Drought in Andhra Pradesh:
Long term impacts and adaptation strategies

Draft Final Report

Volume 2: Technical Annexes

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ANNEX 1   DEFINITIONS OF DROUGHT

A1.1.   Drought is a normal, recurrent feature of climate. It occurs in virtually all climatic zones, but its characteristics vary significantly from one region to another. Drought is a temporary aberration; it differs from aridity, which is restricted to low rainfall regions and is a permanent feature of climate.

A1.2.   Drought is an insidious hazard of nature. It originates from a deficiency of precipitation that persists long enough to produce a serious hydrologic imbalance. Drought should be considered relative to some long-term average condition of balance between precipitation and evapotranspiration (i.e., evaporation and transpiration) in a particular area. Drought differs in three essential characteristics: intensity, duration and spatial coverage. Intensity refers to the degree of the precipitation shortfall and/or the severity of impacts associated with the shortfalls. Intensity is generally measured by the departure of some climatic index from normal and is closely linked to duration in the determination of impact. Impacts are, in turn, related to the timing (e.g., delays in the start of the rainy season, occurrence of rains in relation to principal crop growth staged) and effectiveness of rainfall (e.g. number of rainfall events). Other climatic factors such as temperature, wind and humidity can significantly aggravate its severity.

A1.3.   Droughts are categorized as meteorological, hydrological, agricultural and socio-economic (Nagarajan 2003).

A1.4.   *Meteorological drought* is related to the deficiency of rainfall compared to long-term average amounts on monthly, seasonal or annual tile scales. Another definition if meteorological drought identify periods of drought on the basis of the number of days with precipitation less than some pre-determined thresholds. The India Meteorological Department (IMD) uses a meteorological definition of drought based entirely on rainfall deficiency from normal of the mean annual, mean summer monsoon, mean monthly and mean weekly rainfall. This classification covers special scales from meteorological sub-divisions of India as a whole. As per IMD, meteorological drought is defined as occurring when the seasonal rainfall received over an area is less than 75% of its long-term average value. It is further classified as moderate drought if the rainfall deficit is 26-50% and severe drought when the deficit exceeds 50% of normal. A year is considered to be a drought year for the country if the area affected by the drought is more than 20% of the total area of the country.

A1.5.   *Hydrological drought* is associated with the effects of periods of precipitation shortfalls on surface or subsurface water supply (e.g., stream flow, reservoir and lake levels, ground water). The frequency and severity of hydrological drought is often defined on a watershed or river basin scale. Hydrological droughts are usually out of phase with or lag the occurrence of meteorological droughts. Water in hydrologic storage systems (e.g., reservoirs, rivers) is often used for multiple and competing purposes (e.g, flood control, irrigation, recreation, hydropower), further complicating the sequence and quantification of impacts. Although climate is the primary contributor to hydrological drought, other factors such as changes in deforestation, land degradation and the construction of dams all affect the hydrological system of the basin.

A1.6.   *Agricultural drought* links various characteristics of meteorological and hydrological droughts to agricultural impacts. It is related to precipitation shortages, differences between actual and potential evapotranspiration, soil water deficits, etc. Plant water requirements depend on prevailing weather conditions, biological characteristics of the specific plant, its stage of growth, and the physical and biological properties of the soil. Agricultural drought should be able to account for the variable susceptibility of crops during different stages of crop development, from emergence to maturity. Deficient topsoil moisture at planting may hinder germination, leading to low plant populations per hectare and a reduction of final yield.

A1.7.   *Socio-economic drought* is associated with the supply and demand of economic goods such as water, forage, food grains, fish, hydroelectric power, etc. Socio-economic drought occurs when the demand for an economic good exceeds supply as a result of a water-related shortfall in water supply.

Definitions of droughts
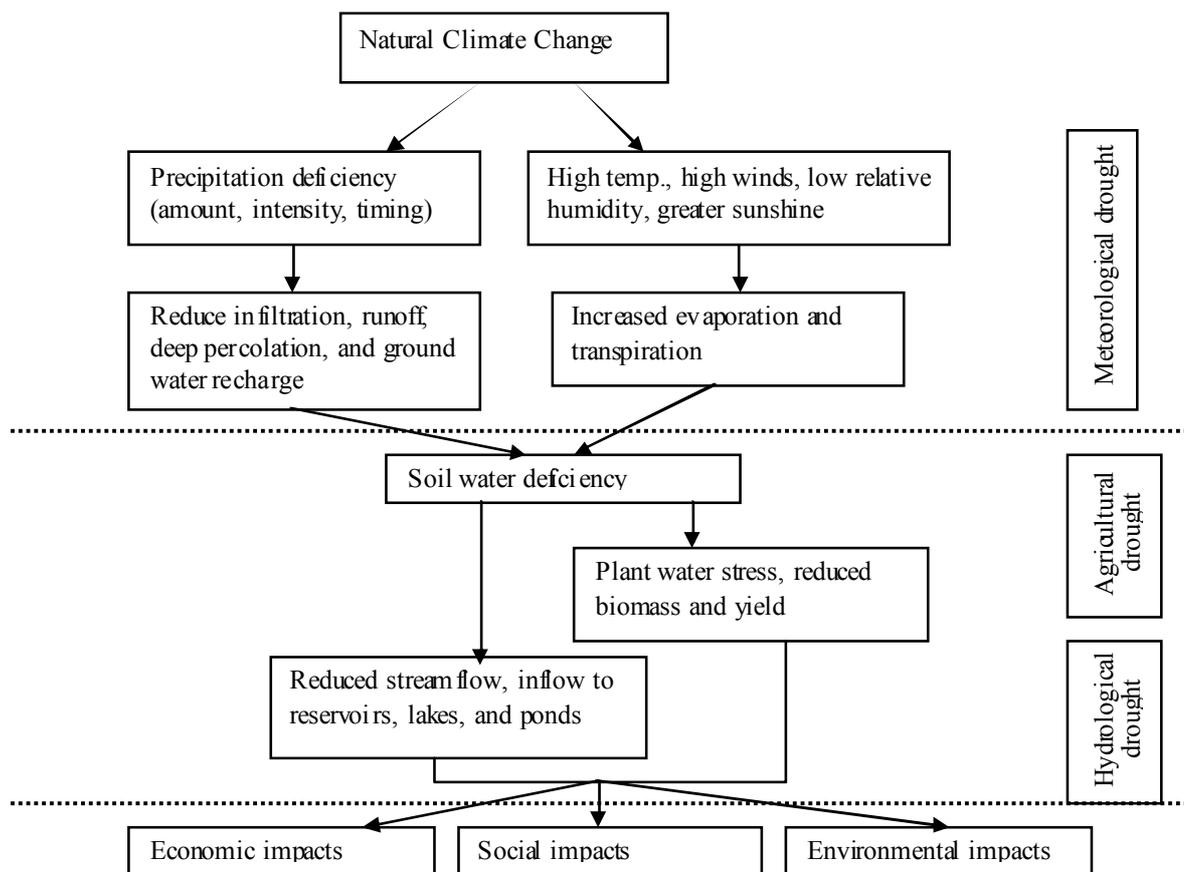
Source: National Drought Mitigation Center, USA, 1999.

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ANNEX 2 DROUGHT PROGRAMS EXISTING IN ANDHRA PRADESH

Risk financing programs

Crop Insurance

A2.1. The National Agriculture Insurance Scheme has been implemented in Andhra Pradesh since 1999-2000. The schemes are a mix of voluntary and compulsory participation. They are voluntary at the state level in terms of specific areas and crops. Once the specific area-crop combinations have been notified, participation is compulsory for farmers in those areas cultivating the specific crops and taking agricultural loans. In the case of loanee farmers the sum insured may be at least equal to the crop loan advanced. All farmers can insure to the value of the threshold yield of the insured crop.

A2.2. Eighteen crops are currently insurable under NAIS during Kharif season (e.g., rice, maize, sunflower, groundnut, sugarcane, and cotton) and ten crops during Rabi season (e.g., rice, maize, sunflower, and groundnut). The standard area yield insurance scheme has recently been extended to farm income insurance and rainfall insurance.

A2.3. The XI Finance Commission noted the need to strengthen the crop insurance scheme as a supplementary measure to what is done by the government for providing relief at the time of natural calamity.

Calamity Relief Fund (CRF)

A2.4. This fund was established separately for each state on the basis of recommendations of the IX Finance Commission and has since been approved for continuation by the X and XI Finance Commissions. This fund should be used for meeting the expenditure for providing immediate relief to the victims of cyclone, drought, earthquake, fire, flood and hailstorm. The table below describes the financial status of this fund over the last 5 years.

Calamity Relief Fund for Andhra Pradesh, 2000-2005, (Rs. lakhs)

Share of	2000-01	2001-02	2002-03	2003-04	2004-05	Total
Centre	14854	15597	16377	17196	18056	82080
State	4951	5199	5459	5732	6019	27360
Total	19806	20796	21836	22928	24074	109440

National Calamity Contingency Fund (NCCF)

A2.5. This fund came into effect in 2000-01 and continues to be in operation till the end of financial year 2004-05. National calamities of cyclone, drought, earthquake, fire, flood and hailstorm considered to be of severe nature requiring expenditure by the State government in excess of the balance available in its own CRF qualify for relief assistance under NCCF scheme. The initial corpus of the National Fund is Rs.500 crores provided by the Government of India. National

Centre for Calamity Management (NCCM) is constituted by the Ministry of Home Affairs, Government of India, to monitor the occurrence of natural calamities relating to cyclone, drought, earthquake, fire, flood and hailstorm on a regular basis and assess their impact on area and population. The assistance from NCCF is only for immediate relief and rehabilitation. Any reconstruction of assets or restoration of damages is financed through plan funds. The unspent balance of NCCF at the end of the financial year 2004-05 will become available to the Central Government to be used as a resource for the next plan.

Drought Proofing Programs

Drought Prone Areas Program (DPAP)

A2.6.   DPAP, a centrally sponsored scheme, in operation since 1973, aims at restoring ecological balance in the drought prone areas and mitigation of the adverse effects of drought on crops and livestock through integrated development of natural resources by adoption of appropriate technologies. However, the program fell short of its initial objectives despite large expenditure.

A2.7.   DPAP is aimed at developing the drought prone area with an objective of drought proofing by taking up of soil land moisture conservation, water harvesting structures, afforestation and horticulture programs on a comprehensive micro watershed basis. During 1994-95 the program was implemented in 69 blocks of 8 districts. From 1995-96 the program is extended further: 11 districts with 94 blocks under the scheme and Anantapur with 16 blocks under Desert Development Programs (DDP). So far, 3518 watersheds were taken up covering 110 blocks in 12 districts covering an area of 17.6 lakh hectares. Almost 30 percent of the total watersheds in country are located in Andhra Pradesh. Total Rs.507.57 crores are spent towards implementation of the program from 1995-96 to 2002-03. The expenditure for this program is shared by center and state governments in the ratio of 75:25.

Joint Forest Management / Community Forest Management

A2.8.   The Government of Andhra Pradesh adopted in 1992 the Joint Forest Management program which envisages a strategy for production, improvement and development of forest with the involvement of local communities by forming them into Vana Samrakshana Samithies (VSS).

A2.9.   There are 7090 VSS actively involved in protection and development of forests. 8.71 lakh hectares has been treated so far out of 17.40 lakh hectares of forest area under VSS. The Joint Forest Management program is being supported by the World Bank funded A.P. Community Forest Management Project, NABARD assistant for RIDF schemes and Government of India funded Forest Development agencies.

Water Harvesting Structures

A2.10.   Forest Department has taken up large-scale water conservation structures in forest areas under **Neeru-Meeru** (Water and You) Program. The structures such as continuous Contour Trenches, Checkdams, Rockfilldams, Percolation tanks and

sunken gully pits etc., 6 Phases of Neeru-Meeru have been completed and the 7th phase has just been completed. So far, including the 7th phase water storage capacity of 1566 lakh Cubic Meters has been created in forest areas incurring an amount of Rs. 309.72 Crores in execution of the water conservation structures in forest areas.

Micro Irrigation Project

A2.11.   The state of Andhra Pradesh has been experiencing severe water stress due to continuous drought situation over the last 3 years. There is therefore an imperative need to promote judicious use of water, particularly in-respect to agricultural activities. With this in view the Government has launched a massive Micro Irrigation Project in 2003-04 throughout the state, with special emphasis on water stress mandals. The project envisages installation of sprinklers, drip irrigation and rain guns to use the irrigation water available underground in the most efficient manner while improving productivity. It is contemplated that in the first phase an extent of 2.50 lakh ha would be covered at an outlay of nearly Rs. 1200 Cr. The farmers will be given 50% state Government subsidy on the unit cost.

Andhra Pradesh Rural Livelihood Project (APRLP)

A2.12.   The Andhra Pradesh Rural Livelihoods Project provides critical support to the on-going watershed movement in five drought prone districts in Andhra Pradesh. The mandate is to position livelihood concerns strategically in watersheds for the inclusion of women, the poor and the landless. The project advocates innovation, lesson learning, convergent actions and policy influence. APRLP will invest in a new stream of approaches and ideas for bringing about a positive change in the well-being of the rural populace.

A2.13.   APRLP has initiated a paradigm shift in watershed development Program by adopting sustainable livelihoods approach. This site is to share the saga of promoting the poor and women into mainstream development through conscious policies, effective implementation and sustainable management. Moreover, this platform is to inform, educate and inspire all concerned stakeholders in the project.

A2.14.   The development of semi arid and rainfed drought prone areas is one of the priority areas of Government of Andhra Pradesh and it is also established that development of natural resources in these areas will lead to sustainable rural livelihood. Participation of the committee of resource poor and landless as primary stakeholders is precondition of sustainable rural livelihood. Therefore, the Government of Andhra Pradesh has entered into an agreement with Department for International Development (DFID, UK), who shares this vision, for implementing AP Rural Livelihoods Project (APRLP) in Anantapur, Kurnool, Mahabubnagar, Nalgonda and Prakasam districts. The APRLP will facilitate the objective of people centered development input to the ongoing watershed Program of government including 500 new innovative watersheds, sustainable rural livelihood initiatives in 2000 ongoing watersheds, capacity building of various stakeholders, research and lesson learning for policy initiatives, and infrastructure support.

Watershed Development

A2.15.   National Agriculture Bank for Rural Development (NABARD) finances a watershed development fund. Due to watershed development Program, the proportion of area under irrigation has increased by 19 to 129 percent among all households. Total employment has gone up by 11 to 29 percent. Yield rates have gone up for irrigated as well as un-irrigated crops. Only 50 percent of the watersheds studied are economically viable in terms of incremental returns. The equity effect is not clearly known, though the impact on rich and medium households possessing of lands seems higher. Drinking water situation improved substantially. Ground water levels improved to a limited extent. Migration of labor decreased during execution period. But in majority of cases, this is not sustained after the executing period. Household's preference for education increased. The role of women in financial matters has improved substantially.

Integrated Wastelands Development Program (IWDP)

A2.16.   Rapid depletion of green cover and vast stretches of marginal lands lying fallow, found to be causing enormous ecological imbalance. Productivity is also negligent on account of soil erosion and marginalization of lands. To arrest this, massive integrated wasteland development project was undertaken during 1991 with 100% central assistance. The project is being implemented in 17 districts, in Andhra Pradesh, with 38 projects covering an area of 362985 ha with an outlay of Rs. 17784.28 lakhs.

Rural Infrastructure Development

A2.17.   A fiscal package has been developed for the purpose of rural infrastructure development. In Andhra Pradesh the Department of Rural Development, Forest, Panchayat Raj, Minor Irrigation have availed this scheme. In this program, each district has selected certain villages for treatment. The implementation at village level is through user groups who are formed on the basis of drainage line. These groups decide treatment of drainage line or common lands. The scheme excludes private land treatment.

Sampoorna Grameen Rozgar Yojana (SGRY)

A2.18.   The Sampoorna Grameen Rozgar Yojana (SGRY) will have the following objectives:

- Primary Objective---The primary objective of the Scheme is to provide additional wage employment in all rural areas and thereby provide food security and improve nutritional levels.

- Secondary Objective ---The secondary objective is the creation of durable community, social and economic assets and infrastructural development in rural areas.

A2.19.   The programme is self-targeting in nature with special emphasis to provide Wage Employment to women, scheduled casts, scheduled tribes and parents of children withdrawn from hazardous occupations. The works to be taken up must be labor intensive, leading to the creation of additional wage employment, durable

assets and infrastructure, particularly those which would assist in drought proofing such as soil and moisture conservation works, watershed development, afforestation, etc.

Employment Programs

A2.20.   There are many other self employment programs, based on income generation, to improve the livelihood of the affected population. These programs are based on people's participatory approach. Andhra Pradesh government has created various employment generation programs to eradicate poverty. While considering self employment schemes the government has given priority for mini and micro enterprises. These programs can be considered as mitigation measures at the time of drought.

Mission based approach to employment generation

A2.21.   The Government of AP has established Employment Generation Mission to coordinate activities of all the concerned departments in employment generation and manpower planning. The Mission will prepare a time bound action plan for implementation. The Government will act as facilitator and would identify and prioritize key sectors with employment potential and ensure successful implementation.

Empowerment of poor women

A2.22.   Self Help Groups of Women (thrift groups) Program has mobilized and organized 48 lakh poor women in the rural areas into 3.7 lakh groups. These women groups have built up a corpus fund of Rs 750 crores consisting of their savings, borrowings from banks and Development of Women and Children in Rural Areas (DWCRA) revolving fund from government. The empowerment process has enabled the DWCRA and thrift group members in addressing all of poverty's dimensions. DWCRA movement has contributed to the augmentation of incomes, improvement of nutrition, better child care of the poor women, and enhanced the status of women in rural households. A similar program for the urban areas has now been started under the name of Development of Women and Children in Urban Areas (DWCUA). 5523 DWCUA groups have been formed and developed in urban areas.

Food for Work Programs (FFW)

A2.23.   India has launched an ambitious food-for-work program aimed at helping millions of the rural poor stave off hunger and unemployment. The basic principle of FFW is to provide employment to the poor during hard times, to create community assets through labor-intensive work and to pay the laborers in food grains or other food items.

Chief Minister's Empowerment of Youth (CMEY) Program

A2.24.   CMEY Program had the main objective of economic development of youth by empowering them with sufficient skills and infrastructure. This was to be achieved by extending financial assistance to the eligible youth associations by way

of subsidy and margin money loans besides group savings for taking up economic activity of their choice.

ANNEX 3   WEATHER GENERATOR (WXGEN) IN EPIC

A3.1.   The weather generator in EPIC (WXGEN) is based on that described by Richardson (1981a). The model generates daily values of precipitation, maximum and minimum temperature, solar radiation, wind speed, and wind direction for any number of years for a location (Sharpley and Williams, 1990). The weather generator in EPIC is designed to preserve the dependence in time, the internal correlation and the seasonal characteristics that exist in the actual weather data. Precipitation and wind are generated independent of the other variables. Maximum temperature, minimum temperature and solar radiation are generated conditioned on whether the day is wet or dry.

A3.2.   A first-order Markov chain is used to generate the occurrence of wet or dry days. When a wet day is generated the precipitation amount is generated based on skewed normal distribution. With the first-order Markov chain model the probability of rain on a given day is conditioned on the wet or dry status of the previous day.

A3.3.   The procedure to generate the daily values of maximum and minimum temperature and solar radiation is based on the weekly stationery generating process given by Matalas (1967). The wind component of the model provides for generating daily values of wind speed and direction as described by Richardson (1982a).

A3.4.   EPIC can be run using either historical weather data or it can generate some or all of the data via its weather generator. The weather generator, however, has to be parameterized based on historical data for the study region. Within the study region, historical daily rainfall data is available at block level but other meteorological data are available at district level. The weather generator parameters at block level are computed using the daily rainfall data at block level and other daily weather data at district level.

A3.5.   WXGEN was evaluated for its effectiveness in simulating weather in the Indian context using 20 years of daily weather data for IMD stations at Anantapur and Mahbubnagar districts. The weather generator model parameters for the simulations were calculated from 20 years of daily weather data for Anantapur and Mahbubnagar.

A3.6.   Using the weather generator model parameters, daily weather was simulated for 50, 100 and 200 years for the two stations. A Chi-square test was then performed to test whether the simulated monthly means of rainfall, air temperature and relative humidity are significantly different from the historical means. It was found that simulation convergence is achieved after simulating 200 years of weather and the null hypothesis was rejected at 5% level of significance for rainfall and 1% for other parameters.

A3.7.   Consistency among the daily parameters is also verified by performing a t-test for regression coefficients between simulated and historical daily values. The test result showed that the model preserved the internal correlation among the variables with a 1% level of significance. Based on these results WXGEN is recommended for weather generation in this study.

A3.8.   There are about 450 blocks in 8 districts. For all the blocks the data extends up to 2003. Rainfall data is available for 1988-2003 for about 60% of the blocks. Remaining blocks have rainfall data starting before 1988 going as far as 1963. Wherever data available prior to 1988, the model parameters for those blocks were computed using data prior to 1988. However, block level rainfall data is used only for simulation of weather which required other parameters as well (temperature, humidity, etc.). Other parameters are taken from the district level IMD data, whose period is generally 1973-1999. So, the final period used in simulation of weather at block level is constrained by rainfall at block and other parameters at district.

A3.9.   The block level historical daily rainfall data available for the study region were subjected to a number of quality control procedures before computing the block level rainfall simulation parameters. The spatial and temporal consistency were checked and suspected data points were replaced with nearby stations data. Missing years and daily gaps in the data were not used for the parameter computation.

A3.10.   For computation of return periods of droughts at district level, rainfall data at district level supplied by DES was used. This data is for 1973-2003 for all 8 districts.

ANNEX 4   EPIC – CROP GROWTH MODEL

About EPIC

A4.1.   EPIC a mathematical model operates on a daily time step to simulate evapo-transpiration, soil temperature, crop potential growth, growth constraints (water stress, stress due to high or low temperature, nitrogen and phosphorous stress) and yield. EPIC uses a single model for simulating all crops, each crop has unique values for model parameters, which can be adjusted or created by the user if needed provided they have enough knowledge of the crop and model operation. The crop growth model uses radiation-use efficiency in calculating photosynthetic production of biomass. The potential is adjusted daily for stress from water, temperature, nutrients (nitrogen and phosphorous), aeration and radiation. Crop yields are estimated using the harvest index concept. Harvest index increases as a nonlinear function of heat units from zero at the planting stage to the maximum value at maturity. The harvest index may be reduced by high temperature, low solar radiation, or water stress during critical crop stages.

Input Data

A4.2.   Two kinds of standard data sets are required as EPIC inputs files. One is basic input about miscellaneous field information such as climatic data, soil data, and management information. The other consists of a growth and fertilizer parameter file. The parameters for most of the major crops have been established by the developers and do not need to be modified if there is no more specific knowledge for the application. The climate variables, the soil physical properties the management information required by EPIC model are described below:

A4.3.   EPIC uses a stochastic weather generator to generate daily weather from monthly maximum and minimum temperatures, precipitation, standard deviation (S.D.) of precipitation, skew coefficient for daily precipitation, probability of a wet day after dry day, and probability of wet day after wet day. EPIC can accept up to 20 parameters for 10 soil layers. However, out of these a minimum of five parameters are required: depth, percent sand, percent silt, bulk density, PH, percent organic carbon, and percent calcium carbonate. Other related soil parameters can be estimated by EPIC itself.

A4.4.   EPIC requires detailed descriptions of management practices. These descriptions must specify the timing of individual operations either by date or by fraction of the growth period (i.e. by heat units). EPIC allows the user to simulate complex crop rotations by specifying options for irrigation and fertilizer applications in the EPIC program: the applications can be made automatically based on rules or manually.

Major Crop Growing Seasons

A4.5.   Kharif (June to October) is characterized by a gradual fall in temperature, more numerous cloudy days, low light intensity, a gradual shortening of photoperiod, high relative humidity and cyclonic weather. During Rabi (November to March),

there is a gradual rise in temperature, bright sunshine, near absence of cloudy days, a gradual lengthening of the photoperiod and a lower relative humidity.

A4.6.   Rabi weather is more conducive for rice and in general, rice yields are higher in Rabi than Kharif. However, this does not hold true for maize. Unlike jowar and sunflower, which are mostly Kharif crops, maize can be grown in any climate. Groundnut is raised both in Kharif and Rabi but crop acreage is more in Kharif season. Out of above five crops validation, we were unable to compare/validate sunflower yield due to unavailability of reported yield data at district level.

Model Testing

A4.7.   This covers rigorous test of model performance involving the comparison of reported crop yield to model outputs achieved with condition similar to those prevailing at the time the real world crop growth. Parameterization is often an iterative process of comparison of model and observed data and parameter adjustment to achieve a better match. Once the crop model is adjusted the next step in testing the model is validation against independent data. In this study, observed yields of crops were compared with the model outputs for the same crop for the kharif season period. However, because economic data is often gathered in political reporting districts, rather than agro-climatic areas current results of crop productivity were compared to political districts to ensure that the same can be used as input to economic models.

Parameterzing EPIC

A4.8.   Most of the crop growth parameter sets in EPIC are developed for temperate conditions. They produce high yield estimates as the potential radiation use efficiency is less in tropical conditions *i.e.,* under Indian conditions. Accordingly potential radiation use efficiency values (WA; also called as biomass-energy ratio) have been lowered from 35 to 10 both for groundnut and sunflower to match Indian data. Also, the base temperature (TG) was changed to $8^{\circ}C$ from $13.5\ ^{\circ}C$ for groundnut (Annual Report of Agro-meteorological Cell, ANGRAU).

A4.9.   Water stress reduces yield in EPIC by reducing accumulated biomass and reducing the harvest index. Water stress is only allowed to reduce the harvest index over the later portion of the growing season. Harvest index has been lowered from 0.40 to 0.30 both for groundnut and sunflower to better match field trials in India (Annual Report of Agro-meteorological Cell, ANGRAU). This is consistent with findings that many crops have developmental phases (such as pollination and grain filling) in which water stress is critical. Each of the crop specific parameters (over 30 in number) helps compute the growing season water stress through accumulated biomass reduction in the form of mid and late season water stress reductions in crop yield (Bryant et al. 1992).

Validation

A4.10.   Validation at districts were carried out using block level simulated outputs for the years 1996, 1997, 1998 and the annual reported yields for the selected five crops rice, maize, jowar, groundnut and sunflower. The validation was done using only Kharif simulated crop yield for the Kharif season which were compared

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with annual (Kharif + Rabi) reported yields which were the only data available. The crops, other than rice, are often grown in the Rabi season in Andhra Pradesh under drought conditions and with irrigation supplements. Since the extent of irrigation for particular crops was not known, models of crop yield in the Rabi season could not be expected to match the reported data. Nevertheless, the validation test is still powerful since a predominance of annual yield is derived from the Kharif season. For instance statistical analysis on crop growing region shows that in the Anantapur district of Andhra Pradesh the area planted in the Kharif versus Rabi season were for rice 2.7 times, maize 3 times and groundnut 41 times.

ANNEX 5   PLANTING AREA MODEL

A5.1.   To estimate crop production estimates of both the year-to-year variation in yield and in area planted are needed. A statistical model was developed to compute area of each modeled crops (and a category or 'other crops') at block level based on the rainfall of that district.

A5.2   Following data sets are available for building the planting area model,

    i.   District wise cropped areas for major crops, Gross Cropped Area (GCA), Gross Irrigated Areas (GIA), cropped areas by source of irrigation are available for the period 1975 –76 to 2002-03.
    ii.   Cropped areas by season and block are available for the period 1999-00 to 2003–04.
    iii.   Daily, Monthly and annual rainfall for IMD stations (1975- 02).

A5.3.   Crop-wise rain-fed areas and Gross Rain-fed Area (GrfA) calculated as difference of crop wise gross areas and irrigated areas.

A5.4.   Planting area model aimed to make use of the available data in building the statistical relationship among the variables. Varieties of combinations of variables are tested to answer the following queries. Dependent variables are rainfall (absolute, lag rainfall, log transformed rainfall, % change in rainfall) and independent variables are Gross Cropped Area, Gross Irrigated Area, Individual cropped areas. One dependent variable taken at a time in building the model.

    i.   To find any significant relation among area with the previous year rainfall;
    ii.   To test whether there is any correlation of previous year monsoon first month rainfall (June) with the Areas;
    iii.   To test whether there is any relation of crop areas with the monsoon strike date; and.
    iv.   Check whether there is any relation of change in areas with the change in rainfall.

A5.5.   To answer the above queries, the following combination of variables are used in building the planting area regression models,

    i.   GCA, GIA, GrfA Vs Previous year annual rainfall (Log Transformation)
    ii.   GCA, GIA, GrfA Vs Previous year June rainfall (Absolute and Log transformation)
    iii.   GCA, GIA, GrfA Vs Current year Monsoon strike date
    iv.   Change in GCA, GIA, and GrfA over previous year with change in rainfall over previous year.

A5.6.   Unfortunately none of the first three versions gave satisfactory results. It was observed that there was a lot of scatter and no significant correlation in first three combinations. The fourth combination gave a good correlation structure among the variables. Hence it is proposed as a candidate Planting are model. Results of these

plots for Anantapur are shown in Figure 1 to Figure 8. Similar patterns have been observed for other districts.

A5.7. Two Linear regression equations separately for irrigated and gross cropped areas regressed on rainfall are developed based on the district level data from 1975-1976 to 2002-03. Gross rain-fed area is determined as difference between Gross Cropped area and gross irrigated area. However, the variables represent their percent changes instead of their absolute values. The percent change in rainfall explains the percent change in area better than their absolute values do. Taking any known year/event as the base the equations can give percent changes for the simulated year/event of interest. Knowing the percent change in rainfall for each of stochastic rainfall, regression equations are used to calculate the change in GCA and GIA, then absolute areas are calculate with reference to areas in 1998-99. Gross Rain-fed areas are determined as the difference of Gross Cropped area and Gross Irrigated area.

A5.8. Distribution factors by crop by season and by block are derived using the 2000-2001 and 2003-2004 block level data separately for irrigated and rain-fed. The structure of the model is given in figure 8. The district cropped area is then disaggregated using the distribution factors. Based on the consistent cropping pattern observed in the four year block level data (although limited) an assumption is made that the same pattern would continue in the future.
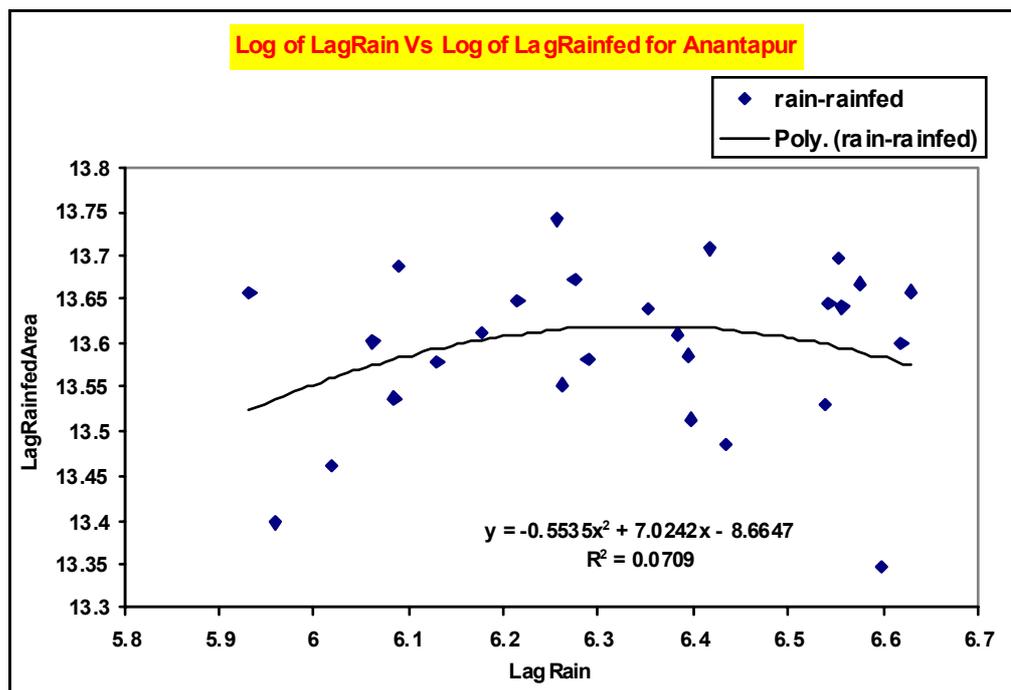

Figure A5.1. Log of Lag Rain Vs Log of Lag Gross Rain-fed Areas for Anantapur.

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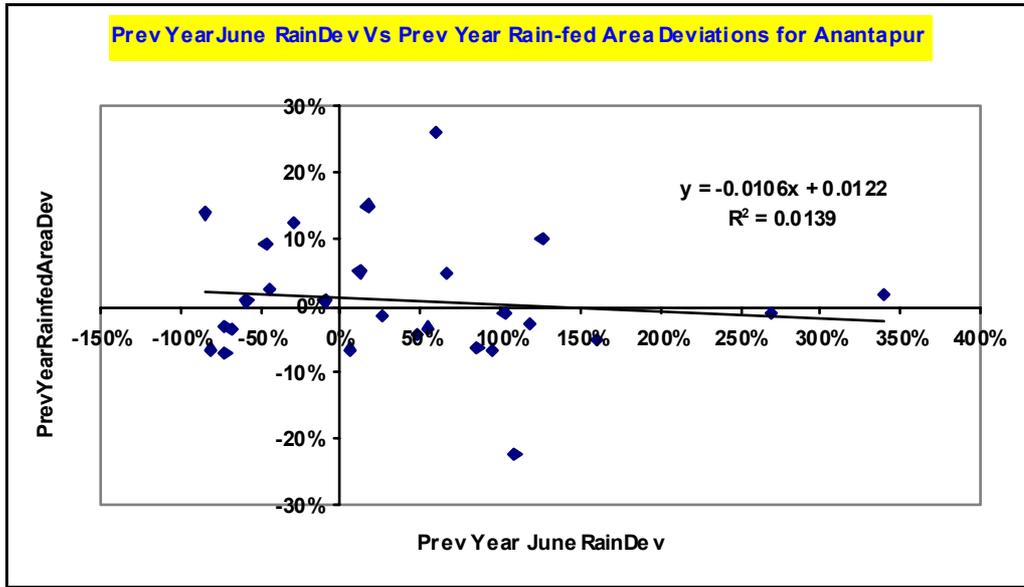
Figure A5.2. Previous year June Rain deviations Vs Current year Gross Rain-fed Area deviation for Anantapur
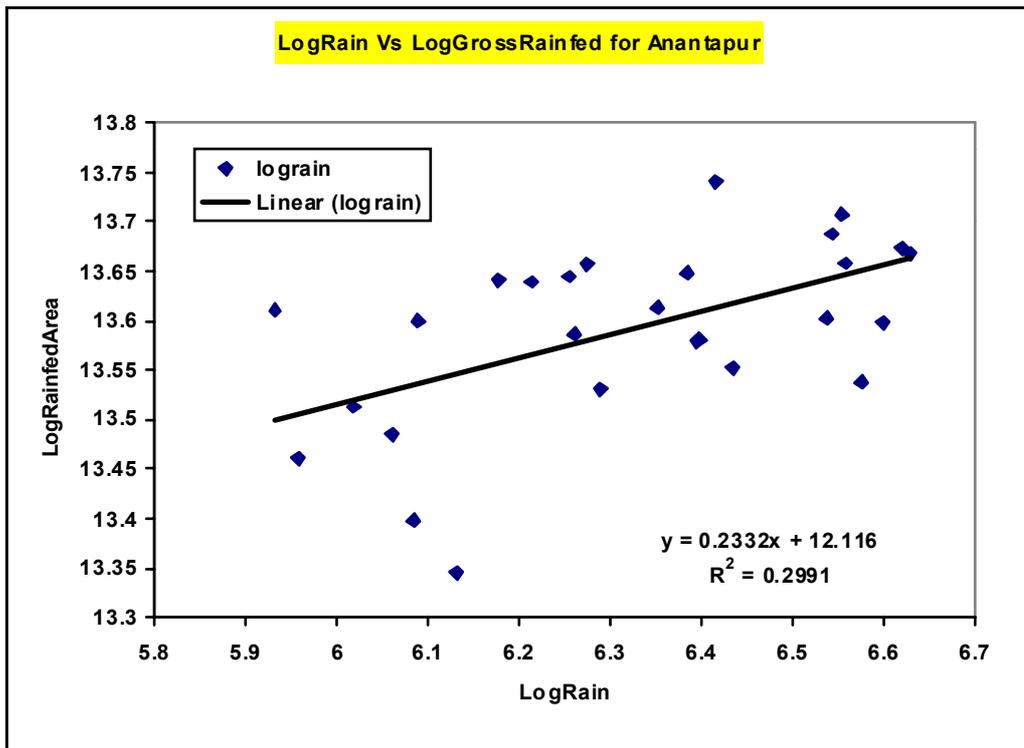

Figure A5.3. Log Transformed Current year Rain Vs Gross Rain-fed Area for Anantapur
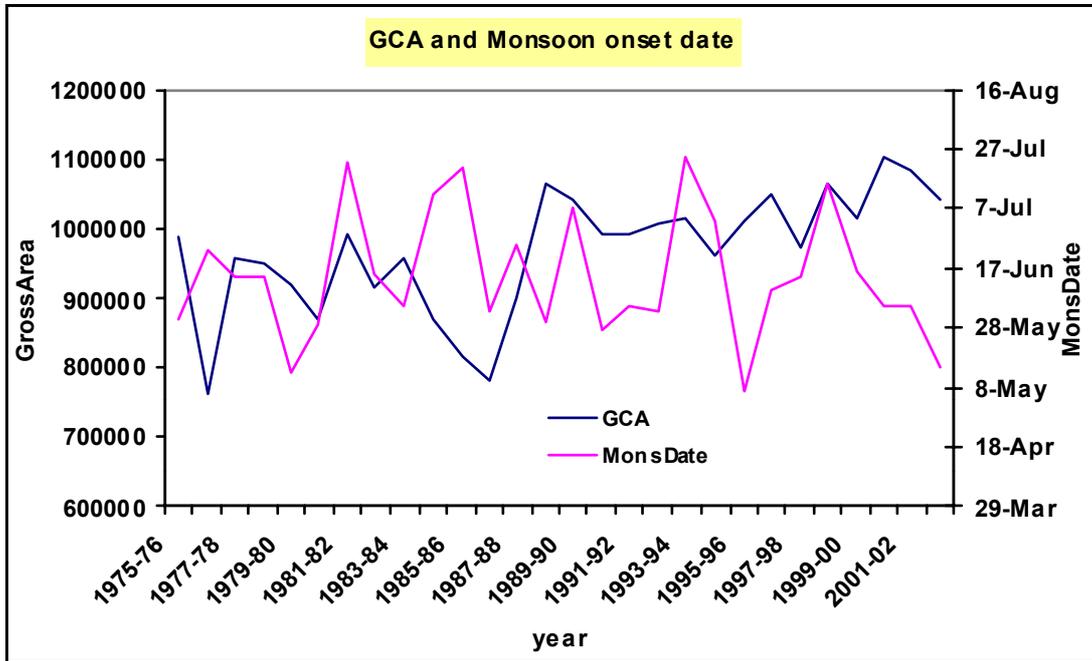
Figure A5.4. Gross Cropped Area and Monsoon strike date variation over the years for Anantapur
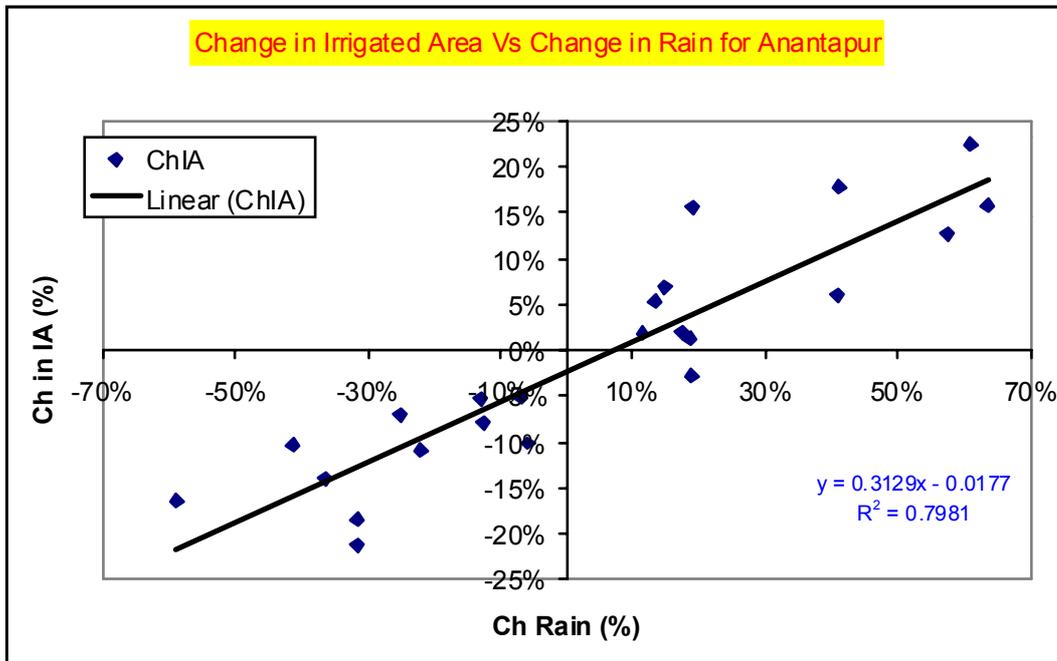
Figure A5.5. Change in Gross Irrigated Area Vs Change in annual rain for Anantapur

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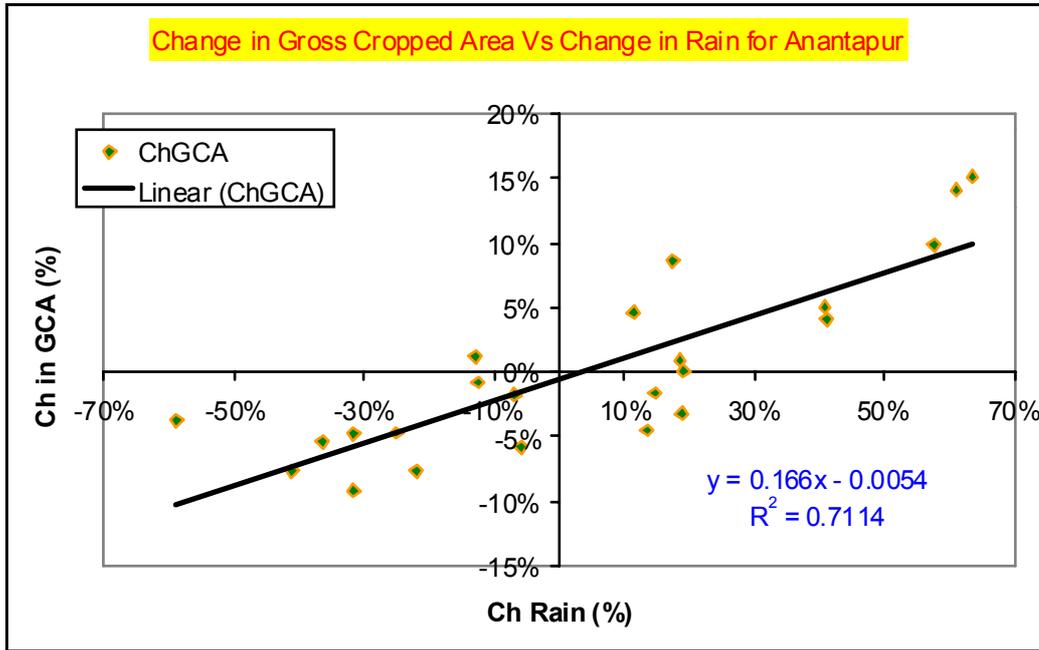
Figure A5.6. Change in Gross Cropped Area Vs Change in annual rain for Anantapur
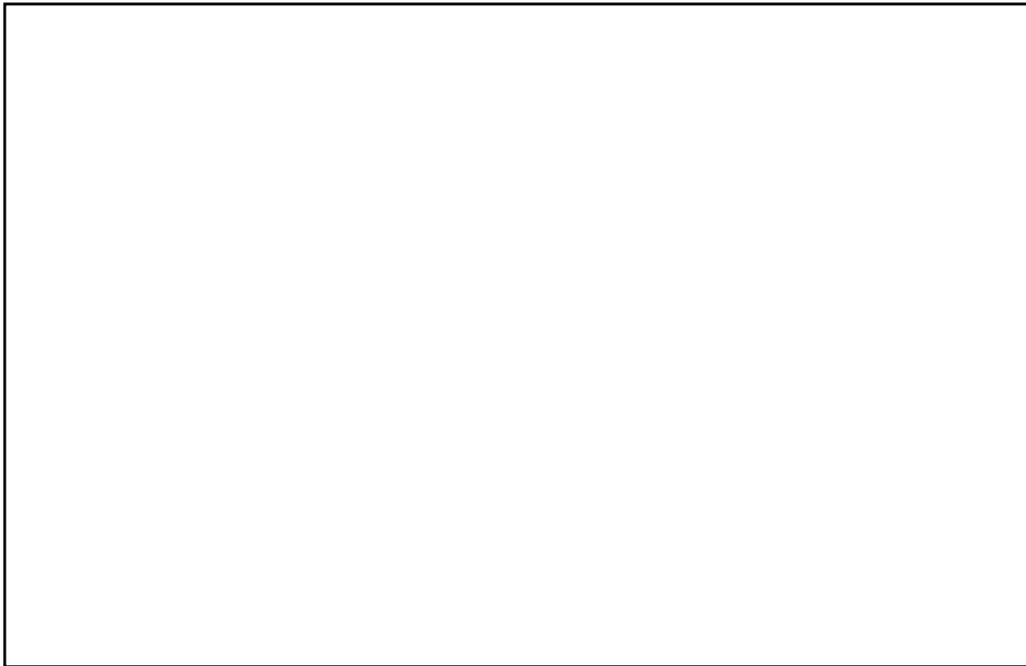
Figure A5.7. Change in Gross Rain-fed Area Vs Change in annual rain for Anantapur

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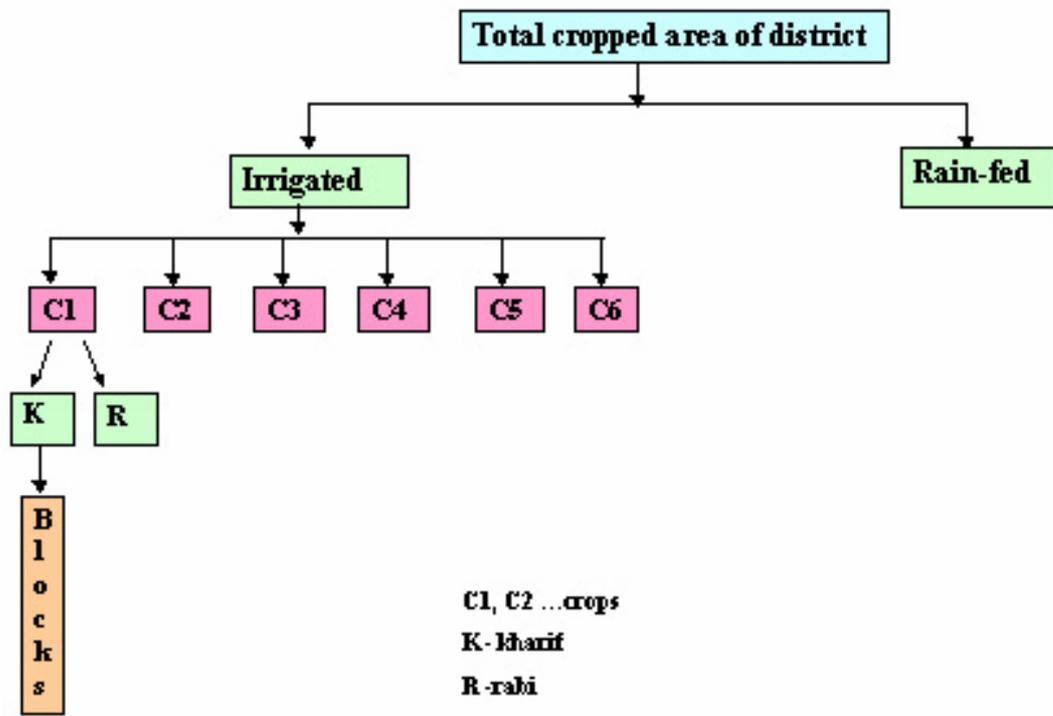
Figure A5.8. Structure of the Planting area Model.

ANNEX 6 STOCHASTIC CROP PRODUCTION LOSS MODEL

A6.1. The stochastic crop production loss model comprises 3 sub-modules:

Stochastic Hazard module

A6.2. Weather is simulated for 500 years using historical weather parameters for each block using the WXGEN weather simulator (See Annex 3). Each of the simulated events (years) is assigned a drought category based on the Standard Precipitation Index (SPI) derived from cumulative seasonal (June to December) rainfall (McKee et al, 1993).

A6.3. The SPI computation for a specific time scale and location requires an historical record of 30 or more years of monthly precipitation. The long-term record is fitted to a gamma probability distribution that is then transformed into a normal distribution (SPI), which, by definition, has zero mean and unit variance. In McKee et al (1993), drought is defined as an event which occurs if the SPI value is -0.1 or less while, in the present study, the SPI value of -0.5 or less is used to define a drought event. The drought categories as defined in this study are are:

Seasonal SPI	Drought Category
0.5 to –0.5	Normal year
-0.5 to –1.0	Minor Drought
-1.0 to –2.0	Moderate Drought
-2.0 to –3.0	Severe Drought
-3.0 and below	Extreme Drought

A6.4. An event with SPI value greater than 0.5 is assumed to represent a year with excess rainfall. SPI is computed for each year at district and state (8 districts combined) levels by aggregating cumulative seasonal rainfall for all the blocks in the district or state. For aggregation simple average of the rainfall of all the blocks is taken. Figure A6.1 shows the results of validating the modeled SPI index with historical data for Anantapur.

Figure A6.1. Validation of SPI for Anantapur

Anantapur District EP (Historical Vs. Modeled)
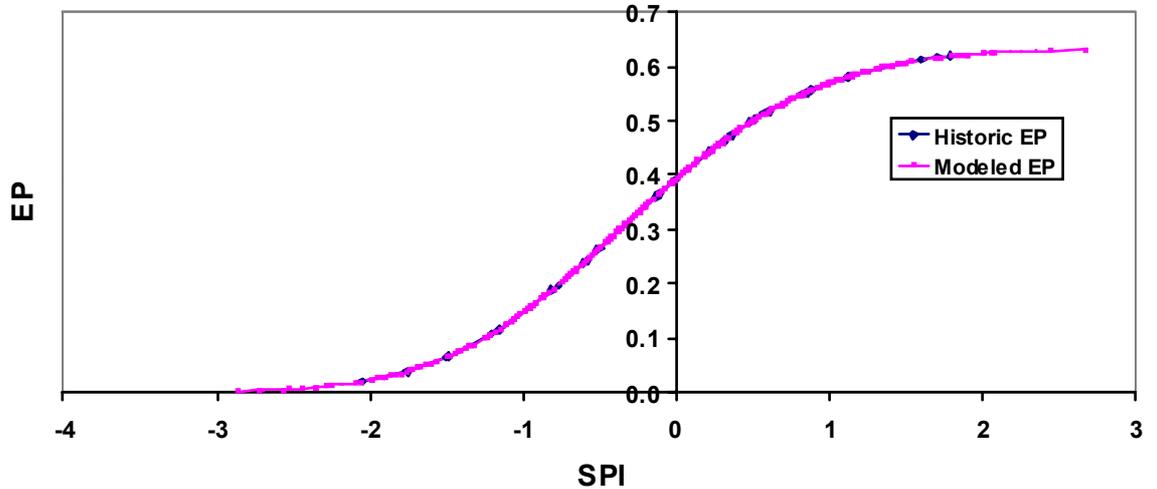
A6.5.   The rate of occurrence for any event in the 500-event set is assumed to be 1/500. Thus the frequency of a given category of drought among the simulated events is computed as the number of events of the particular category divided by 500.

Vulnerability and exposure module

A6.6.   In the vulnerability and exposure module the average yield and planting area associated with each of the simulated events is determined for each crop at block level.

A6.7.   Average yield of 5 crops (Jowar, Maize, Groundnut, Sunflower and Rice) associated with each block and category of drought is determined with the help of EPIC model. EPIC runs are made at block level for selected events (10 nos.) representing different categories of drought. The events are selected from the 500-year event set for every block to represent each of the drought categories based on a representative SPI value.

A6.8.   The Planting area model computes the planting area associated with each crop and for each of the 500 events at block level based on annual rainfall corresponding to the event.

Loss Module

A6.9. In the Loss module the crop-wise loss in production associated with the 4 categories of drought is computed at block, district and state (8 districts combined) level.

A6.10. For each crop, production is computed for each of the 500 events at block level as Production=Planted area x Average yield. The block level production is then summed up to get the production at district and level. Average normal production at district / state level is computed as the simple average of production for all the events categorized as Normal year in the 500-year event set at the corresponding (district or state) level. Percentage Loss in production for each event and crop is then calculated at the required level as:

% Loss in Production=100 x (Average Normal Year Production – Production for the event) / Average Normal Year Production

ANNEX 7   INPUT-OUTPUT ANALYSIS FOR ANDHRA PRADESH

A7.1.   The Central Statistical Organization (CSO) has been constructing Input-Output (I-O) tables in India since 1973-74 at an interval of about 5 years. The latest (unpublished) table relates to the year 1998-99. The published tables for the years 1989-90 and 1993-94 are for 115 sectors of the economy while for earlier years these relate to 60 sectors only. At the state level, however, I-O tables are not prepared on a regular basis. Some of the states like Punjab, U.P., Assam and Hariyana have prepared the tables but only once. The table for Andhra Pradesh for the present analysis has been constructed for the year 1998-99 by making use of all-India I-O table along with the available data at state level. This table in addition has been extended for 2000-03. The I-O tables for 1998-99 and 2002-03 are provided in the Appendices. The first sections provide, in brief, the theoretical background for the Input-Output analysis. The second section gives some details about the sources of data and the methodology used for constructing the I-O tables for Andhra Pradesh, by broad sectors of the economy. The third section presents the output and employment multipliers. The last section provides the comparative analysis of the constructed I-O tables for the state.

Data and Methodology

A7.2.   The all India Input-Output (I-O) table is available for the year '98-'99. The I-O matrix in terms of their coefficients (A) for all India along with directly available details of crop wise Value of Outputs (VOP's) for agriculture and the Gross Value Added (GVA) and VOP for Livestock, Forestry and Logging and Fishing, Mining & Quarrying, Construction, GVA estimates for registered & unregistered manufacturing (2- digit level) and the GVA estimates of various services directly available for the state has been used to prepare the I-O table for Andhra Pradesh (AP).

A7.3.   A.P. economy has been broadly classified into the following sector. The broad categories are:
- Agriculture
  - Paddy
  - Jowar
  - Maize
  - Other food grains
  - Groundnut
  - Other crops.
- Livestock.
- Forestry & Logging.
- Fishing.
- Mining & Quarrying.
- Manufacturing.
  - Food products.
  - Textile products.
  - Wood products.
  - Paper products.
  - Leather products.

- o Rubber, plastic, coal & tar and Petroleum products.
- o Fertilizers
- o Pesticide.
- o Chemicals.
- o Non-Metallic Mineral Products
- o Basic Metals & Alloys.
- o Metal Products, Elect. & Non-elect. Machinery & Equipments
- o Transport Equipments & Parts.
- o Miscellaneous Industry.
- Construction.
- Services
  - o Electricity, Gas and Water supply.
  - o Railway transport services.
  - o Other sources of Transport & Storage
  - o Communication
  - o Trade Hotels & Restaurants
  - o Banking and Insurance
  - o Ownership of dwellings, real estate and business services.
  - o Education, Medical & Other Services
  - o Public Administration

A7.4. Detailed methodology and sources used for constructing the I-O tables by different broad sectors are given in the following paragraphs.

Agriculture

A7.5. The VOP data for all the crops (1998-99) for the agricultural sectors were obtained from the Directorate of Economics & statistics (DES), AP. The values are aggregated to 6 sectors mentioned above. Certain adjustments were made in some sectors (like paddy) to take into account the milling, because in the all India tables milling is included under agriculture so using the ratios based on the all India table adjustment was done. The National Accounts Statistics (NAS) figures for agriculture and same figures from the I-O table (all India) were considered. The ratio between the I-O output figures and the NAS figures obtained were used for adjustment.

A7.6. These adjusted figures (VOP data) were used along with the all India coefficients to calculate the AP input vectors for the six agricultural sectors. The adjustments were made to have the inputs of fertilizers, electricity, and petroleum products consistent with the estimates provided by the DES. Thus obtaining the structure of the inputs for the agricultural part of the 98-99 I-O matrix at current prices for AP

A7.7. The VOP data for 2002-03 were available for paddy, jowar, maize, other food grains and also the total VOP for all the crops from DES.

A7.8. The VOP of groundnut for the year 2002-03 has been calculated by using the output/production data for 2002-03 and the wholesale price of groundnut for that year. The production figure multiplied with the price data gave the VOP of groundnut for 2002-03. The VOP of other crops is obtained by subtracting the values of output of first 5 sectors from the total VOP of all the crops made available by DES. The

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sector-wise ratio of VOP for 2002-03 over 1998-99 were used over the I-O 1998-1999 VOP's to get the I-O 2002-03 VOP.

A7.9.   The adjusted GVA and VOP data for the six sectors for 2002-03 were converted to 1998-99 constant prices using the price *indices*[1]. The total inputs for each of these sectors were calculated by deducting the GVA from the VOP. All the calculations were done on data of 2002-03 at 1998-99 constant prices. These total inputs were distributed to sector wise inputs by using the AP 1998-99 coefficients.

A7.10.   Hence the structure of the inputs for the agricultural part of the I-O matrix for A.P for 2002-03 at 1998-99 prices have been constructed.

Livestock, Forestry & Logging, Fishing and Mining & Quarrying

A7.11.   The GVA and VOP data for the livestock; forestry and logging; fishing; and mining and quarrying sector for AP were obtained from the DES. The difference between the VOP and the GVA gives the inputs to these sectors. The inputs were then distributed using the all India coefficients. Thus the input structure for these sectors for AP for 1998-99 was obtained by using the all India structure.

A7.12.   The GVA and VOP for the livestock; forestry and logging; fishing; and mining and quarrying sector for 2002-03 were available both at current and constant 1993-94 prices. The GVA and VOP for 2002-03 (at current prices) were converted to 1998-99 constant prices using the price indices. These figures were used to calculate the inputs for each of these sectors which were then distributed using the I-O 1998-99 coefficients. Thus obtaining the input structure for livestock; forestry and logging; fishing; and mining and quarrying sector for AP for 2002-03 at constant 1998-99 prices.

Manufacturing Sector

A7.13.   The manufacturing sector at the 2-digit level for all India as well as for AP was classified under the previously mentioned headlines.

A7.14.   The detailed data of GVA for both registered and unregistered factories were available from the DES, AP for 1998-99 at current prices at 2 digit level of industrial classification. The Annual Survey of Industries (ASI) for the *registered*[2] manufacturing sector gives the GVA and VOP for different sectors of the economy at state level. The Un-registered sector estimates of GVA and the VOP were obtained from the survey conducted by the National Sample Survey Organization (NSSO) with reference to 2000-01. It is assumed that the ratio between VOP and GVA for 1998-99 & 2000-01 are the same for the unregistered sector. Using the ratio of VOP to GVA from these sources on the GVA provided by DES, the VOP's were obtained separately for registered and unregistered parts of different sectors for 1998-99 and then added. These adjusted figures were used for the calculation of the Value of Inputs (VOI).

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[1] The methodology for the calculation of the price indices is provided in the Appendix B.
[2] The Factories, which have 10 or more workers and use power or factories, which have 20 or more workers and do not use power are registered (organized) factories. The remaining enterprises are unregistered.

VOI = VOP – GVA.

A7.15.   These values of inputs for 1998-99 at current prices for the sectors obtained were at the purchaser's prices. The all India I-O matrix gave us the corresponding VOI at the purchaser's prices as well as their sectoral distribution.

A7.16.   The input structure of 1998-99 for the manufacturing sector for A.P was obtained by assuming the all India input structure for different sectors. This had to be done because at state level the detailed data of inputs were not available. This assumes that the structure of inputs for different sectors is the same for the state and all India.

A7.17.   The detailed data of GVA for both registered and unregistered factories for all the above sectors were available from the DES, AP for 2002-03 both at current and constant 1993-1994 prices. The GVA data thus obtained was converted to GVA at 1998-99 constant prices The values of output as well as input structure for different sectors under manufacturing were estimated by using the 1998-99 I-O AP structure on the 2002-03 GVA at 1998-99 prices. Hence the input structure of the manufacturing sector for the year 2002-03 at constant 1998-99 prices has been constructed.

Services

A7.18.   The GVA data for the services sector for 1998-99 for A.P were obtained from the DES, AP and data at the all India level were available from the I-O 1998-99 matrix (all India). The ratio of A. P to all India was computed and then used to adjust the all India I-O structure for the services sector. The input structure for the services sector for AP was thus obtained by using the all India structure.

A7.19.   The services sector GVA growth rate from 1998-99 to 2002-03 was obtained from the constructed I-O 1998-99 table and the DES data was used on the I-O 1998-99 VOP data and the VOP for the year 2002-03 was calculated. The 2002-03 current price VOP data was converted to constant 1998-99 prices using the index. The inputs at 1998-99 constant prices were calculated using the converted GVA and VOP data. These inputs were distributed to different sectors using the 1998-99 I-O coefficients. Hence the input structure for the services sector of I-O 2002-03 at constant 1998-99 prices has been constructed.

Final Demand

A7.20.   The various components of final demand are private consumption expenditure, government current expenditure, gross fixed capital formation, change in stocks and exports and imports.

A7.21.   The following paragraphs give the   detailed methodology and sources used for estimating the different components of the final demand for 1998-99 and 2002-03 .

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Private Final Consumption Expenditure (PFCE)

A7.22.   At all-India level the private consumption expenditure is obtained by using the commodity flows approach. This method cannot be applied at the state level because of the openness of the economy. National Sample Survey (NSSO) conducts quinquennial household surveys on consumption expenditure. Detailed item wise estimates of consumption expenditure for 1999-2000 are available at state level and also for the country as a whole. There is a vast difference between the all-India estimates obtained from the NSSO survey and those obtained by the commodity flow approach. For this exercise the sector-wise ratios of NSSO expenditure for Andhra Pradesh to that of all-India have been applied to the all-India estimates given in the all-India I-O table for the year 1998-99. Here it is assumed that the degree of difference between NSSO and commodity flow approach estimates for Andhra Pradesh is the same as for all-India.

A7.23.   The PFCE is different from the household consumption. PFCE includes the expenditure of the non-profit institutions serving households, while the NSSO estimates are only for the households. Also the estimates based on the household survey are different from those of the estimates given by the I-O table using commodity flow approach and since our estimates are to be consistent with the I-O table this method has been used.

A7.24.   For 2002-03 the per capita expenditure estimates were available separately for rural and urban areas of AP by broad groups of items available from the NSSO survey on the consumption expenditure. These along with corresponding population estimates were used to estimate the total expenditure for the same groups of items. Similar estimates for 1998-99 were obtained using 1998-99 NSSO survey. From these two sets of estimates the indices s of sector-wise growth of expenditure in 2002-03 over 1998-99 was obtained. These indices were applied on the 1998-99 PFCE estimates to get the similar estimates for 2002-03. It is assumed here that the growth rate under a group remained the same.

Gross Fixed Capital Formation (GFCF)

A7.25.   DES provided the total GFCF estimates for the year 1998-99. GFCF of Construction was estimated by subtracting the row total of construction (i.e. Intermediate use in the form of repair and maintenance) from the value of output.

A7.26.   The capital formation under livestock was obtained by using the ratio of increment in livestock in AP and increment in all India livestock to the capital formation in animal husbandry at all India level.

A7.27.   The estimate of the value of GFCF for rest of the sectors of AP for 1998-99 was obtained by subtracting the estimates of GFCF in livestock and construction from the total GFCF for AP. Similar estimates were obtained from the all India table I-O 1998-99. The ratio of these two estimates was used to get the sector wise estimates of GFCF for the remaining sectors. Here the assumption is that the distribution of GFCF of machinery sectors is the same for all India and AP.

A7.28.   The total GFCF for the year 2002-03 at current prices was made available by the DES. The GFCF data for the sectors for 2002-03 was obtained by

using the growth index over the 1998-99 GFCF data. The GFCF data obtained at current 2002-03 prices was then converted to constant 1998-99 prices using the sector-wise price indices

Government Final Consumption Expenditure (GFCE)

A7.29.   GFCE data for the state for the year 2001-02 to 2003-04 was available from " Economic cum purpose classification of Andhra Pradesh government budget 2003-04. The growth rate for the above mentioned years was used to calculate the GFCE for the year 1998-99 for the state. The ratio of the state to all India GFCE for the year 1998-99 was used on the all India I-O GFCE sector-wise estimates to get the estimates of GFCE for the state for the year 1998-99 .

A7.30.   The total GFCE figure of 2002-03 for the state was available from the above-mentioned source. The growth index of GFCE was used on the 1998-99 sector-wise GFCE figures to get the GFCE for all the sectors for the year 2002-03 at current prices. These figures were then converted to 1998-99 constant prices using the sector-wise price indices.

Imports & Exports

A7.31.   The Imports and exports for the sectors for the years 1998-99 and 2002-03 were obtained by subtracting the GFCE, PFCE, GFCF and the Intermediate use (row total) from the VOP of each sector. The Change in stocks (CIS) was not considered because of non-availability of data.

Employment Coefficients

A7.32.   This provides the number of workers required to produce Rs.1 lakh value of output. Employment coefficients will be used to calculate the employment multipliers that will capture the total employment change scenarios.

A7.33.   The ASI provided the employment data for the registered manufacturing and from NSSO surveys the unregistered sectors employment data were obtained. Using these two sources the employment coefficients for the manufacturing sector of AP was calculated.

A7.34.   The agricultural employment figures were available at the state level, which are used to get the coefficients for the agricultural sector. It's assumed over here that the coefficients for all the crops are the same.

A7.35.   Since data for other sectors were not available presently estimates based on the all India employment data available form the Central Statistical Organization(CSO) and VOP's from the all India I-O table have been used.

Multipliers

A7.36.   It represents a quantitative expression of the extent to which some initial, "exogenous" force or change is expected to generate additional effects through

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interdependencies associated with some assumed and/or empirically established, "endogenous" linkage system.

Two types of Multipliers will be considered

• Output.

• Employment.

A7.37.   The constructed I-O matrix has been used to calculate the multipliers.
A: I-O matrix expressed in terms of their coefficients.
I: Identity matrix of the same order as A.
$R = (I - A)^{-1}$
The R matrix is of the same order as A, and the column total for each of the sectors in the R matrix gave the output multipliers for those sectors.

A7.38.   Table 1 presents the employment coefficients and output multipliers calculated from the Input-Output matrix for the year 1998-99 . The employment coefficients are pretty high for the agricultural sector implying that agricultural sector is the major employment generator for the state. So any external shock to the agricultural sector has a direct impact on the states employment scenario. The output multiplier for paddy shows that one unit (lakh) increase in final demand of paddy results in increase of 1.46 units (lakhs) of gross output in the economy. The output multiplier is highest for metal products, electricity and non-electric machinery and equipments followed by pesticides. Sectors like basic metal and alloys, electricity, gas and water supply also have very high output multipliers. Overall, the manufacturing sectors have the highest output multipliers. This suggests that manufacturing sectors have very high backward linkages.

Analysis

A7.39.   Comparative study of the two I-O tables reveals that that there has been significant effect of drought on the economy. The effect of 2002-03 drought gets revealed in the production figures of the different sectors.

A7.40.   Table 2 presents the Value of output (VOP) for all the sectors classified in the I-O table for 1998-99 and for 2002-03 at 1998-99 constant prices. The VOP of the agricultural sector has gone down by as much as 27%. The output of crops like jowar, maize and other food grains has shown a rise in their values but the drastic fall in output of rice and groundnut has outweighed the rise in other sectors. The total VOP of rice relative to the total agricultural output is around 39% (1998-99) showing that rice is the major crop grown in Andhra Pradesh. Rice and groundnut is supposedly a much more water sensitive crop than the other crops grown in the state. Hence water scarcity will result in production loss and the total agricultural sector will be hit as a result of a drought. 2002-03 was a major drought when the VOP of rice and groundnut went down by as much as 38% and 57% (relative to 1998-99) respectively and this has resulted in the loss of VOP for the total agricultural sector. The rise in the value of output for the food products, which depends on agricultural sector, has been very small.

A7.41.   The shift from rice and groundnut particularly rice to other crops would also results in savings in terms of the inputs required for producing these crops. From the I-O table it can be seen that for producing 1 unit of paddy .23 units of input is required while for producing 1 unit of jowar and maize .16 and .20 units of inputs is

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required. At times of drought the output drops but the inputs for production remains the same. This can be seen by comparing the input proportions for different sectors under agriculture for 1998-99 and 2002-03. So any shift in the cropping pattern will result in savings.

A7.42.   The employment situation of a sector gets affected due to the loss in the production. Employment coefficients provide a measure to account for the loss in employment for any loss in the production. The agricultural employment coefficient for the state is 5.48. This has been generalized for the agricultural sector as a whole because of the lack of detailed data on the crop wise employment structure for the state. The total employment loss for 2002-03 because of the loss in the agricultural value of output is more than 44 lakhs. Encouraging dry land cropping would moderate the effect of drought on the employment scenario.

Table A7.1. Employment coefficients & Output multipliers

Sectors	Employment coefficients	Multipliers	Sectors	Employment coefficients	Multipliers
Paddy	5.40	1.45	Pesticides	0.89	2.61
Jowar	5.40	1.43	Chemicals	0.89	1.82
Maize	5.40	1.45	Non-Metallic Mineral Products	0.95	1.95
Other Food Grains	5.40	1.52	Basic Metals & Alloys	0.05	2.54
Groundnut	5.40	1.40	Metal Products, Elect. & Non-elect. Machinery & Equipments	0.06	2.67
Other Crops	5.40	1.22	Transport Equipments & Parts	0.59	2.10
Livestock	5.40	1.42	Miscellaneous		2.20
Forestry and logging	1.44	1.17	Construction	0.86	1.69
Fishing	0.68	1.25	Electricity, Gas and Water supply	0.08	2.20
Mining & Quarrying	0.47	1.41	Railway transport services	0.32	2.00
Food Products	1.01	2.23	Other Transportation and storage	0.62	2.00
Textile Products	3.15	2.08	Communication	0.41	1.27
Wood Products	9.27	1.61	Trade, Hotels & Restaurants	1.29	1.45
Paper Products	0.37	2.17	Banking & Insurance	0.16	1.36
Leather Products	1.14	2.11	Ownership of dwellings, real estate & business services	0.02	1.12
Rubber, Plastic, Coal & Tar	0.45	2.12	Education, Medical & Other services	1.09	1.79
Fertilizers	0.89	1.09	Public administration	0.92	-

Table A72. Sector-wise VOP at current 1998-99 and 2002-03 at constant 1998-99 prices

SECTORS	VOP ('98-'99)	VOP (2002-03) at constant 1998-99 prices
Paddy	1203027	741465
Jowar	35957	41443
Maize	68442	73502
Other Food Grains	159296	173853
Groundnut	298189	128745
Other Crops	1308995	1092593
Livestock	948749	1677690
Forestry and logging	167625	170715
Fishing	351600	583779
Mining & Quarrying	341449	560930
Food Products	1771993	1979670
Textile Products	228304	419022
Wood Products	156431	197028
Paper Products	294141	214297
Leather Products	39573	44068
Rubber, Plastic, Coal & Tar	321623	1078885
Fertilizers	127262	155265
Pesticides	30351	36456
Chemicals	558991	570962
Non-Metallic Mineral Products	346845	422691
Basic Metals & Alloys	1616309	1338809
Metal Products, Elect. & Non-elect. Machinery & Equipments	520105	620527
Transport Equipments & Parts	61350	97024
Miscellaneous	52298	152693
Construction	1022581	1524684
Electricity, Gas and Water supply	929165	1097889
Railway transport services	313288	369824
Other Transport & Storage	1093358	1481011
Communication	199006	433838
Trade, Hotels & Restaurants	2173966	2553891
Banking & Insurance	593644	728509
Ownership of dwellings, real estate & business services	749610	1000480
Education, Medical & Other services	1794171	2577852
Public administration	509668	699591

A7.43.   Livestock sector experienced a rise of 77% in the production despite drought. This clearly points out that drought had no effect on the sector. The different components contributing to this sector have behaved differently in the drought years than in the normal years. The three major components of this sector are milk, meat and eggs. The value of milk as a proportion of the total value of livestock has gone down from 55.1% to 50.1%, % while that of meat has remained the same (28.5% to

27.4%). But the important thing to note is that the value of eggs has shown a rise; the contribution has gone up from 8.09% to 15.23%. So it's quite obvious that the poultry sector (not meat) needs to be encouraged. The good performance of this sector during drought may be due to some government interventions in the poultry sector.. The livestock feed has also declined over the years and from the I-O table it can be inferred that has been substantial decrease in the cost of feed between 1998-99 to 2002-03 (figure 4.1). This may be due to the substantial increase in the share of eggs because of poultry promotion.

A7.44.   The primary sector as a whole has experienced a rise in spite of the drought although agricultural sector performance has been on the lower side.

A7.45.   The Construction has shown a 49 % increase in the Value of output (VOP). This may be due to the fact that government expenditure in this sector might have increased as a result of the poverty alleviation programs, and hence employment in this sector has gone up. The construction output multiplier obtained from the I-O is 1.69. Any expenditure in the construction sector will lead to the rise in outputs for sectors like cement, steel, bricks and tiles. Interpreting the multiplier, a 1 unit rise in the output of the construction sector will result in an additional .69 units rise in outputs of other sectors because of interlinkages between the sectors. So any investment relating to construction by the government will boost in addition the rise in the output in the other sectors. The labor displaced from the agricultural sector may have been absorbed in this sector, moderating the employment loss in the agricultural sector due to drought.

A7.46.   Comparative study of the demand components of the I-O tables reveals that the agriculture sector has been the worst hit because of the 2002-03 drought. As a result of the 2002-03 drought the production of paddy has gone down to such an extent that the state had to import paddy. Similarly for sectors like other food grains and other food crops the decline in output has resulted in imports for these sectors for other states. The intermediate consumption of paddy and other food crops has gone down by 24% and 2% and the private final consumption expenditure on paddy has also gone down by 2% for the year 2002-03 in absolute terms in spite of about 8 % increase in population revealing the impact of drought on the agricultural sector.

ANNEX 8   STRUCTURE OF ANDHRA PRADESH ECONOMY (1980-81 TO 2002-03)

A8.1.   The structure of Andhra Pradesh economy may be described in terms of changes in the gross value added (GVA) in various sectors of the economy and interrelations between them. The four major sectors included in the model and analysis are the following:

(i)   **Primary Sector,** of which two major sub-sectors were examined separately for sensitivity to drought

      (i) – A: Agriculture, and

      (i) – B: Livestock.

(ii)   **Secondary Sector -** manufacturing (both registered and unregistered), electricity, gas and water supply, and construction.

(iii)   **Tertiary Sector** – trade, hotels and restaurants, railways, transport by other means and storage, communications, banking and insurance, ownership of dwelling, real estate and business, public administration, and other services.

A8.2.   The year 1993-94 is chosen as the **bench mark** year because the GVA has been measured in 1993-94 prices. We propose to compare fluctuations in GVA during 1980-81 and 1992-93 with those during 1993-94 and 2002-03. The postulated models have been estimated for these sub-periods separately and also for the entire period 1980-81 to 2002-03 in order to detect any structural changes.

Descriptive Analysis of Changes in the GVA of Major Sectors

Primary Sector

A8.3.   Agriculture and livestock have been clubbed together because separate data on agriculture and livestock GVA were not available for the earlier sub-period 1980-81 to 1992-93.

Changes in the GVA of Agriculture and Livestock

A8.4.   1984-85 and 1986-87 were the years of rather low productivity in agriculture and livestock. The annual percentage change in their combined GVA was of the order of –8.7 and –10.8, respectively. These years may be classified as the years of severe drought. The years 1990-91 and 1992-93 also indicate mild drought conditions, as the annual percentage change in GVA of agriculture and livestock were –2.9 and –1.1, respectively.

A8.5.   During the sub-period 1993-94 to 2002-03 we observe highly negative annual percentage change in the GVA of agriculture and livestock in the years 1997-98 and 2002-03. These were –18.8 in 1997-98 and –12.5 in 2002-03. Thus 1997-98 and 2002-03 are years of severe drought. However, 1999-00 also showed a highly negative (-4.02) percentage change in the GVA of agriculture and livestock. Thus

1999-2000 should also be treated as the year of severe drought even though it was relatively of lower intensity than of 1997-98 and 2002-03. The other years showing negative annual percentage change in agriculture and livestock are 1994-95 (with –2.14) and 2001-02 (with –0.95).

A8.6.   The share of agriculture and livestock in the primary sector GVA has consistently declined over the entire period 1980-81 to 2002-03. It was as high as 88% in 1982-83 and 1983-84 and it declined to 85% in 1992-93 and further declined over the second sub-period (1993-94 to 2002-03). It remained in the range of 80 to 84 percent during 1993-94 and 2001-02; and was 75.52 percent in 2002-03.

Changes in the GVA of Components other than Agriculture and Livestock in the Primary Sector

A8.7.   Mining and quarrying and fishing have consistently improved their share in the primary sector GVA. During 1980-81 and 1992-93 the share of mining and quarrying was in the range 3 to 6 percent and it increased to be in the range 7 to 9 percent during 1993-94 and 2001-02. It was 11.3% in the year 2002-03. Similarly, the share of fishing was in the range 4 to 6% during 1980-81 to 1992-93, and it increased to be in the range 5 to 8% during 1993-94 to 2001-02. It stood at 10.32% in the year 2002-03.

A8.8.   Forestry and logging had its share in PGVA in the range 3 to 5 percent over the entire period 1980-81 to 2002-03.

A8.9.   It would, therefore, appear that whereas, agriculture, livestock and forestry were worst hit by drought the sectors like mining and quarrying and fishing improved their position. Mining and quarrying recorded 12% and fishing 19.6% annual percentage change in their GVA in 2002-03.

Secondary Sector

A8.10.   The percentage share of various components in the GVA of the secondary sector. Manufacturing (both registered and unregistered) dominates eminently over other components of the secondary sector. Construction and electricity, gas and water supply are next to manufacturing in that order.

A8.11.   The share of manufacturing in the secondary sector GVA ranged between 55 and 64 percent during 1980-81 and 1992-93 and between 62 and 67 percent during 1993-94 and 2002-03. We observe a decrease in the percentage share of manufacturing during the period 1999-00 to 2002-03. This was between 62 and 63 percent during this period compared to more than 66% during 1993-94 and 1998-99. This may be attributed to drought conditions during 1997-98 and 2002-03 because the raw material for manufacturing comes from agriculture.

A8.12.   The share of construction in the secondary sector GVA declined consistently from 36 to 21 percent over the period 1980-81 to 1996-97 but it picked up slowly during 1997-98 to 2002-03 to range between 22 and 26%. Should we interpret this as a result of efforts made to mitigate hardships caused by drought conditions?

Tertiary Sector

A8.13. The percentage share in GVA of communications, banking and insurance has consistently increased over the entire period 1980-81 to 2002-03. Although the share of communications is small (ranging from 2.28 in 1980-81 to 7.08 in 2002-03, it has almost trebled over years and that of banking and insurance has doubled. The sub sectors of trade, hotels and restaurants and transport by other means and storage have maintained almost the same percentage share over the years. Surprisingly the share of railways has declined from about 5% during 1980-81 to 1987-1988 to less than 4% during 1993-94 to 2002-03.

Specification of the Macro Model in Terms of Sector-wise GVA

A8.14. Specification of a macro model requires postulating structural equations, which describe changes in the GVA in terms of certain variables, changes that directly influence the GVA. We should identify these variables and determine their relationship with the GVA in each of the sectors.

A8.15. In the present study, we postulate the model in the form of a set of interdependent regressions, in log linear form, and estimate the parameters by the method of Seemingly Unrelated Regressions (SUR). The estimated coefficients may be interpreted as partial elasticity coefficients.

A8.16. The gross value added (GVA) is calculated as the difference between the values of output and inputs (at current or constant prices). However, the inputs do not include the consumption of fixed capital.[3] For example, in case of agricultural GVA the inputs are seed, chemical fertilizers, organic manure, current repairs and maintenance of fixed assets, market charges, irrigation charges, electricity, pesticides and insecticides, and diesel. Therefore, the specification of structural equations for GVA, in each of the sectors, should include consumption of fixed capital as one of the explanatory variables.

Macro Model for the Major Components of Different Sectors of the Andhra Pradesh Economy

A8.17. Agriculture is the major constituent of the primary sector and manufacturing that of the secondary sector. In fact, agriculture and livestock are worst hit during drought years. It would have been better if we could postulate a model taking agriculture and livestock separately during both the sub periods (1980-81 to 1992-93 and 1993-94 to 2002-03) and compare the performance of the model over the sub periods. Unfortunately the data on gross value added from agriculture and livestock have been aggregated for 1980-81 to 1992-93. They are not available separately for agriculture and livestock. However, agriculture GVA and Livestock GVA are separately available for 1993-94 to 2002-03.

A8.18. The estimated model for 1993-94 to 2002-03 is given below.

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[3] The net value added is defined as the difference between the gross value added and consumption of fixed capital.

$$\ln(AGVA) = 1.03 \ \ln(ACFC) + 0.25 \ \ln(VOP_{4,8}); \ \overline{R}^2 = 0.73$$
$$(10.53) (2.98)$$

$$\ln(LGVA) = 0.98 \ \ln(LCFC) + 0.24 \ \ln(AGVA); \ \overline{R}^2 = 0.90$$
$$(14.64) (5.32)$$

$$\ln(SGVA) = 0.72 \ \ln(SCFC) + 0.37 \ \ln(AGVA_{-1}); \ \overline{R}^2 = 0.84$$
$$(8.77) (4.94)$$

$$\ln(TGVA) = 1.33 \ \ln(TCFC) - 0.12 \ \ln(AGVA_{-1}); \ \overline{R}^2 = 0.98$$
$$\mathbf{(26.05)} \mathbf{(-2.70)}$$

[From the t-distribution on 8 d.f. P (|t|>1.86)=.05]

In the above equations

AGVA = agricultural GVA
LGVA = livestock GVA
SGVA = Secondary GVA
TGVA = tertiary sector GVA
ACFC = consumption of fixed capital in agriculture
LCFC = consumption of fixed capital in livestock
SCFC = consumption of fixed capital in secondary
TCFC = consumption of fixed capital in tertiary sector
$VOP_{4,8}$ = Value of output for four crops eight districts
$AGVA_{-1}$ = last year's agricultural GVA

Figure : A8.1. Agriculture Gross Value Added, 1993-94 to 2002-03, Estimated and Observed

AGVA & Est AGVA (1993-94 to 2002-03)
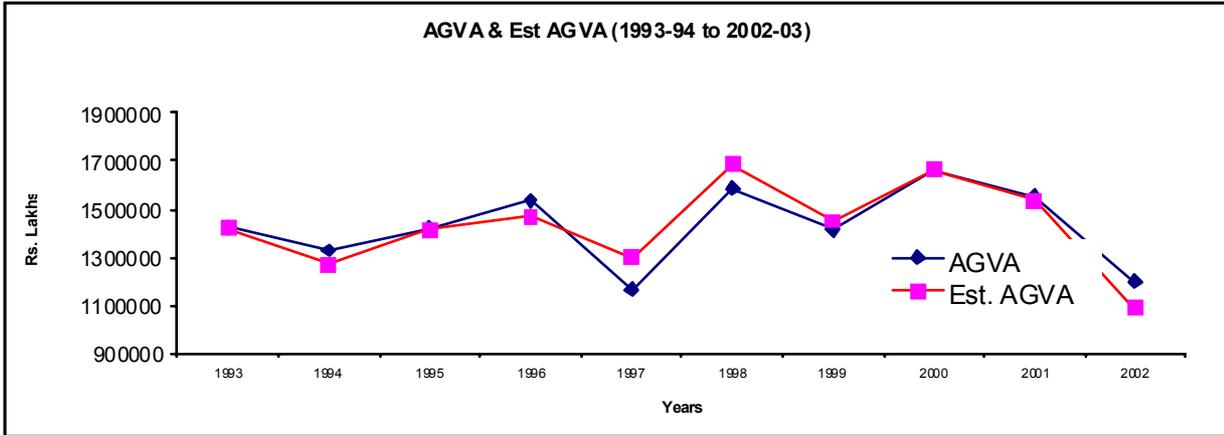
Figure A8.2. . Livestock Gross Value Added, 1993-94 to 2002-03, Estimated and Observed

LGVA & Est LGVA (1993-94 to 2002-03)
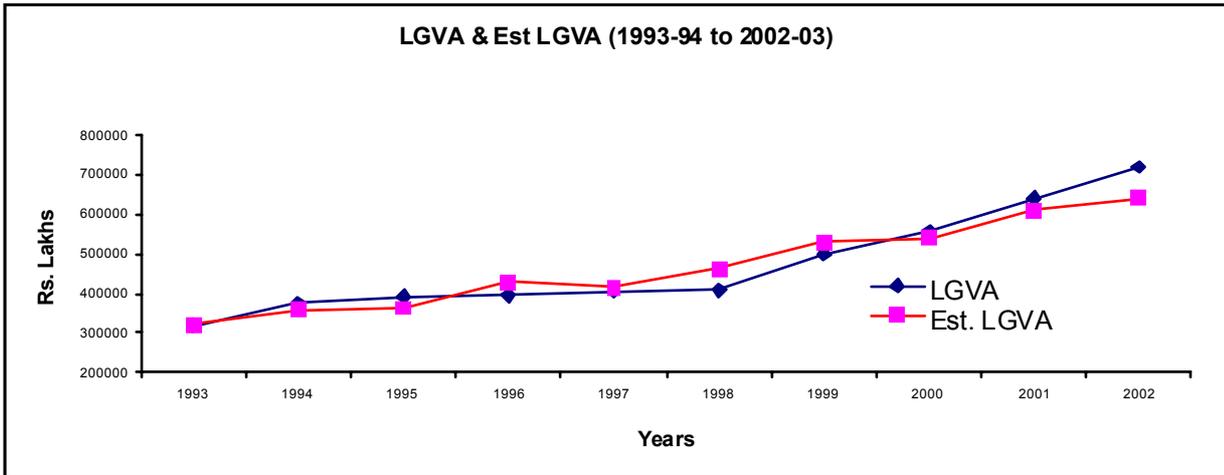
Figure A8.3. Secondary Sector's Gross Value Added, 1993-94 to 2002-03, Estimated and Observed

SGVA & Est SGVA (1993-94 to 2002-03)
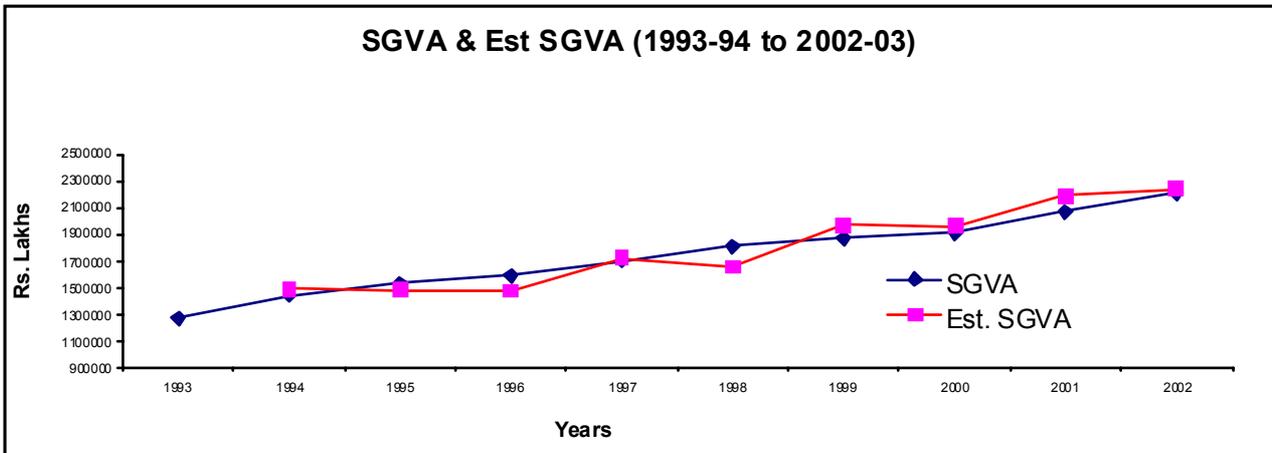
Figure A8.4. Tertiary Sector's Gross Value Added, 1993-94 to 2002-03, Estimated and Observed

TGVA & Est TGVA (1993-94 to 2002-03)
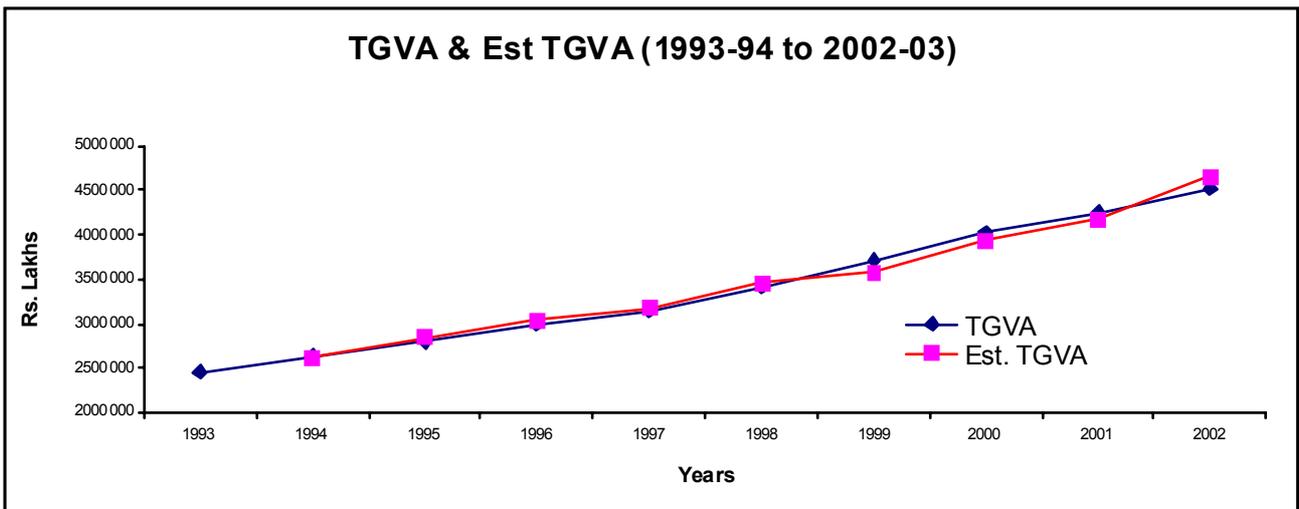
A8.19.   It is recognized that the key data series exhibit strong trends and are non-stationary which may lead to the familiar problem of "false inference". To identify the appropriate cointegrating relationships a number of detrended regressions were conducted. Among these the following is a representative example. It involves a regression over the period 1981-2002 and yields the following model:

$$\ln(dAGVA) = 4732 + 5.31\,\ln(dACFC) + 0.14^{*}\,\ln(dVOP_{4,8}); \; \overline{R}^{2} = 0.32$$

$$\ln(dSGVA) = 40700^{*} + 1.76^{*}\,\ln(dSCFC) + 0.04\,\ln(dAGVA_{-1}); \; \overline{R}^{2} = 0.44$$

$$\ln(dTGVA) = 110260^{*} + 5.28^{*}\,\ln(dTCFC) - 0.05\,\ln(dAGVA_{-1}); \; \overline{R}^{2} = 0.30$$

where (*): statistically significant at 5% confidence level.

In the above equations

$dAGVA = AGVA - AGVA_{-1}$
$dSGVA = SGVA - SGVA_{-1}$
$dTGVA = TGVA - TGVA_{-1}$
$dACFC = ACFC - ACFC_{-1}$
$dSCFC = SCFC - SCFC_{-1}$
$dCFC = TCFC - TCFC_{-1}$
$dVOP_{4,8} = VOP_{4,8} - (VOP_{4,8})_{-1}$

A8.20.   Under this model, an increase in AGVA the previous year would create a positive impact on the secondary sector and a negative impact on the tertiary sector, as found under the previous model. However, these coefficients are not statistically significant at 5% confidence level. The small size of the sample dilutes the statistical power of the usual battery of specification and model selection tests. Hence it is not possible to statistically identify the most appropriate model. Under the circumstances we opt for the trended specification, on the basis of its superior predictive power. However, it needs to be emphasized that because of the statistical limitations of a restricted sample size, the choice should be viewed as tentative. Estimates obtained from most of the alternative specifications lie within about 3 standard errors of the chosen model. Hence, the coefficients of the chosen model are best viewed as indicative of sectoral linkages, rather than precise estimates.