through September as well as its timing. After giving a margin of 25% to the mean index value for normal years, frequencies of flood/drought years have been calculated on that scale. Bringing the simple probabilistic seasonal climate forecasts scale (we have come across before, see for example WMO 2010) into management decisions can reduce the vulnerability of agriculture to floods and droughts caused by ENSO (El Niño Southern Oscillation) phenomena (Sivakumar 2006), provided that a series of participatory precautions are taken and livelihood issues are understood (Stigter 2004). See also Tsubo and Walker (2007) and Chap. IV.12. For multiple cropping just again complexity increases.

If one considers the farming system holistically, then it is important to know what the objectives of the farmer are so that one can classify them into risk averse or risk tolerant. If the household or family is totally dependent on the crop for its food security, then usually they will make decisions with low risks, also when they do not produce the maximum yields. Many times, the use of multiple cropping is to help spread the risks of a variable climate. This means that when a wide variety of crops are grown, the risk of complete crop failure is a lot smaller. The unfavorable climate or hazard will usually not occur during the critical physiological phases of all the crops. Thus multiple cropping spreads the risk and allows the farmer to produce a crop from at least one of a group of crops cultivated that season. However, very little detailed information is available concerning scientific analysis of such systems. One could use a whole farm type model where the loss is calculated according to production or farm income.

In order for the risks of specific crops or combinations of crops in multiple cropping systems to be quantified, one needs to locate the available crop-climate relationships information in such a way as to develop boundaries within which these crops can grow optimally. These crop specific climate windows can then be used as yardsticks against which to compare the climate of a region, to assess the climatic risks involved if the crops were to be cultivated.

The types of climate risk quantification tools, scales and indexes exemplified above could then be applied to various agricultural cropping systems. If one were to consider multiple cropping systems, then one would need to use research results for each of the crop components, together with a full range of weather parameters. All specific weather parameters that were critical for the particular crop would be included. Thus, the different crops would be differently sensitive to weather parameters and at different critical levels.

Crop-climate matching exercises can themselves be done using various models or indices. One such simple method assigns a suitability ecological class to each of the areas within a region (Ehlers 1988). Then a whole range of suitable crops (but also marginal crops) can be listed for that area. Another tool is the FAO Ecocrop2 model which uses the long term climate together with the crop requirements, to select suitable crops for a specific area (FAO 2004; Zuma-Netshiukhwi and Walker 2007, 2009).

If the temperatures (maximum and minimum) and rainfall probability density functions have been calculated, the risk involved in the various crop choices can be determined. The advantage of these systems is that one can develop good combinations of legumes and cereals for use in multiple cropping systems. As Ecocrop2 also has a range of herbs and spices and tree crops (fruits and nuts), one can easily develop optimal combinations for new multiple cropping systems that are suitable for the particular climatic zone.

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