Study on Crop Diversification based on Long term Rain fall analysis of Dry farming tracts in southern India

Abstract. A study was conducted based on 30 years of rainfall data from the year 1985 to 2015 from the regions of semiarid districts of Karnataka, Telangana and Rayalaseema region of Andhra Pradesh states to recommend the alternate crops based on the rainfall variability and potential evapotranspiration (PET) *in kharif* and *rabi* seasons and found that moisture-sensitive crops specially Rice, Sugarcane and Banana must be taken in high rainfall areas and should go for less moisture-sensitive crops at the time of rainfall shortages and vice versa to avoid risk at farm level. The crops which are suggested based on rainfall and PET can thrive well, grow very efficiently and gives reasonable yields to farmers under limited rainfall situations and these crops were mostly of drought tolerant and drought resistant and short duration types. In *rabi* season most of these regions received less rainfall (<200mm) particularly in Telangana and North interior Karnataka regions. Under this situation, the crops which demand more water like cotton and sunflower crops were under cultivation, instead of these crops less water required short durationed and drought tolerant Bengal gram and Cowpea crops were suggested. These crops can survive well and give good yields without crop failures under these situations.
Keywords-Diversification, Drought resistant, Potential evapotranspiration, Rainfall.

I Introduction

Traditionally diversification was used more in the context of a subsistence kind of farming wherein farmers grow many crops on their farm. The farmers all over the world, especially in the developing countries, try to grow several crops in their holdings in an agricultural year. The level of crop diversification largely depends on the geo-climatic/socio-economic conditions and technological development in a region. Moreover, rich farmers prefer to specialize in agricultural enterprise while the poor and subsistent farmers are generally more interested in diversification of crops.

Under weather uncertainty and almost exclusive dependence of small holders on rainfall for productivity, several studies have investigated the nature and degree of crop riskiness in relation to the presence of production and market risks (Fafchamps 1992; Haile 2007; Dercon 1996). It should be noted, however that these earlier studies either rely on subjective measures of the riskiness of the crops or focus on selected major crops. An objective way of measuring the riskiness of individual crops and aggregating them (in a multiple-crop setting) allows a more accurate measurement of the contribution of individual crops to the riskiness, incorporating the mutual interdependence across crops at a farm-household level.

Diversification is to take up less profitable, but less risky crops. It is an example of conservative crop production strategies, is one such risk coping mechanism (Benin *et al*. 2004; Morduch 2002). Diversification especially is to hedge against weather risk (Kurukulasuriya and Mendelsohn 2006). In a pioneering study of crop choices under multivariate risk, Fafchamps (1992) showed that crop diversification, which is a characteristic feature of small farmers in developing countries, is a response to high variance in food prices and other risks that they are poorly insured against. Similarly, using data from the Punjab area of Pakistan, Kurosaki Fafchamps (1992) demonstrated that farmer crop choices are dependent on price and yield risk. Crop diversity, crop sequencing or rotation (Amede*et al*. 2001; Benin *et al*. 2004), and intercropping (Corbeels*et al*. 2000) are traditional ways of restoring soil productivity (renewing soil nutrients) and obtaining the maximum return from cultivated land under uncertain conditions. Planting varieties that mature earlier in the season (short-season crops) and protecting crops against the moisture shortage and yield loss are also common agricultural practices of farmers. Di Falco and Chavas (2009) showed that greater diversity can reduce the risk of crop failure. Seo and Mendelsohn (2008) and Kurukulasuriya and Mendelsohn (2006) also looked at the climate sensitiveness of crop choices, using cross-country data in Latin America and Africa understanding household-level crop choices can generate important information about how farm households change the riskiness of their crop composition in reaction to weather related risk. Haile (2007) showed that Ethiopian farmers choose crops most suited to a specific rainfall condition as a strategy for coping with unpredictable rainfall. In times of low rainfall, farmers predominantly choose moisture and stress tolerant crops and not moisture-sensitive crops.

The semi-arid tropics are characterized by low and highly variable rainfall in space and time, limiting potential crop yields in these areas (Graef and Haigis, 2001). Very few studies have tried to quantify the spatial and temporal variability of rainfall in the semi-arid tropics. The high degree of rainfall variability, when combined with relatively low asset base of most rural households restricts household crop management strategies and overall crop water productivity.

Karnataka

Agriculture plays an important role in the overall growth of Karnataka's economy despite a fall in its share in the state domestic product. It is characterized by wide crop diversification and remains highly dependent on the vagaries of the southwest monsoon. Rainfall plays an important role in crop production in Karnataka as more than 70 per cent of the cropped area is rainfed.

Districts like Bijapur, Bellary, Bagalkot, Koppal, Gadag, Raichur and Chitra Durga can be classified as low rainfall districts where average annual rainfall (1998-2010) is less than 650 mm. The normal rainy days varied from less than 40 in low rainfall districts to more than 80 in high rainfall districts. (Economic survey of Karnataka 2011-12).

Telangana

Telangana is a semi-arid area and has a predominantly hot and dry climate. Summers start in march and peak in may with average high temperatures in the 42°C (108 °F) range. The monsoon arrives in June and lasts until September with about 755 mm (29.7 inches) of precipitation. A dry, mild winter starts in late November and lasts until early February with little humidity and average temperatures in the range of 22–23°C (72–73°F) range (Economic survey of Telangana 2011-12). The Central Deccan Plateau dry deciduous forests eco-region covers much of the state including Hyderabad. Over 80% of the original forest cover has been cleared for agriculture, timber harvesting or cattle grazing, but large blocks of forest can be found in Nagarjunsagar-Srisailam Tiger Reserve and elsewhere. The more humid Eastern Highlands moist deciduous forests cover the Eastern Ghats in the eastern part of the state. The cropping system diversity in the same time has decreased from 23 to 10 crops in the *kharif* (monsoon) season with access to improved agricultural technology. These changes are also associated with a shift from intercropping to monocrop-based systems. The results indicate that these changes in cropping systems have resulted in a decreased management of production risk with increased investments in agriculture and lesser flexibility in the decision making on crops.This diversity in agro-ecology, socio-economic characteristics and resource availability does place a need to distinguish these regions for determining their agricultural development strategies.

II. Material and methods

i. Locality: The study was conducted in semi-arid regions of Telangana, Karnataka states and Rayalaseema region of Andhra Pradesh for the period 1985 to 2015. Telangana, a state on the south-eastern coast of India has a net cropped area of 4.5 million hectares of which 2.5 million hectares (56% of net cropped area) are under rainfed Agriculture (Directorate of Economics and Statistics 2011). Telangana is located between latitudes 18.1124^0N and 79.0193^0E longitudes, Rayalaseema is located between latitude 15.7722^0N and 78.0641^0E longitude and Karnataka is located between latitude 15.3173^0N and 75.7139^0E longitudes.

ii. Quantitative Analysis: 30 years rainfall data of Telangana and Karnataka states and Rayalaseema region of Andhra Pradesh have been collected from NDC IMD Pune.

1. **Rainfall Analysis:** A Rainfall trend was done in Microsoft Excel.
2. **Potential Evapotranspiration calculations'** using Penman and Monteith equation.
3. **Soil and crop information** collected from CRIDA website.

Results and Discussion

Based on 30 years of rainfall data set from the regions of semiarid districts of Karnataka, Telangana and Rayalaseema region of Andhra Pradesh states, the following trends were observed in corresponding regions. The Rainfall trends of different districts of south interior Karnataka during *kharif* season i.e. Chickmangalore, Mysore, Kodagu, Hassan and Chitra Durga districts showed increasing trend whereas Shivamogga, Bangalore urban and Chamarajanagar districts showed decreasing trend. Kolar, Tumkur and Bangalore Rural districts showed no trend. In *Rabi* season Kolar, Tumkur and Mysore districts showed increasing trend whereas Shivamogga district showed decreased trend. Remaining districts in south interior Karnataka had no significant trend was observed.

The Rainfall Trends of different districts of North interior Karnataka during *kharif* season i.e. Haveri, Gadag, Gulbarga and Koppal districts showed increasing trend whereas decreasing trends were observed in Raichur, Dharwad, Bidar and Belgaum districts. Bagalkot and Bijapur districts showed no trend. During *rabi* season Koppal and Belgaum districts showed increasing trend but Haveri, Raichur, Gulbarga, Dharwad, Bidar and Bijapur districts showed decreasing trend. Gadag and Bagalkot districts showed no trend. In rainfall trends of different districts of Rayalaseema during *kharif* season, Anantapur district showed decreasing trend and Kurnool district showed increasing trend, whereas Chittoor and Kadapa districts showed no trend.

In case of *rabi* season rainfall, Anantapur district showed increasing and Kurnool district showed decreasing trend. Whereas Chittoor and Kadapa districts showed no trend. In case of the rainfall trends of different districts of Telangana during *kharif* season, Karimnagar, Adilabad, Medak, Ranga Reddy, Nalgonda, Nizamabad and Medak districts showed decreasing trend, whereas Hyderabad, Khammam and Mahbubnagar districts showed increasing trend and Warangal district showed no trend. In case of the rainfall during *rabi* season Mahbubnagar, Adilabad, Karimnagar, Medak, Nalgonda, Nizamabad, Ranga Reddy, Warangal and Hyderabad districts showed decreasing trend, whereas Khammam district showed no trend.

In semiarid regions of Karnataka, Telangana and Rayalaseema districts agriculture is almost exclusively rainfed, so rainfall variability comprises an important source of uncertainty in agricultural production decisions. Better understanding of production risk and its management is important to help farmers, make informed and to take critical decisions about their crops because their welfare depends on their ability to withstand the risk of crop loss. In line with this, the study shows the choice of crops as an extent of risk management mechanism, when crop insurance is limited or non-existent. Our central premise is that in an alternate-cropping system, the crops chosen are likely to be sensitive to weather risk, measured by *kharif* and *rabi* rainfall variability.

The ability to adjust in response to a change in temperature is common in plants, and includes both higher and lower values relative to the optimum temperature. Besides, the availability of liquid water depends not only on the amount of water present, but also on temperature (Tiziana*et al*.,2000).Heat and drought are undoubtedly the two most important stresses having huge impact on growth and productivity of the crops (Google.com).Crop Water Stress Index is a means of irrigation scheduling and crop water stress quantification based on canopy temperature measurements and prevailing meteorological conditions. Plant temperature is an indicator of plant water status because stomata close in response to soil water depletion causing a decrease in water uptake and an increase in leaf temperature(Payero*et al*.,2006) Inadequate rainfall and soil bound water leads to water deficiency in crops(Sekhon*et al*.,2010; Vadez*et al*.,2011). Plant-water relations and water-stress tolerance at the scale of physiology and molecular biology can significantly improve plant productivity and environmental quality. (Liu *et al*.,2005; Shao*et al*.,2008).

Drought severity is conventionally assessed by drought indices. Several drought indices with varying complexity have been used in many geographical areas. Recently, a powerful drought index, the Reconnaissance Drought Index (RDI), is gaining wide acceptance mainly in the arid and semiarid climatic regions. Since RDI is based both on precipitation and potential evapotranspiration (PET), it is interesting to assess the effect of the PET calculation method on the drought severity characterisation obtained by RDI. The FAO Penman–Monteith method is used as reference method.

In South and North interior Karnataka, Telangana and Rayalaseema areas PET was calculated based on Penman and Monteith equation. Districts wherever rainfall is less than potential Evapotranspiration, one or two irrigations should be given at critical stages of crop growth.

In the districts of South and North interior Karnataka, Telangana and Rayalaseema regions, the existing crops under cultivation are shown in tables from 1-8 in both *kharif* and *rabi* seasons. According to rainfall pattern and potential evapotranspiration at different districts, suitable crops were suggested. The crops which are suggested based on rainfall and potential evapotranspiration can thrive well, grows very efficiently and give reasonable yields to farmers under limited rainfall situation. The suggested crops were mostly of drought tolerant and drought resistant short duration types.

Summary and Conclusions

Based on 30 years average rainfall and Potential Evapotranspiration losses in regions of semiarid districts of Karnataka, Telangana and Rayalaseema region of Andhra Pradesh states, the results indicate that the rainfall variability both in *kharif* and *rabi* seasons, it is concluded that moisture-sensitive crops like Rice, Sugarcane and Banana have to be taken up in high rainfall areas and in the areas with good irrigation facilities and should go for less moisture-sensitive crops at the time of rainfall shortages and vice versa to avoid risk at farm level.

The timely arrival of Southwest monsoon rains is crucially important for seed-bed preparation for short and long durationed *kharif* crops such as maize, sorghum and Rice crops. This implies that, favourable Southwest monsoon rains are important for crop production.

In semiarid regions of Karnataka, Telangana and Rayalaseema districts of Andhra Pradesh, agriculture is almost rainfed, so rainfall variability becomes an important factor of uncertainity in agricultural production decisions. Better understanding of production risk and its management is important to help farmers to make them informed and to take critical decisions about their crops because their welfare depends on their ability to withstand the risk of crop loss. In case monsoon rains stop early towards the end of season, normal sowing of short duration upland rice, blackgram and sesame crops may be taken up. If the rain ceases very early i.e. by the end of August or first week of September, only fodder crops or grain legumes could be harvested. Depending upon the soil moisture condition, relay sowing of crops like chickpea, lentil, mustard, linseed and barley could be done in *rabi* season.

The crops which are suggested based on rainfall and potential evapotranspiration can thrive well, grows very efficiently and gives reasonable yields to farmers under limited rainfall situations. Districts where the rainfall is less than potential evapotranspiration, one or two irrigations may be given at critical stages of crop growth.

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Table:1 **SOUTH INTERIOR KARNATAKA *Kharif***

S.NO	DISTRICT	EXISTINGCROPS	RAIN FALL (mm)	PET (mm)	RECOMMENDED CROPS
1	CHICKMANGALUR	Ragi, Paddy, Sunflower, Jowar, Horse gram	1268.1	416.1	Ragi,Paddy, Sunflower, Jowar,Red gram
2	KOLAR	Ragi,Ground nut, Maize, Red gram and Pulses	376.8	595.2	Ragi, Red gram and Pulses
3	TUMKUR	Ragi, Maize, Redgram, Ground nut and Horsegram	354.6	460.2	Ragi, Redgram, and Horsegram
4	SHIMOGA	Paddy, Maize, Sugarcane,and Cotton	2200.4	41.1	Paddy, Maize, Sugarcane,and Cotton
5	MYSORE	Maize,Ragi, Cotton and pulses	359.5	429	Ragi and pulses
6	KODAGU	Horti crops	221.4	416.1	Bajra and Sesame
7	BANGLORE URBAN		449	460.2	
8	HASSAN	Paddy, Ragi, Maize and Cowpea	858.5	435.9	Ragi, Maize and Cowpea
9	CHITHRADURGA	Groundnut, maize, Ragi, Sunflower, Jowar and Redgram	295.3	537.7	Bajra, Bengal gram and Sesame
10	CHAMARAJNAGAR	Ragi, Paddy, Sunflower, Horsegram Sorghum and Bengal gram	343.8	424.2	Ragi, Soybean, Horsegram and Bengal gram
11	BANGLORE RURAL	Ragi, Maize, Redgram and Ground nut	433.4	456.4	Ragi, Redgram and Soybean

Table:2 **SOUTH INTERIOR KARNATAKA *Rabi***

S.NO	DISTRICT	EXISTINGCROPS	RAIN FALL (mm)	PET (mm)	RECOMMENDED CROPS
1	CHICKMANGALUR	Black gram, Green gram and Bajra	239.7	613.2	Bengal gram
2	KOLAR	Horse gram	201.8	609	Bengal gram
3	TUMKUR	Bengal gram	189.3	582.5	Horsegram
4	SHIMOGA	Fallow	209.9	613.2	Bengal gram
5	MYSORE	Fallow	219.5	593.5	Bengal gram
6	KODAGU	Fallow	319.9	602	Bengal gram and Soybean
7	BANGLORE URBAN	Fallow	214.1	582.5	
8	HASSAN	Ragi, Maize and Cowpea	247.2	596.6	Blackgram Green grm and Bengal gram
9	CHITHRADURGA		165.3	609.3	Bengal gram
10	CHAMARAJNAGAR	Sunflower, Sorghum,Bengal gram and Horsegram	272	544.5	Bengal gram and Horsegram
11	BANGLORERURAL		205	571.7	Bengalgram

*Water requirement of Bengal gram is 150mm, Black gram 250mm, Green gram 250mm Horsegram 200mm.

Table:3 NORTH INTERIOR KARNATAKA *Kharif*

S.NO	DISTRICT	EXISTINGCROPS	RAIN FALL	PET(mm)	RECOMMENDED CROPS
1	GADAG	Greengram, Groundnut and Sorghum	323.6	422.7	Greengram and Bajra
2	HAVERI	Maize, Oilseed, Sorghum, Paddy and Cotton	450.4	410.9	Maize, Sunflower and Safflower and Sorghum
3	RAICHUR	Sunflower,Sorghum, Bajra, Groundnut, Cotton,Redgram	403.2	633.1	Sunflower and Redgram
4	KOPPAL	Sunflower,Sorghum, Bajra, Groundnut and Maize	344	551.4	Greengram and Bajra
5	GULBARGA	Redgram, sorghum, Sunflower and Bajra	504.1	560.2	Redgram, sorghum, Sunflower and Bajra
6	DHARWAD	Cotton, Chilli, Sorghum,Groundnut, Paddy,Soybean and Greengram	470.1	453.1	Redgram, Sorghum,Soybean and Greengram
7	BIDAR	Sorghum, Redgram, Soybean,Blackgram, Green gram	622	753.7	Cotton, Sorghum,Grpundnut, Redgram and Soybean
8	BIJAPUR	Redgram, Sunflower and Bajra	351.4	483.1	Soybean and Bajra
9	BELGAUM	Soybean,Maize,Groundnut, Sorghum and Cotton	831.4	453.1	Maize,Groundnut, Sorghum and Cotton
10	BAGALKOTE	Gram, Sorghum and Groundnut	337.8	540.1	Gram, Greengram and Bajra

Table:4 NORTH INTERIOR KARNATAKA *Rabi*

S.NO	DISTRICT	EXISTINGCROPS	RAIN FALL(mm)	PET(mm)	RECOMMENDED CROPS
1	GADAG	Sorghum, Bengalgram	140.9	585.2	Bengalgram
2	HAVERI	Maize,Oilseed, Sorghum and cotton	160.6	599.9	Sorghum
3	RAICHUR	Sorghum, Bengalgram	140.6	608	Sorghum, Bengalgram
4	KOPPAL	Sunflower,Sorghum,Maize,Bengalgram and cotton	150	632.7	Bengalgram and Sesamum
5	GULBARGA	Sorghum, Bengalgram and Sunflower	125.4	613.3	Sesame
6	DHARWAD	Cotton, Bengalgram and Sorghum	154.3	585.2	Bengalgram and Sorghum
7	BIDAR	Bengalgram, Sorghum and Sunflower	124	616.5	Sesame

8	BIJAPUR	Sorghum,Bengal gram and Sunflower	133.5	592.5	Sesame
9	BELGAUM	Maize and cotton	135.6	585.2	Sesame
10	BAGALKOTE	Sorghum and Bengalgram	140.6	592.5	Sorghum and Bengalgram

* Water requirement of Bengal gram is 150mm, Sesamum 150 mm and Sorghum 500mm

Table:5 **RAYALASEEMA** ***KHARIF***

S.NO	DISTRICT	EXISTINGCROPS	RAIN FALL(mm)	PET(mm)	RECOMMENDED CROPS
1	ANANTHAPUR	Groundt, Sunflower, Redgram,Maize and Cotton	326.5	789.6	Redgram, Black gram and Green gram
2	CHITTOOR	Groundnut and Redgram	436.4	726	Redgram and sunflower
3	KADAPA	Groundnut,Sunflower, Cotton andRedgram	393.1	689.2	Red gram and Bajra
4	KARNOOL	Groundnut,Sunflower, Sorghum, Redgram,	457.8	738.8	Sunflower and Redgram,

Table:6 **RAYALASEEMA** ***RABI***

S.NO	DISTRICT	EXISTINGCROPS	RAIN FALL(mm)	PET(mm)	RECOMMENDED CROPS
1	ANANTHAPUR	Bengalgram and Sorghum	164.9	675.2	Bengal gram and Vegetables
2	CHITTOOR	Groundnut, Paddy, Redgram and sunflower	418.4	635	Redgram
3	KADAPA	Sunflower, Bengalgram,Cotton and Sesamum	267	641.4	Bengalgram, Black gram, Sesame and Green gram
4	KARNOOL	Bengalgram and Chilli	163	643	Bengal gram and Chilli, Lablab

*Water requirement of Lablab is 160mm

Table:7 TELANGANA *KHARIF*

S.NO	DISTRICT	EXISTINGCROPS	RAIN FALL(mm)	PET(mm)	RECOMMENDED CROPS
1	ADILABAD	Cotton, Soybean, Redgram and Sorghum	933	576.1	Cotton, Redgram and Soybean
2	HYDERABAD	Redgram, Sorghum and Maize	614	426.3	Redgram, Sorghum and Maize
3	KARIMNAGAR	Cotton, MaizeandGreengram	750.7	539.1	Cotton, MaizeandGreengram
4	KHAMMAM	Cotton, Maize, Greengram and Redgram	895.1	576.8	Cotton,Maize, and Redgram
5	MAHBUBNAGAR	Maize, Cstor, Groundnut,Redgram, Sorghum and Cotton	472.1	668.4	Castor, Redgram and Sorghum
6	MEDAK	Maize, Sorghum Cotton Greengram, Redgram and Blackgram	644.7	581.5	Maize, Sorghum and Cotton
7	NALGONDA	Cotton, Castor, Redgram and Groundnut	508.5	586.8	Castor and Redgram
8	NIZAMABAD	Maize and Redgram	843.6	581.5	Maize and Redgram
9	WARANGAL	Cotton, Maize, Paddy, Groundnut, Green gram	812.8	601.5	Cotton, Maize, Groundnut, Green gram
10	RANGAREDDY	Redgram, Sorghum, Maize and Cotton	627.1	426.3	Redgram, Sorghum, Maize and Cotton

*Water requirement of Castor crop 500mm

Table:8 **TELANGANA** ***RABI***

S.NO	**DISTRICT**	**EXISTINGCROPS**	**RAIN FALL(mm)**	**PET(mm)**	**RECOMMENDED CROPS**
1	ADILABAD	Sorghum, Redgram and Bengal gram	114.1	549.1	Bengal gram
2	HYDERABAD	Sorghum and Bengal gram	156.9	544.5	Bengal gram and Green gram
3	KARIMNAGAR	Green gram	117.5	544	Bengal gram and Fodder crop
4	KHAMMAM	Maize, Green gram and Redgram	152.9	580.1	Bengalgram and Greengram
5	MAHBUBNAGAR	Maize and Sorghum	134.7	297.5	Bengalgram and Sesame
6	MEDAK	Sorghum,Safflower and Bengalgram	99.8	549.2	Fodder crop(cowpea)
7	NALGONDA	Groundnut	145.5	567.8	Bengal gram
8	NIZAMABAD	Maize	134.3	549.2	Bengal gram and Sesame
9	WARANGAL	Maize and Chilli	126.9	591.9	Bengal gram and Sesame
10	RANGAREDDY	Sorghum, Bengal gram and Groundnut	92.6	544.5	Fodder crop(cowpea)

*Most drought tolerant, as per the followmg ranking· Soybean < black gram < moong bean < ground nut <maize< sorghum < pearl mlliet< lab lab bean < cowpea.