WHOSE DECISION IS IT ANYWAY? – FARM LEVEL DECISION MAKING IN A SEMI ARID INDIA

By

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- Based on work done with
  - Prof. Sulochana Gadgil – (Monsoons, Mathematical biology, ....) Indian Institute of Science, Bangalore, India
  &
  - Dr Narahari Rao – (Mechanical engineer, Boundary layer dynamics) Indian Institute of Science, Bangalore, India.
Climate risk & farming decisions

Farming under large climate variability

Uncertainty of benefits / consequences of alternative options for decisions

Sub optimal Farming options

Better farming options

Availability of coping strategies

Social, cultural, economic, policy and ecological contexts
Annual Mean Rainfall in cms

Anantapur Station

Figure 5
<table>
<thead>
<tr>
<th>Location</th>
<th>Centered around 14° N &amp; 77° E.</th>
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</thead>
<tbody>
<tr>
<td>Elevatio</td>
<td>550 to 750 MSL.</td>
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<tr>
<td>Extent</td>
<td>About 50,000 km²</td>
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<tr>
<td>Predominant soil type</td>
<td>Shallow Alfisols, Red, sand loam texture</td>
</tr>
<tr>
<td>Land use</td>
<td>80-90% of Total cultivated area - under single crop rainfed Peanut (Groundnut), Mostly Variety -TMV-2</td>
</tr>
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</table>

Rainfed groundnut is the engine that runs this region.
## Climate Risk

<table>
<thead>
<tr>
<th>Socio-economics</th>
<th>About 50-60% of farmers have farm size of &lt;2ha.</th>
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<tbody>
<tr>
<td>Climate</td>
<td>Cropping season avg. rain (Jul- Dec) = 41 cm, Std. deviation of 16 cm</td>
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<tr>
<td></td>
<td>Crop water demand = 35 cm. Avg. No. rainy days = 26</td>
</tr>
<tr>
<td>Climate risk</td>
<td>Abiotic - Moisture stress, water logging, rot of haulm</td>
</tr>
<tr>
<td></td>
<td>Biotic, pests - Insects, large mammals</td>
</tr>
<tr>
<td></td>
<td>Biotic, Pathogens – Fungi, virus</td>
</tr>
<tr>
<td></td>
<td>Market price - rain in other peanut growing regions</td>
</tr>
<tr>
<td>Climate event</td>
<td>During crop stage</td>
</tr>
<tr>
<td>-------------------------------------</td>
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</tbody>
</table>
| Dry spell, 15-25 days               | • Pod set to pod filling  
• At harvest                         | Moisture stress    | High        |
|                                     |                                         | Difficulty in harvest | Moderate    |
| Dry spell >25 days                  | Flowering to pod filling                 | + leaf miner       | Moderate    |
| Wet spell of >7 days                | • Pod set to pod filling  
• Pod filling to harvest            | • Poor pod development  
• + Pod rot, late leaf spot       | Low          | Moderate    |
| Yet to be understood                | Flowering to pod filling                 | • Hairy caterpillar* \n• Virus*                         | High         | Low         |
| Rain in Gujrat                      | Flowering to pod filling                 | Determines the market price | Moderate    |
| Patchy sowing rains                 | Sowing, pod filling                      | Wild boar*, Sloth bear* | High        |
Impacts of Climate Risk on Peanut

Impact 1- Peanut yields
- 60% of the years- Do not recover the cost of cultivation
- Due to low soil fertility-- Small farm yields worse than the medium and large farms.

Impact 2- On livelihood
- Large drain on income from other sources, Common cause of debts
- Monitoring data of 25 small farm families 1998-2005
Impacts of Climate Risk on Groundnut

- Impact 3 – Local environment
  - Small farms → Nutrient mining
  - Large farms → +Ground water mining

+ Large build up of endemic pest, pathogen populations in both soil, air and co-hosts
Impacts of Climate Risk on Groundnut

- **Impact 4 – Regional economy**
  - In Pavagada Block, center of this region,
    - Peanut total sown area ---- 85,000 ha
    - Cost of cultivation -------- 510 million Rs
  - Investment is **25 times more** than the development grants received
    - Probability of recovery – less than 60%
    - Probability of high returns > twice the investment – 20%
  - National level, climate impact- Similar processes??
Scale and Yield Variability

Variability of groundnut yields at multiple scales, residuals about smoothed trend.

Groundnut yield coefficient of variation

- World
- India
- India states
- Gujarat
- Gujarat districts
Impact of the deficits of the monsoon rainfall significant despite the Green revolution
Why has such risk prone cropping pattern persisted???

Recent shift – from traditional multiple crop based adaptive farming over the past 30-40 years

Predominant reasons

- **Peanut trap**-
  - Expansion due to higher profits/unit time. → Low yields, ecological problems. → Unable to shift due to social and cultural factors

- **Debt trap**-
  - About 90% credit for small farm families is from local money lenders
  - linked to cultivation of groundnut on their farm
Sorghum / Safflower / Niger / Castor / Pigeonpea / Peanut / Field bean

Sesamum / Horsegram / Cotton / Chillies / Cowpea / PearlMillet

Cow pea / Horsegram / Greengram / Castor / Pigeonpea

Horsegram

Peanut

Minor Millets (I, II)

Minor Millets (III, IV, V)

Castor

Pigeonpea

Sorghum

Current Cropping System

Traditional Cropping System
Peanut trap - Historical, economic, ecological, social and cultural factors

1. Large losses - Endemic pests, pathogens, low water retention and fertility, low price advantage

2. Lack of experience with alternatives. Safety in numbers

Higher profit in less time, other income sources

High profits - virgin soils, low pest and pathogens, higher price than alternatives

Profits/ha/yr

High

Medium

Low

Traditional cropping 1975 Shift to & expansion of peanut 1995 Peanut trap
How do farmers cope up with climate risk??

RAINFED FARM RISKS - ABSORBED AT THE LIVELIHOOD LEVEL

- Mix of livelihood options as an adaptation (Preparedness).
- + Sets of well tested coping mechanisms (Contingency planning)
  - 1998 and 2000 ----very high rainfall
  - 2001 to 2004 -------consecutive years crop failure & severe drought.
  - 2005 ----------------moderate rainfall
<table>
<thead>
<tr>
<th>Families</th>
<th>Mix of livelihood options</th>
<th>Coping mechanisms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small farms</td>
<td>Rainfed farm + wage labor + share cropping in irrigated farms + sheep, goat and pig rearing + Annual lease fruit trees</td>
<td>Borrow from money lenders + Sell Manure, seeds, trees, livestock + lease farm + migrate in search of wages and fodder for sheep</td>
</tr>
<tr>
<td>Large farms</td>
<td>Rainfed farm + irrigated crops and trees + govt. contracts + trade + money lending</td>
<td>Borrow from banks + lease rainfed farm + Use drought benefits + more bore wells</td>
</tr>
</tbody>
</table>
Impact of climate—beyond rainfed peanut
to all resource use / livelihood options

- Impact of Climate in this region—
- As dry spell and wet spell events
- Depending on type of resource use, timing and intensity of event
- Benefits / problems & Extent of impact of dry spells and wet spells
CLIMATE EVENT--- *Wet spell of > 7 days during pod set to pod fill of ground nut in Pavagada region.*

<table>
<thead>
<tr>
<th>Impact on</th>
<th>Benefits</th>
<th>Problems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Groundnut</td>
<td></td>
<td>Poor pod development, diseases</td>
</tr>
<tr>
<td>Pigeon pea, Castor</td>
<td>Enhanced growth and yield</td>
<td></td>
</tr>
<tr>
<td>Rice, finger millet</td>
<td></td>
<td>Blast disease, decrease growth</td>
</tr>
<tr>
<td>(irrigated)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weeds</td>
<td>Vigorous growth leads higher employment and income for wage earners</td>
<td>Increase in cost of weed removal</td>
</tr>
<tr>
<td>Impact on</td>
<td>Benefits</td>
<td>Problems</td>
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<tr>
<td>Sheep</td>
<td>Better fodder and water availability for open grazing in the following summer</td>
<td>High disease incidence</td>
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</table>
| Trees under rainfed condition | ▪ Increase in yield of Tamarind, Mango  
▪ Also in Neem and Pongamia.  
(Poor families collect seeds) | |
| Areca nut (irrigated) |  | fungal disease |
| Surface water and ground water | ▪ Increase in irrigated crop area in the following summer- large farm families  
▪ Better income through wages and share cropping – small farm families | |
Climate risk from extreme events- Thresholds of coping mechanisms

Given the severity of drought of 2001 to 2004 - the usual coping mechanisms were not adequate.
Several new options were explored and adopted

<table>
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<tr>
<th>New options</th>
<th>Extent of adoption</th>
<th>Likely consequences</th>
</tr>
</thead>
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<tr>
<td>Permanently migration to Bangalore</td>
<td>50-70 % of young men</td>
<td>▪ Acute shortage of skilled labor and services, reduction in sheep herd size.</td>
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<tr>
<td></td>
<td></td>
<td>▪ Increase in income and further migration</td>
</tr>
<tr>
<td>Large scale sale of cattle. Shift to goats</td>
<td>▪ Only 10% of the farms have cattle</td>
<td></td>
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<tr>
<td></td>
<td>▪ 20 fold raise in</td>
<td>▪ Shortage of FYM, increased dependence on tractors, consider alternative crops to groundnut.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>▪ Conflict between farm owners and grazers. High and assured</td>
</tr>
<tr>
<td><strong>New response</strong></td>
<td><strong>Extent of impact</strong></td>
<td><strong>Likely consequences</strong></td>
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</table>
| Process and sell Areca from high rainfall regions | Typically, 20-30 entrepreneurs / village  
Estimated trade of 50 million Rs / yr in the region | The assured profits will lead to further rapid spread  
Shift of capital from share cropping, lease of trees, sheep  
As profits are density dependent, the new entrepreneurs will switch to other products. |

Adoption of successful practices is very rapid during distress situations
Search for better farming options

- Rainfed farming recommendations by the agriculture scientists-
  - Not adapted by farmers
  - Ignores local rainfall variability and its impact on farming
- Our attempt of Participative research with local people- 13 years of experience.
  - Limited success, adoption
- New paradigm of rainfed farming options in semi arid regions
Working with farmers

Two networks of farmers-
- 25 best farmers from different locations in 4000 sq km area
- 15 poor farmers in a single location.

- Participative research with farmers
  - Set research priorities and questions
  - Discuss results and further follow-up work
  - On farm daily meteorological data
  - On farm monitoring of growth, yield, pests, diseases & decision making on farming operations
  - Farm level characterization of Soils, Socio-economic and Agri-ecological profile
Tools / data used

- 100 year daily rainfall data, Other relevant Met data
- Soil profiles from the region
- Simple model developed for land preparation, sowing and pests & diseases
- Crop models – APSIM, PNUTGRO
- Input from farmers in the region
<table>
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<th>Research issue</th>
<th>Results</th>
<th>Acceptance</th>
<th>Reasons/ Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pest and disease management</td>
<td>Simple model for risk assessment Benefit cost analysis of sprays</td>
<td>Yet to be provided</td>
<td>Further validation and refinement needed</td>
</tr>
<tr>
<td>Optimal sowing window</td>
<td>15-25 days later than current practice</td>
<td>Very small</td>
<td>Increase in pests and diseases High penalty- May not sow the crop</td>
</tr>
<tr>
<td>Planting density</td>
<td>50-75% of recommended</td>
<td>Partial</td>
<td>Poor crop establishment</td>
</tr>
<tr>
<td>Research issue</td>
<td>Results</td>
<td>Acceptance</td>
<td>Reasons/ Benefits</td>
</tr>
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<td>--------------------------------</td>
<td>-------------------------------------------------------------------------</td>
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</tr>
<tr>
<td>Forecast rain prior to sowing</td>
<td>El-Nino and El-Nino + 1 years linked to seasonal total</td>
<td>Yet to be provided</td>
<td>Choice of crops, inter crops, Invest in crop insurance</td>
</tr>
<tr>
<td>Alternative crops</td>
<td>Evaluation of potential crops</td>
<td>Yet to be provided</td>
<td>Needs further quantification</td>
</tr>
<tr>
<td></td>
<td>Early sowing of Pigeon Pea better than groundnut</td>
<td>Yet to be provided</td>
<td>Pest impact to be considered</td>
</tr>
<tr>
<td>Enhance soil fertility in small farms</td>
<td>Add appropriate soils @ 150-200 t / ha</td>
<td>High</td>
<td>▪ Partly subsidized, ▪ Enhanced water holding capacity</td>
</tr>
</tbody>
</table>
Matching the large climate variability with even larger variability of farming options

Impact of climate risk on farming

Current practice

Current cropping

Current livelihood options

Participative research options

Climate risk and farming options

Proposed

Multiple cropping

+ High density agro-forestry

+ livestock rearing

+ farm based enterprises

Extent of variability posed / covered

Low

Medium

High

Very high
FARMING THE RAIN through ADAPTIVE FARMING

- Basic foundation → Soil and water conservation measures - Watershed based approach
- + Trees and shrubs in trench cum bunds and farm ponds –
  - very high density alley cropping of multipurpose species
  - Dry land horticulture trees
  - live hedge trees, creepers
- + Main crop – resilient to moisture stress, pests and diseases
  - Intercrops
- + Farm based enterprises
<table>
<thead>
<tr>
<th>CROPS - fodder, medicinal plants</th>
<th>WATER CONSERVATION STRUCTURES</th>
</tr>
</thead>
<tbody>
<tr>
<td>800-1500 Multi purpose trees</td>
<td>Sensor - for soil moisture (upto 1m), temp, humidity, radiation, rain,</td>
</tr>
<tr>
<td></td>
<td>Productivity and growth studies</td>
</tr>
</tbody>
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Adaptive farming options

- Similar to tree based farming designed and implemented in several parts of semiarid India by BAIF, an NGO.

Area treated — about 20,000 ha.

Beneficiaries - about 50,000 families.

- Experience of BAIF in implementing such farming options

<table>
<thead>
<tr>
<th>Constraints</th>
<th>Solutions evolved</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Compatibility with other income sources</td>
<td>Evolve new combinations</td>
</tr>
<tr>
<td>2. Reluctance to adapt unfamiliar farming options</td>
<td>Motivation - material and non material incentives, exposure, demonstration</td>
</tr>
<tr>
<td>Constraints</td>
<td>Solutions evolved</td>
</tr>
<tr>
<td>-------------</td>
<td>-------------------</td>
</tr>
<tr>
<td>3. Low Density - problems of theft and grazing</td>
<td>Area based approach</td>
</tr>
<tr>
<td>4. Uncertainty of timing and extent of benefits</td>
<td>Motivation - material and non material incentives, exposure, demonstration</td>
</tr>
<tr>
<td>5. High initial investment</td>
<td>Credit through SHGs</td>
</tr>
<tr>
<td>6. Enhanced requirement of labor / ha</td>
<td>Surplus family labor, farm based enterprises for quick returns</td>
</tr>
<tr>
<td>7. Conflict with open field grazing by shepherds</td>
<td>Live hedge, increased watch and ward – remains a problem</td>
</tr>
<tr>
<td>8. Lack of knowledge of design, seedlings, aftercare</td>
<td>Local up gradation of skills, training, to SHGs. Presence of trained staff with community</td>
</tr>
</tbody>
</table>
Current work in Adaptive farming

- Working with BAIF to adapt tree based farming to this study area
- Moisture along the soil profile is the most critical parameter that drives the productivity of the system
- It’s dynamics monitored using a network of soil moisture sensors and ad-hoc wireless network
- Intend to use multiple cropping and tree models like APSIM to further explore and improve farming options