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29

WATER FOOD SECURITY SCENARIO ANALYSIS FOR 2025: STUDY OF AGRO-ECOLOGICAL REGION 12 OF INDIA

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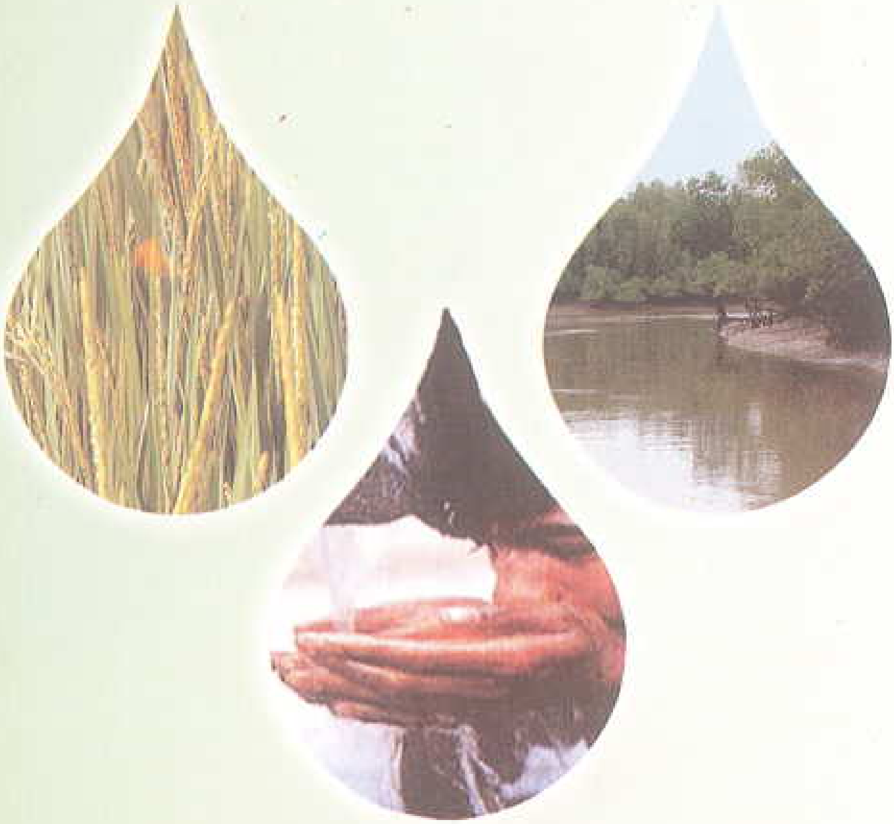

WTCER

WATER TECHNOLOGY CENTRE FOR EASTERN REGION
(Indian Council of Agricultural Research)
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Preface

Food security is defined as physical, social and economic access for all people to sufficient, safe and nutritious food that meets their dietary needs and food preference for an active and healthy life (FAO). At an individual level, food security is having access to an adequate level of energy intake to meet the body's daily requirement. The energy requirement for an adult is in the range of 2800-3100 kcal/day with a threshold value of 2200 kcal/day. Food security issues cannot be addressed without addressing water security issues. It is a matter of concern that in spite of having plenty of fresh water availability, the food production scenario is far from satisfactory in agro ecological region 12 (AER 12), which is characterized as one of the poverty stricken and low agricultural productivity pockets in India. Any effort to eradicate poverty has to take into account the agricultural production enhancement measures, which is primarily governed by efficient water management. The per capita water availability is decreasing due to larger domestic and industrial demand. The available quantity of water for irrigation is also depleting with time. To feed the growing population, the production and productivity from the irrigated as well as rainfed area has to be increased substantially, that can be achieved by moving from 'more crop per drop to more crop less drop' through judicious management of available water resources. Present study has addressed both water and food security issues through PODIUM (Policy Dialogue Interactive Model) developed by IWMI, so as to optimize agricultural production by efficient use of water and other resources in agro-ecological region 12 of India.

The AER 12 covers a total area of 26.8 m ha comprising 31 districts of six states (Orissa, Jharkhand, West Bengal, Chhattisgarh, Maharashtra and Andhra Pradesh) and 8.1% of total geographical area of the country. The analysis of data on different food and water security parameters reveals interesting trends. Slowing down of population growth rates and increasing diversification of diets away from cereals are distinctly observed from BAU (Business As Usual) scenario for all the AESRs (Agro Ecological Sub Regions) and AER 12. The annual population growth is projected to decline to 1.21% in 2025 from about 2% in 2001 for the region. With the same trend, proportion of cereal in consumption basket is also projected to come down to 67% in 2025 from 71.5% in 1995 for AER 12. The gross cereal yield in AER 12 is expected to rise by 18.75% from 1.64 t/ha in 1995 to 1.96 t/ha in 2025. The degree of development of ground water that was about 25% in 1995 is projected to be 60% in 2025. As per the BAU scenario of AER 12, the region is projected to be a food insecure region by the year 2025 with food deficit of 7.26 million tonne. The degree of development of water is absolute scarce (60%) during predicted year 2025 as per the BAU scenario. However, if there is improvement in water use efficiency, substantial reduction in population growth and crop diversification to more nutritive ones, the region may be able to achieve food and water security to some extent.

Date: 19.12.2005
Bhubaneswar

Ashwani Kumar
Director

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1.0 INTRODUCTION

Land and water are two basic natural resources for sustaining the agricultural production systems. The endowment of land and water determines the livelihood conditions as well as developmental options for a region. The pressure of growing demand for food and fodder with increase in population and animal resources pushes the utilization of natural resources beyond the sustainable limit and the consequences are unfolding in terms of climatic imbalances, drying up of rivers, riparian right conflicts and dwindling human and animal health and overall the quality of life gets discounted irreversibly. It is a matter of concern how to make burgeoning population and future generation food secure, free from hunger and malnutrition. The issues have already been taken up by different professional groups and intellectuals. India being an agrarian economy where agriculture is the mainstay of its majority of population, scarcity of freshwater for agricultural and domestic purposes poses a great threat; as such addressing issues of water scarcity along with food security is of prime importance. So far different studies have undertaken independently focussing either food supply, food demand or food supply & demand; or water supply, water demand or water supply & demand. No study has tried to link food demand& supply with water demand & supply. Since water security issue are intimately related with food security issues, there is an urgent need of addressing these two kinds of security issues simultaneously with a disaggregated approach so as to optimise resource allocation and utilisation and to decide viable policy options.

Agro Ecological Region 12 constituting about 8.1% of geographical area of India with 83.3 millions population (2001 census) experiences poor socio-economic conditions resulting from low agricultural and animal productivity. Rainwater being excess in kharif and deficit in rabi impedes input utilization for agricultural growth. In some parts of this region, high intensity rainfall within short span of time creates inundation and damages crop growth during southwest monsoon period (June to September) and the saucer shaped topography does not allow the runoff to be drained soon in some of the coastal tracts, creates seasonal water logging. Whereas, agricultural droughts of varying intensities limit the crop production potential in other seasons. Due to these multiple problems, the agricultural productivity of the region is very low. It is forecasted that the eastern part of the country would face severe food insecurity in terms of quality of life indicators. As per the

M.S. Swaminathan Research Foundation's food insecurity map, out of 31 districts of AER 12, 8 districts of Jharkhand are extremely food insecure, 16 districts (including all the 13 undivided districts of Orissa, 1 district of Chhattishgarh and 2 districts of Maharashtra) are severely food insecure and remaining 7 districts (3 of Andhra Pradesh and 4 of West Bengal) are moderately food insecure.

Being situated in the coastal belt of Bay of Bengal, most of the districts under AER 12 are vulnerable to frequent occurrence of climate induced natural disasters - drought, flood and cyclones. Calamities in this region are not only becoming more frequent but striking areas that never had a vulnerability record (Mahapatra, 2001). The life and livelihood of the people have been severely affected over a long period of time forcing the region to be a severely food insecure region, consequently resulting in high level of poverty incidence and large-scale out migration. High vulnerability of this region to recurrent natural disasters and climate change poses significant potential impacts on the future water and food security situations of the region. On this background it is a challenge for planners and policy makers to develop viable policy options in order to efficiently address the future water and food security issues of the region. It is of prime importance to understand the future scenarios based on past performance, future requirements and risks in order to delineate the future strategies to cope up with the situation. This study particularly attempts to address the issues: whether agriculture in the region will be able to supply adequately food to the increasing population, and whether the present regional imbalances in food supply will be solved in the future without deteriorating water balance.

1.1 Objectives of the Study

Overall goal of the study is to strengthen the knowledge base on sustainable water-food security related issues of AER 12 and to develop exploratory models as a tool for policy analysis in an integrated framework at national and regional levels. The major objectives of the study are:

- To formulate an integrated policy interactive dialogue model for simulating alternative scenarios of water-food security for 2025
- To explore technical, social and economic aspects of alternative visions of the future water-food security differentiated by AESRs

1.2 About AER 12

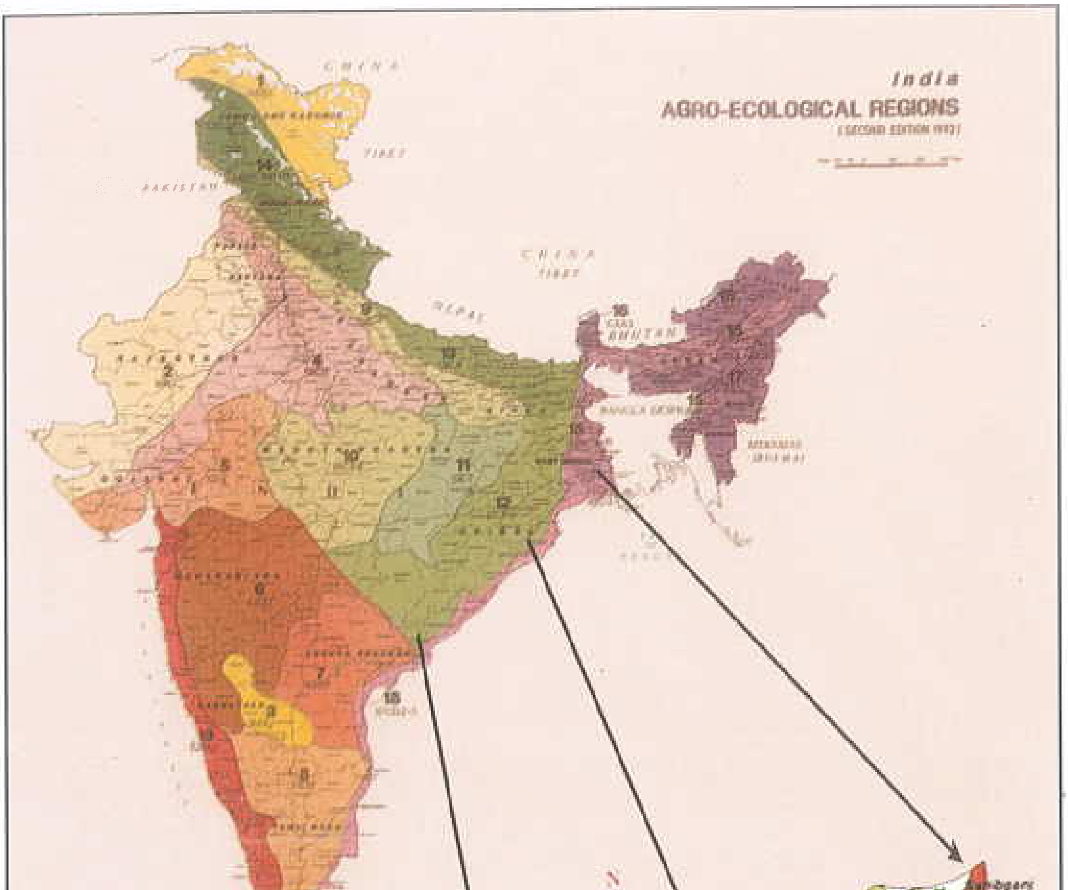
1.2.1 Project Coverage and General Features

The AER 12.0 of India comprises of three agro ecological sub regions (AESR), namely 12.1 (parts of Eastern Ghat highlands of Orissa, Maharashtra, Bastar region of

Table 1: Area coverage of AER 12 and AESRs

AESR	Topography of Sub Regions	Total area (m ha)	% of AER 12	% of total geographical area of India	Districts covered	States
AESR 12.1	Gujarat hills, Dandakaryana, Eastern ghats (hot, moist, sub humid eco-sub region)	17.9	66.8	5.4	East Godavari,	Andhra Pradesh
					Chandrapur, Gadchirolli	Maharashtra
					Bastar	Chhattishgarh
					Koraput, Bolangir Sambalpur, Sundargarh, Dhenkanal, Kalahandi, Mayurbhanj, Phulabani	Orissa
AESR 12.2	Eastern ghats, hot, moist, sub humid eco region	3.3	12.3	1.0	Vishakhapatnam, Vijaynagaram	Andhra Pradesh
					Ganjam, Puri, Cuttack, Balasore	Orissa
AESR 12.3	Chhotanagpur plateau, Gujarat hills, hot, dry and moist, sub humid, transtern eco sub region	5.6	20.9	1.7	Deoghar, Dhanbad, Giridh, Ranchi Singbhum(W), Singbhum(E), Sahibganj, Dumka	Jharkhand
					Keonjhar	Orissa
					Bankura, Birbhum, Midnapore and Purulia	West Bengal
AER 12		26.8	100	8.1		

Source: National Bureau of Soil Survey & Land Use Planning, Publication No. 35, ICAR, 1999



Map.1: Agro Ecological Region No.12 of India

Chhattishgarh and non coastal part of Andhra Pradesh), 12.2 (south eastern windward side of western highland of Orissa and north eastern parts of Andhra Pradesh) and 12.3 (Chhotanagpur Plateau of Bihar, parts of eastern ghats of Orissa and western parts of West Bengal). Red laterite soil type is predominant throughout the region with small area under coastal alluvial tract (flood plain) in Orissa and Northern Andhra Pradesh.

The AER 12 covers a total area of 26.8 m ha comprising 31 districts of six states (Table 1 and Map 1). The AESR 12.1 occupies maximum geographical area of 66.8% of total area of AER 12. The region is characterized by normal growing period from June to October as moist months with July, August and September as humid months. Other growing period during rabi is November to March when most of the area is put under rabi crops. Tribal population in AER 12 constitutes 40% of total population with low level of literacy, high infant mortality rate, low level of crop and animal husbandry productivity. The demographic characteristics are reflected by average level of literacy (60.15%), gender ratio of 969 female per 1000 male and population density of 363 people per sq.km. Proportionately more tribal and poor people of this region directly rely on natural resources as the sources of livelihoods.

1.2.2 Land Use Pattern

The land use pattern of different AESRs of AER 12 are given in Table 2 which depicts that the net sown area of the region is about 36 % of its total geographical area followed by forest coverage (34.3%). Barren land and uncultivable waste cover about 4.7 % and 4.3 % of geographical area, respectively. AESR wise analysis reveals that forest coverage is highest (53%) in AESR 12.1 followed by AESR 12.2 (26%); where as the net sown area is highest in AESR 12.2 with 41% of total geographical area followed by AESR 12.3 (38%). Barren and uncultivable waste each constitutes 4.7% and 4.3% respectively of total geographical area of AER 12.

Table 2: Land use pattern as a percentage of geographical area

Land use	AESR 12.1	AESR 12.2	AESR 12.3	AER 12
Geographical area (m ha)	17.9	3.3	5.6	26.8
Net sown area (%)	29	41	38	36.0
Forest (%)	53	26	24	34.3
Barren lands (%)	2	6	6	4.7
Uncultivable waste (%)	2	4	7	4.3

Source: National Bureau of Soil Survey & Land Use Planning, Publication No. 35, ICAR, 1999

1.2.3 Rainfall Distribution and Variability

The seasonal distribution of rainfall for different AESRs of AER 12 has been computed and is presented in Table 3. It is revealed that 66% to 79% of total annual rainfall occurs during southwest monsoon period in different AESRs of the region. Pre-monsoon showers contribute 7.7 to 8.4 % of total annual rainfall, which are of special significance for off-season tillage operation and land preparation for upland crops or seedbed preparation for rice in the region.

Table 3: Seasonal distribution of rainfall (mm) in AER 12

AESRs	Pre monsoon (March to May)	Monsoon (June to Sept.)	Post monsoon (Oct to Nov.)	Winter (Dec to Feb)	Annual Total
12.1	114 (7.7%)	1182 (79.8%)	150 (10.2%)	36 (2.5%)	1482 (100%)
12.2	111 (8.2%)	898 (66.2%)	306 (22.5%)	42 (3.1%)	1357 (100%)
12.3	113 (8.4%)	1074 (79.6%)	118 (8.7%)	45 (3.3%)	1350 (100%)
AER 12	113 (8.1%)	1051 (75.3%)	191 (13.7%)	41 (2.9%)	1395 (100%)

Source: NCAP, New Delhi and climatological Table, IMD, New Delhi, 1951-1980.
Note: Figures in parentheses denote percentages of total

1.2.4 Ground Water Development

The ground water status in different AESRs is given in Table 4. On the basis of groundwater assessment and its draft for irrigation, domestic, industrial and other

Table 4 : Ground water status (ha-m) in AER 12

	RWGR	PDI	UGWR	Net draft	Balance	UIP	GWD (%).
AESR 12.1							
Mean	287001	34034	244804	26606	251065	168702	11.4
CV (%)	42.8	63	39.2	19.6	42.4	163	40.4
AESR 12.2							
Mean	164340	12018	202737	24941	121157	105039	12.7
CV (%)	68.3	22.9	35.6	80.7	64.1	44.6	28.7
AESR 12.3							
Mean	72579	5557	39689	12422	80143	61379	10.6
CV (%)	75	41	88	281	37	5	119

Note: TRWGR = Total Replenishable Ground Water Resources, PDI = Provision for Domestic and Industrial Use, UGWRI = Utilizable Ground Water Resources for Irrigation, UIP = Utilizable Irrigation Potential for Development, GWD = Ground Water Development uses, the groundwater development is highest (12.7%) in AESR 12.2 compared to AESR 12.1 (11.4%) and AESR 12.3 (10.6%). The mean total replenishable ground water resources of the sub region was 72579 ha-m with ground water development of only 10.6 % and utilisable ground water resources for irrigation of 39689 ha-m.

1.2.5 Existing Crops and Crop Sequence

Rice is the predominant kharif crop occupying 70-90 % of the entire region under irrigated and rainfed conditions. At some places pulses and oilseeds are also grown as rainfed kharif crops but productivity is very less (2-3 q/ha). Wheat, potato, sugarcane, pulses and oilseeds are the major rabi crops while jute is also grown as pre monsoon crop in some areas. Under AER 12, rice is most dominant crop during kharif in all AESRs. However, during rabi season type of crops varies in different AESRs. The soil moisture stress, continuous loss of soil fertility, accumulation of toxic decomposition products, imbalanced use of fertilizer in uplands, poor drainage, low-lying physiography and high rainfall in submergence-prone lowlands, continuous use of traditional varieties of seeds, heavy infestation of weeds and insect pests, poor crop stand establishment and poor adoption of improved crop production technologies are some of the major constraints for rice cultivation in the rainfed area of AER 12.

1.2.6 Yield of Major Crops

Examining the crop yield of major crops across the sub regions it is revealed that AESR 12.3 has performed better than other sub regions in terms of productivity of rice, wheat, green gram, sesamum, mustard, sugarcane and potato, while the productivities of maize, ragi, black gram, horse gram and groundnut are maximum in the sub region 12.2 (Table 5).

Overall performance of sub region 12.1 remained poor compared to other two sub regions of AER 12 because except rice and maize productivity where it is slightly better than AESR 12.2 and AESR 12.3 respectively, the productivity of all other crops are below the respective average productivities of AER 12.

2.0 METHODOLOGY

The major objectives of this study are to formulate an integrated policy interactive dialogue model for simulating alternative scenarios of water-food security for 2025 and to explore technical, social and economic aspects of alternative visions of the future water-food security differentiated by AESRs of AER 12. Future water and

Table 5: Yield of major crops in AER 12 (t/ha)

Crops	AESR 12.1	AESR 12.2	AESR 12.3	AER 12
Rice	1.44	1.19	1.62	1.42
Wheat	1.19	1.43	1.81	1.48
Maize	1.54	1.60	0.96	1.37
Ragi	0.58	0.94	0.69	0.74
Green gram	0.27	0.40	0.93	0.53
Black gram	0.34	0.51	0.23	0.36
Horse gram	0.31	0.39	0.38	0.36
Sesamum	0.31	0.32	0.38	0.34
Groundnut	1.18	1.55	1.26	1.33
Mustard	0.33	0.39	0.59	0.44
Potato	8.83	10.14	13.79	10.92
Sugarcane	54.27	43.82	65.22	54.44

Source: Agricultural Statistics 1998-99; Department of Agriculture, Respective State Governments under AER 12,

food security issues have been addressed by several studies, but they are mostly at aggregate level with simplistic assumptions and independently for water & food sector. Their approaches are either demand or supply side approach. Very few studies have integrated demand & supply; and water & food. The linkages between water and food security aspects at disaggregated levels have not been addressed. Regional variations are always ignored in demand & supply estimation of waters. Hence there was a serious methodological gap to address such a complete and integrated study of addressing both 'food demand & supply' and 'water demand & supply' simultaneously.

PODIUM (1997) developed by IWMI integrates both 'Water demand & supply' and 'Food demand & supply' and hence provides a unique framework for addressing both water and food security issues simultaneously with a disaggregated approach. Its original version has analyzed food and water issues in 2025 for 45 countries taking 1995 as the base year. However, this component of the study covers 31 districts of AER 12 comprising 6 states and three AESRs of India as indicated in previous section and it has also taken 1995 as the base year to generate future scenarios for 2025. Accordingly the model has been fed with data on different parameters of water-food security issues of the 3 sub regions (AESR 12.1, AESR 12.2 and AESR 12.3) of AER 12.

2.1 About PODIUM Model

The policy dialogue model is developed as part of the Vision 2025 exercise through a joint effort by IWMI (International Water Management Institute, Colombo, Sri Lanka) and IFPRI (International Food Policy Research Institute, Washington, USA). The model builds upon IWMI's previous research on food and water demand, described in "World Water Demand and Supply, 1990 to 2025: Scenarios and Issues" (Seckler et al., 1998).

2.2 Scope of the Model

The model provides sufficient scope for analysing future water and food security issues from different angles. It determines increasing water demand in 2025 as a result of population growth and changing diets. The model does not provide hard and fast predictions but rather analyses "what-if" questions. For example, it helps analysing and answering questions such as: "If AER 12's population in 2025 will consume 2396 kcal per capita per day, what does this imply for grain requirements, what does this require in terms of rainfed and irrigated grain production and ultimately, what does this mean for irrigation policy and water requirement? Will water and land resources be sufficient to produce the required food, or should the country import more grains? And what if the calories intake rises up to 3600 k cal (USA level) and people start eating more meat? The user can modify all major variables and directly monitor the effects of these changes on water demands. This feature makes the program a very suitable tool for scenario testing and sensitivity analysis.

Policy and decision makers involved in natural resources management are increasingly confronted with questions concerning food and water scarcity. They may find this tool useful to determine future directions in policy. For example, if India Government aims at a certain level of food intake in 2025, what are the paths to take to achieve this goal: yield increase, augment irrigation cropping intensity, cereal area, increase imports etc. What is the appropriate mix of policy measures?. The program raises the issues without addressing site specific questions such as how to increase yields, or how much investments would be needed. This makes it an excellent starting point for further in-depth discussions among stakeholders. Policy planners and people interested in food and water demand issues might find this program a suitable tool to increase their knowledge and insight in food and water issues.

2.3 Modules of the Model

The PODIUM model consists of three modules. They are

1. Consumption Module
2. Area-Production-Yield Module
3. Water Balance Module

Accordingly, the computation process consist of three steps:

The **first step** is to determine the grain requirements (food as well as feed) based on user-defined assumptions concerning calories intake and diet composition in the year 2025.

The **second step** computes the production of the required cereals using data and estimates of yields and cultivated areas with and without irrigation.

The **third step** converts this predicted grain production into irrigation water demands and compares this irrigation water demand with actual withdrawals in 1995 and available renewable water resources. The flow chart of these modules are given in page no.11,12,13.

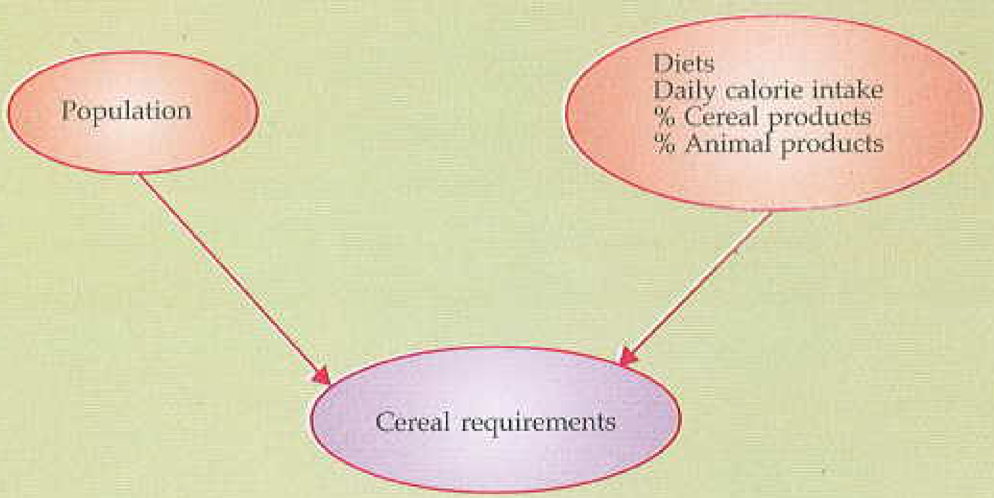
Further, it assesses expected adverse impacts of increased water withdrawals on the groundwater balance. The program takes into account water needs for domestic and industrial uses. The program uses 1995 as the base year. By default, 2025 predictions are based on historical growth rates (1985-1995) computed for each of the districts/AESRs of AER 12.

2.4 Assumptions of the Model

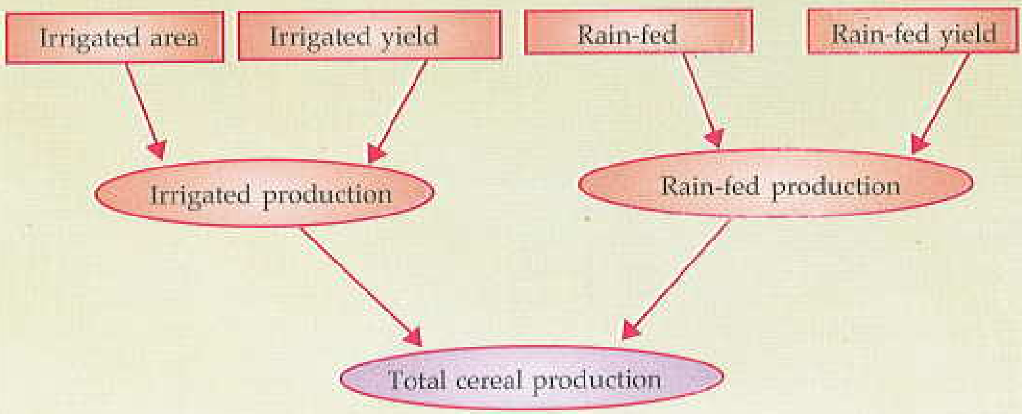
Some assumptions of the model are:

1. Water demand for non-farm sector is 25% & continues to remain same
2. Feed-meat conversion ratio is 0.05 and to continue
3. 65% of irrigated area is occupied by cereal & to continue
4. Water use efficiency is same in both season (dry & wet)
5. Food demand and calorie intake data from IMPACT model
6. Feed-meat conversion ratios to continue & same for poultry and meat
7. Per capita domestic demand for water is 50 litres/day and to continue

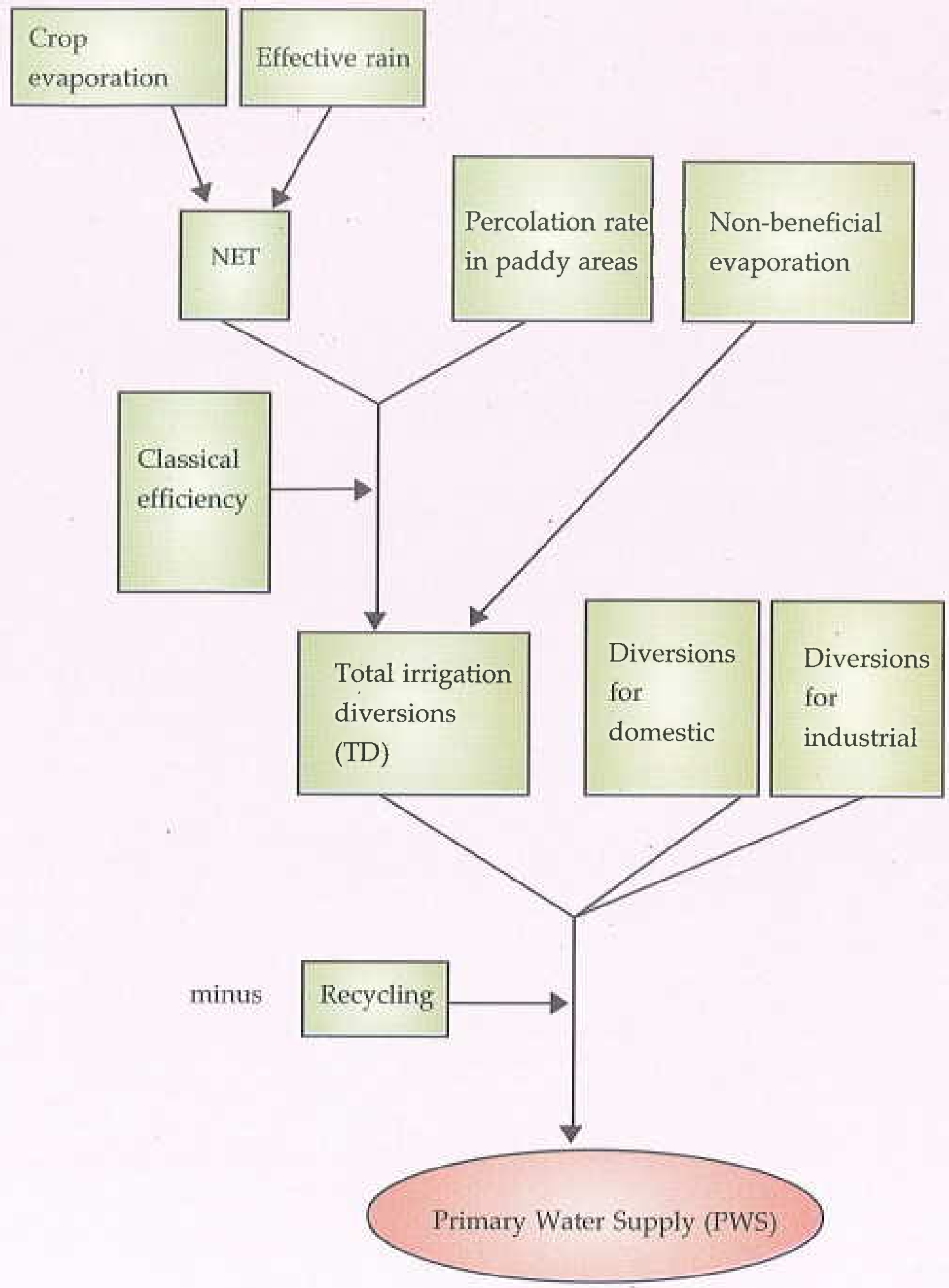
a) **Cereal requirement variables**



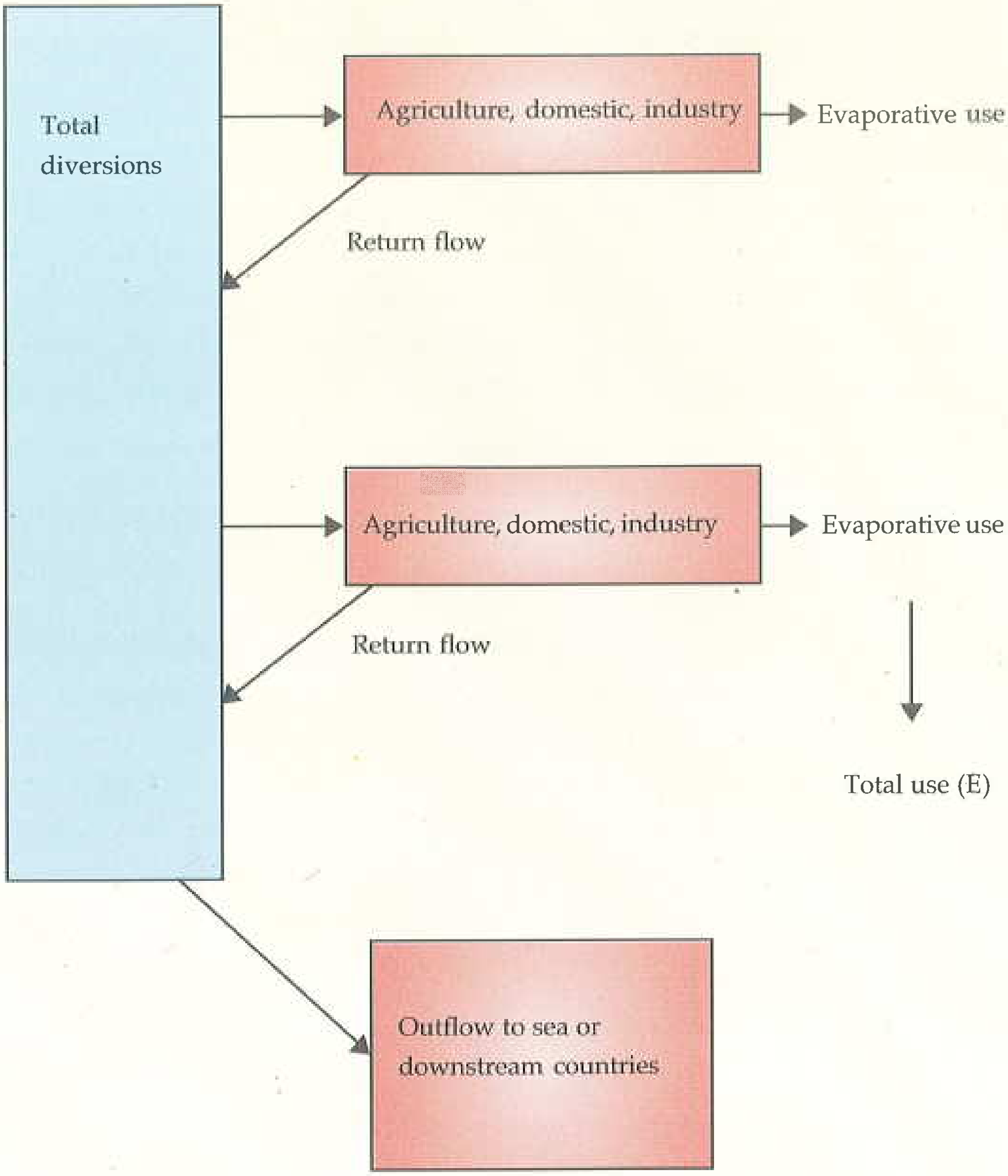
b) **Cereal production variables**



c) Water requirement variables



d) Recycling


Total diversions
Agriculture, domestic, industry
Evaporative use
Return flow
Agriculture, domestic, industry
Evaporative use
Return flow
Total use (E)
Outflow to sea or downstream countries

3.0 WATER-FOOD SECURITY SCENARIO ANALYSIS

3.1 Scenario Analysis

Future water –food security issues are of prime concern for the AER 12, which is significantly affected by the relatively uncontrolled factors like climate induced hazards, vulnerability and poor governance. Besides fundamental policy choices that drive water and food supply and demand in long term are key to determining actual outcomes. Such policies address income, population growth, investment in water supply, urban water system irrigation, other water infrastructure; relative allocation of water to irrigation, domestic, industrial and environmental uses, water prices, technological change in agriculture etc. (Rosegrant et al., 2002). The Policy decisions, resource endowments and natural disasters are three most important factors those have significant potential impacts on its future water-food scenarios of the region.

A scenario analysis is a coherent, internally consistent and plausible description of possible future state of the world. It is not a forecast but rather a snapshot of how the future could unfold. We have discussed here four types of scenarios: Business As Usual Scenario (BAU); Food Secure Scenario (FSS); Water Secure Scenarios (WSS); and Food and Water Secure Scenario (FWSS). BAU projects the likely water and food outcomes for a future trajectory based on the recent past, whereby current trends of cereal consumption, production and water balance are broadly maintained. FSS projects food security scenario and its linkages with other drivers of cereal consumption, production and water balance. It describes how food security situations can be achieved by altering different parameters of food and water security scenarios. The WSS discusses future ground water and surface water scenarios and how we can achieve water secure scenarios in AER 12 with different combinations of cereal production and consumption. FWSS projects wide range of water scenarios and trends along with the inter relationship with all three modules of the model and it analyses different options those facilitates to achieve both food and water secure scenarios simultaneously by altering all the drivers of the PODIUM Model. Before the scenario analysis it is imperative to have a brief discussion about the scenario narratives and specifications.

3.2 Scenario Narratives

The primary drivers in the model are used as the building blocks for the scenarios.

The PODIUM model includes three types of drivers. They are cereal demand drivers, cereal production drivers and water balance drivers.

- **Cereal demand drivers** consist of daily calorie intake, % cereal product, % animal product, foodgrain and feed grain consumption, seed, waste and other uses, total domestic consumption and requirement.
- **Cereal production drivers** include grain area growth; irrigation intensity growth, irrigation yield growth and rainfed yield growth etc.
- **Water balance drivers** include efficiency surface irrigation and area with ground water irrigation (both wet season and dry season), primary and total withdrawal, depletion and ground water balance.

A wide range of actions can induce changes in the value of these drivers across the BAU and other scenarios those are discussed in next section and onwards.

3.3 Business As Usual Scenario

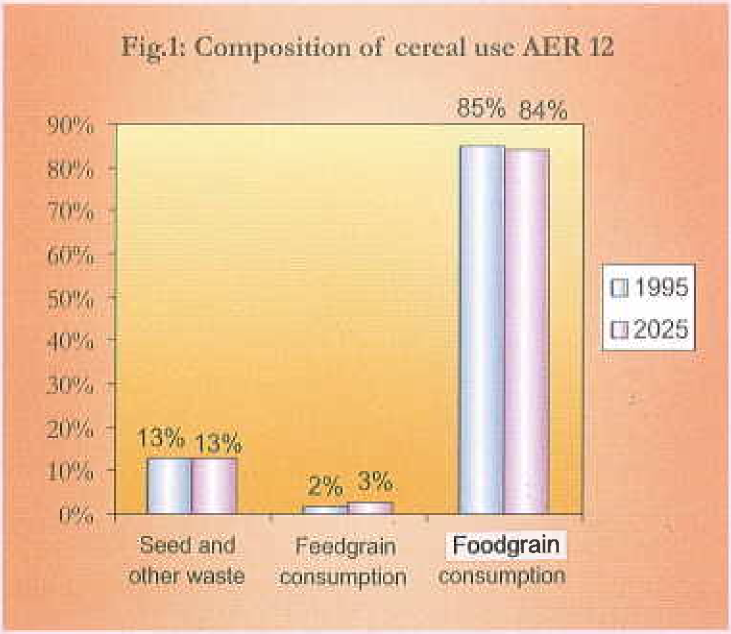
Business As Usual Scenario (BAU) assumes continuation of current trends and existing plans in water and food policy, management, and investment upto 2025 with 1995 status as the base. BAU is used throughout this study as a benchmark against which the results of other scenarios are compared.

3.3.1 Cereal Consumption, production and Requirement

Slowing down of population growth rates and increasing diversification of diets away from cereals are distinctly observed from BAU scenario for all the AESRs and AER 12. It is a positive sign of dietary improvement and overall prosperity of the region. The annual population growth is projected to decline to 1.21% in 2025 from about 2% in 2001 for the region. With the same trend, proportion of cereal in consumption basket is also projected to come down to 67% from 71.5% in 1995 for AER 12 (Table 6). Among the AESRs, AESR 12.2 is projected to consume less cereal (65%)compared to other two AESRs. There is no significant change in consumption pattern of cereal as revealed in Fig.1. Cereal use as foodgrain is projected to come down slightly from 85% in 1995 to 84% in 2025 where as its use as feed grain consumption is projected to rise by around 1%. On the other hand, cereal production from both irrigated and rainfed region is projected to grow by 19.02 % from 15.99 million tonne in 1995 to 19.1 million tonne in 2025 in AER 12. Cereal requirement

Table 6: Cereal Consumption and Requirement under BAU scenario

Parameters	Units	AESR 12.1				AESR 12.2			
		1995	2025	Total change (%)	Annual growth (%)	1995	2025	Total change (%)	Annual growth (%)
Population	million	26.8	36.7	36.9	1.04	21	30	42.9	1.2
Daily calories intake	kcal/cap	1909	2407	26.0	0.27	1822	2550	39.9	1.1
Cereal products	%	73.0	69.0	0.2	-0.01	69.3	65.0	-6.3	-0.2
Animal products	%	6.0	7.0	20.9	0.63	6.5	7.8	20.7	0.6
Food grain consumption	m t	5.38	8.70	61.82	1.62	3.09	5.79	87.43	2.12
Feed grain consumption	m t	0.13	0.27	108.21	2.47	0.08	0.18	141.30	2.98
Total domestic consumption	m t	6.27	10.21	62.93	1.64	3.60	6.79	88.72	2.14
Grain-meat ratio		0.12	0.12	0.0		0.08	0.08	0.0	
Cereal requirements	m t	6.2	10.2	64.4	1.7	3.60	6.80	91.0	2.2
Grain balance 2025	m t	-0.33	-3.280			-0.27	-2.88		
		AESR 12.3				AER 12			
Population	million	29.4	44.2	50.3	1.4	77.2	110.8	43.5	1.21
Daily calories intake	kcal/cap	1747	2230	28.0	0.4	1826	2396	31.2	0.91
Cereal products	%	71.6	67.0	-6.5	-0.2	71.5	67.0	-6.3	-0.22
Animal products	%	7.3	7.3	0.5	0.0	6.5	7.7	18.2	0.56
Food grain consumption	m t	4.11	7.38	79.6	2.0	1.14	2.01	76.51	1.91
Feed grain consumption	m t	0.14	0.28	93.0	2.2	0.04	0.08	122.71	2.70
Total domestic consumption	m t	5.07	9.13	80.0	2.0	1.21	2.16	78	1.94
Grain-meat ratio		0.10	0.10	0.0		0.01	0.01	0.0	
Cereal requirements	m t	5.0	9.1	82.5	2.0	14.8	26.6	180	2.42
Grain balance 2025	m t	1.8	-0.8			1.2	-7.46		

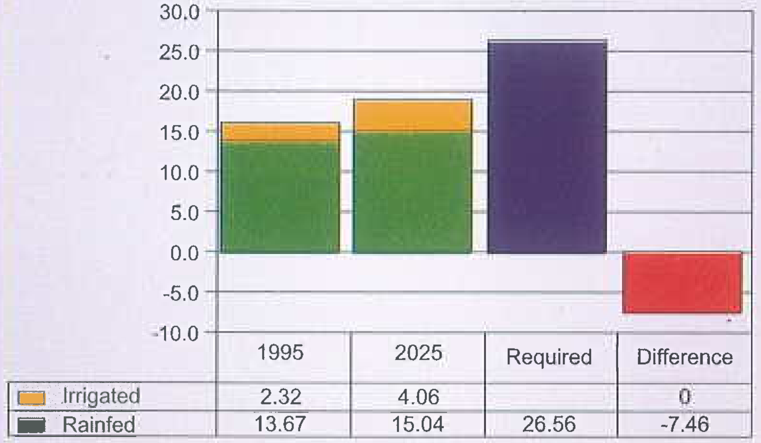


for all-purpose has been projected to 26.56 million tonne giving rise to net deficit of cereal production is around 7.46 million tonne for AER 12 (Fig.2). It may be noted that the grain balance is projected to be negative in 2025 for all the AESRs as well.

In terms of total calorie intake, there is a requirement of a rise of 31.2% in 2025. Across AESRs, the proportionate requirement (39.9%) is more in AESR 12.2 and lowest (26.0%)in AESR 12.1. Unlike trends in cereal products, demand for animal product is expected to rise by 18.2% in 2025 for AER 12. Consumption of animal product is expected to be more (7.8%) in AESR 12.2 compared to other AESRs. Though the calorie consumption from cereal as a percentage of total calorie consumption showing a declining trend, aggregate demand for cereal production has not declined. Expected deficit need to be filled by raising crop yield, cropping intensity and improved technological intervention.

The gross cereal yield in AER 12 is expected to rise by 18.75% from 1.64 t/ha in 1995 to 1.96 t/ha in 2025. The gross yield expected to be highest (2.2 t/ha) in AESR

Fig. 2: Cereal production and requirements (Million tonne) in AER 12



12.3 compared to other AESRs (Table 7 & Table 8). The production of cereal from rainfed area alone is projected to increase to 15.04 m t in 2025 from 13.67 m t in 1995 and production from irrigated land is significantly less in this region which is not adequate to meet the growing demand of food grain by 2025 (Fig.2). On the other hand the net cereal area is projected to marginally rise by 1.91% where as the harvested area is projected to fall by a marginal 0.38% by 2025.

3.3.2 Water Requirements and Water Balance

Total potential utilisable water resources available in AER 12 is 40.3 km^3, out of which AESR 12.1 has a maximum share of 21.74 km^3 followed by AESR 12.2 with 10.2 km^3 of renewable water resources. Total diversion by all sectors in AER 12 was about 15.36 km^3 in 1995 which is projected to be 27.91 km^3 (82% of previous level) by 2025, (Table 9). Major share of total diversion has been devoted to agriculture sector in both base year 1995 and projection year 2025. There has been projected increase of total consumptive use by 51% for AER 12 and net ground water balance has been found to be nil (Fig.3).

Table 7: Growth of Cereal Production in AER 12 under BAU scenario

Parameters	Units	AESR 12.1			AESR 12.2			AESR 12.3			AER 12.0		
		1995	2025	Total change (%)	1995	2025	Total change (%)	1995	2025	Total change (%)	1995	2025	Total change (%)
Net cereal area	m ha	3.5	3.66	4.57	1.62	1.72	6.17	2.83	2.66	-6.01	7.86	8.01	1.91
Cereal harvested area	m ha	4.11	4.12	0.28	2.22	2.18	-1.85	3.41	3.42	0.44	9.74	9.70	-0.38
Net irrigated area	m ha	1.43	1.47	2.16	0.84	1.44	71.20	1.06	2.12	100.12	3.34	5.09	52.44
Cropping Intensity	%	108	100	-7.41	114	100	-12.28	101	100	-0.99	108.0	100	-7.41
Cereal production	m t	5.4	6.08	12.59	2.68	2.89	7.84	5.52	5.98	8.33	13.67	15.04	10.02
Gross cereal yield	t/ha	1.4	1.7	21.43	1.5	1.7	13.33	1.9	2.2	15.79	1.6	1.9	18.75
Total production from irrigated agriculture	%	8	12	50.00	19	26	36.84	19	28	47.37	15	21	40.00

Fig.3: Total Diversions (All Sectors)

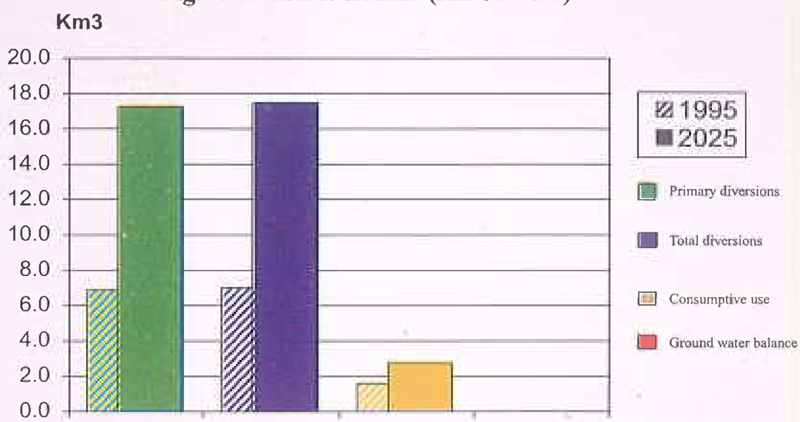


Table 8 : Cereal Area, Yield and Production, 1995 and 2025

Parameters	Cereal production 1995 estimates				2025 predictions		
	Unit	Annual	Season 1	Season 2	Annual	Season 1	Season 2
		AESR 12.1					
Average yield	t / ha	1.43	1.52	0.40	1.69	1.68	1.91
Gross irrigated area	m ha	0.33	0.27	0.06	0.45	0.37	0.08
Gross rainfed area	m ha	3.77	3.50	0.28	3.66	3.66	0.00
Yields irrigated	t / ha	1.46	1.42	1.64	1.91	1.91	1.91
Yields rainfed	t / ha	1.43	1.53	0.14	1.66	1.66	0.15
Production irrigated	m t	0.48	0.39	0.10	0.86	0.70	0.15
Production rainfed	m t	5.40	5.36	0.04	6.08	6.08	0.00
		AESR 12.2					
Average yield	t / ha	1.48	1.61	0.69	1.76	1.75	2.02
Gross irrigated area	mha	0.38	0.31	0.07	0.51	0.42	0.09
Gross rainfed area	mha	1.85	1.62	0.23	1.72	1.72	0.00
Yields irrigated	t / ha	1.65	1.50	2.36	2.02	2.02	2.02
Yields rainfed	t / ha	1.45	1.63	0.20	1.68	1.68	0.21
Production irrigated	m t	0.62	0.46	0.16	1.02	0.84	0.18
Production rainfed	m t	2.68	2.63	0.05	2.89	2.89	0.00
		AESR 12.3					
Average yield	t / ha	2.00	2.01	1.32	2.44	2.43	3.14
Gross irrigated area	mha	0.55	0.53	0.02	0.74	0.71	0.03
Gross rainfed area	m ha	2.86	2.83	0.03	2.66	2.66	0.00
Yields irrigated	t / ha	2.34	2.33	2.61	3.14	3.14	3.14
Yields rainfed	t / ha	1.93	1.95	0.20	2.24	2.24	0.23
Production irrigated	m t	1.29	1.23	0.06	2.33	2.24	0.09
Production rainfed	m t	5.52	5.51	0.01	5.98	5.98	0.00
		AER 12					
Average yield	t / ha	1.64	1.73	0.65	1.96	1.95	2.36
Gross irrigated area	m ha	1.28	1.10	0.17	1.72	1.49	0.24
Gross rainfed area	m ha	8.46	7.86	0.60	8.01	8.01	0.00
Yields irrigated	t / ha	1.82	1.75	2.24	2.36	2.36	2.36
Yields rainfed	t / ha	1.62	1.73	0.18	1.88	1.88	0.20
Production irrigated	m t	2.32	1.93	0.39	4.06	3.51	0.55
Production rainfed	m t	13.67	13.56	0.11	15.04	15.04	0.00

Table 9 : Water requirements in AER 12

Parameters		1995		2025	
	Unit	Season 1	Season 2	Season 1	Season 2
Gross irrigated area	m ha	3.3	0.5	4.5	0.7
Area with tube wells %	%	7%	7%	7%	7%
NET (beneficial ET)	mm	0	534	0	534
Non-beneficial ET (% of NET)	%	30%	30%	30%	30%
Recycling drainage water	%	0%	0%	0%	0%
Crop consumptive use groundwater	%	40%	40%	41%	41%
Crop consumptive use surface water	%	29%	29%	30%	30%
Recharge of ground water	%	33%	33%	33%	33%
Annual diversions (all)		**1995**	**2025**	**Growth (%)**	**Annual growth%**
Potential utilizable water resources	km^3	40.30	40.30		
Agricultural primary diversions	km^3	11.7	15.8	31%	0.89%
Agricultural total diversions	km^3	12.2	16.0	31%	0.89%
Domestic total diversion	km^3	1.2	2.5	118%	2.64%
Industrial total diversion	km^3	2.00	9.44	373%	5.32%
Primary diversions all sectors	km^3	14.1	24.3	72%	1.83%
Total diversion all sectors	km^3	15.4	27.9	82%	2.01%
Total consumptive use	km^3	1.47	2.63	79.01%	1.39%
Water use indicators		**1995**	**2025**	**Indicator**	
Degree of development	%	35	60	Absolute Scarce	
Country consumptive use	%	28	25	Okay	
Ground water balance	%	0.0	0.0	Okay	
Total recycling factor all sectors	%	9	15		
Agricultural Use	**Unit**	**1995 Season 1**	**Season 2**	**2005 Season 1**	**Season 2**
Withd for surface irrigation	km^3	0	11.74	0	15.30
Primary withdrawals surface	km^3	0	11.74	0	15.30
Volume pumped	km^3	0	0.50	0	0.65
total NET surface	km^3	0	2.62	0	3.53
total NET groundwater	km^3	0	0.20	0	0.27
Recharge aquifers	km^3	0	2.85	0	3.66
Surface outflow	km^3	0	8.93	0	11.50
Groundwater balance	km^3	0	2.35	0	3.01
Country consumptive use	%	0	24%	0	25%
Non beneficial ET		0	0.84	0	1.14
Productivity per unit ETa	kg/m^3	0.27	0.40	0.37	0.42
Water productivity annual	kg/m^3	0.29	0.38		

The degree of development of ground water was about 25% in 1995, which is projected to be 60% in 2025 in AER 12. AESR wise analysis reveals that the degree of development is much higher in AESR 12.2 than other AESRs in both base and projection year. It was about 50% in 1995 which is projected to be 73% in 2025 in AESR 12.2. On the other hand the degree of development is just 29% in AESR 12.1 and 22% in AESR 12.3 in 1995 those are projected to be 53% and 46% respectively in 2025 (Annexures 1, 2 and 3).

3.3.3 Domestic and Industrial Water Use

Water demand, which may be described in terms of water withdrawal, water consumption, depletion or its use for different domestic, industrial and agricultural purposes. Water withdrawals through agricultural surfaces, agricultural tube wells, domestic and industrial purposes for different AESRs of AER 12 are indicated in Table 10 and Table 11. It may be noted that the amount of renewable water resources withdrawn for all purposes taken together is maximum (50% in 1995) in AESR 12.2, which is projected to increase by 73% in 2025. Depletion is also highest (13% in 1995 that is expected to be 16% in 2025) in this sub region compared to other sub regions of AER 12. The total withdrawal for agricultural uses (both through agricultural surfaces and agricultural tube wells) is highest (4.78 km^3) in AESR 12.2 where as the net withdrawal for agricultural purpose is just 1.22 km^3 for AESR 12.3, implying that there is low utilisation of water resources in this sub region. This may be due to low irrigation intensity, less ground water exploitation particularly in eight districts of Jharkhand (1.45 to 11.65 % ground water development). Total water requirement for AER 12 for agricultural purposes (both through agricultural surface and agricultural tube wells) is about 12.22 km^3, which is projected to increase by about 31% (15.95km^3) with annual growth rate of 0.89 % in 2025.

The withdrawals for agricultural purposes (agriculture surface and agriculture tube wells is 1.22 km^3 in AESR 12.3, and for domestic purposes is 0.44 km^3 in 1995 in this sub region which is projected to rise to 2.18 and 1.0 km^3 in respective sectors in 2025. On the other hand, withdrawal for industrial purposes is maximum of 1.29 km^3 in 1995 (which is expected to rise to 6.08 km^3 in 2025) in AESR 12.1 compared to other sub regions in AER 12. The total withdrawals for domestic and industrial

Table 10: Water Demand, 1995 and 2025

Variables	Units	AESR 12.1			AESR 12.2			AESR 12.3			AER 12		
		1995	2025	% change	1995	2025	% change	1995	2025	% change	1995	2025	% change
Case 1: Agricultural surface													
Total withdrawals	km^3	4.9	6.4	130	4.62	6.02	130	1.17	1.54	131	11.7	15.3	131
Primary withdrawals	km^3	4.9	6.4	136	4.62	6.02	130	1.17	1.54	131	11.7	15.3	131
Depletion	km^3	1.1	1.4	135	1.03	1.39	130	0.26	0.35	131	26.1	3.53	135
Case 2: Agricultural tube wells													
Total withdrawals	km^3	0.3	0.3	132	0.16	1.39	131	0.05	0.06	132	0.5	0.65	132
Primary withdrawals	km^3	0	0	0	0	0	0	0	0	0	0	0	0
Depletion	km^3	0.1	0.14	135	0.06	0.08	135	0.02	0.03	132	0.2	0.27	135
Case 3: Domestic purposes													
Total withdrawals	km^3	0.4	0.83	208	0.31	0.68	217	0.44	1.00	229	1.15	2.51	218
Primary withdrawals	km^3	0.3	0.62	208	0.23	0.51	217	0.33	0.75	229	0.86	1.88	218
Depletion	km^3	0.1	0.12	208	0.05	0.10	217	0.07	0.15	229	0.17	0.38	218
Case 4: Industrial purposes													
Total withdrawals	km^3	1.3	6.08	471	0.28	1.31	468	0.43	2.05	477	2	9.44	472
Primary withdrawals	km^3	0.9	4.56	475	0.210	0.980	467	0.320	1.54	481	1.5	7.080	472
Depletion	km^3	0.1	0.46	460	0.020	0.100	400	0.030	0.15	400	0.15	0.710	473
Renewable water resources	km^3	21.74			10.22			8.33			40.3		
	With drawn (%)	29	53	183	50	73	132	22	46	152	35	60	171
	Deplet-ed(%)	8	10	125	13	16	123	7	8	114	10	12	120

Table 11: Domestic and industrial water use, 1995 and 2025

Parameters	Units	AESR 12.1			AESR 12.2			AESR 12.3			AER 12.0		
		1995	2025	Growth (%)	1995	2025	Growth (%)	1995	2025	Growth (%)	1995	2025	Growth (%)
Domestic water use													
Population	million	26.85	36.66	37	21.0	30.0	43%	29.370	44.174	50.41	77.2	110.8	43.5
%Access to piped water	%	81	81		81	81		81	81		81	81	
daily use per capita	l/day	50.3	77	52	50.3	76.5	52.07	50.301	76.5	52.1	50.3	76.5	52.1
Recycling	%	25	25		25	25		25	25		25	25	
Fraction of depletion	%	20	20		20	20		20	20		20	20	
Total withdrawals	km^3	0.40	0.83	108	0.312	0.678	117.3	0.437	0.999	128.7	1.148	2.506	118.3
Primary withdrawals	km^3	0.30	0.62	108	0.234	0.509	117.3	0.328	0.749	128.7	0.861	1.880	118.3
Depletion	km^3	0.06	0.12	108	0.047	0.102	117.3	0.066	0.150	128.7	0.172	0.376	118.
Industrial water use													
Total withdrawals	km^3	1.286	6.084	373.3	0.277	1.311	373.3	0.433	2.050	373.3	1.996	9.445	373.3
Recycling	%	25	25		25	25		25	25		25	25	
Fraction of depletion	%	10	10		10	10		10	10		10	10	
Primary withdrawals	km^3	0.96	4.6	373.3	0.208	0.983	373.3	0.325	1.538	373.3	1.497	7.9	373.3
Depletion	km^3	0.96	0.46	373.3	0.021	0.098	373.3	0.032	0.154	373.3	0.150	0.71	373.3

requirements in AER 12 is estimated to be 2.51 km^3 and 9.44 km^3 respectively in 2025 from the 1995 base level of 1.15 km^3 and 2 km^3.

Sector wise analysis of water use reveals that agriculture sector that was using 84% of total primary withdrawals in 1995 in AER 12, is projected to use only 64% primary withdrawals in 2025, i.e. a decline of about 23%. On the other hand, it is envisaged that water requirements for industrial sector will sharply increase by 2025. As indicated in Fig. 4, withdrawal for industrial use is expected to increase to 28% by 2025 from base year level of 10%. It may be noted that the sector wise depletion of ground water resources also follows the same trends as revealed by Fig. 5. Depletion by industrial sector is projected to increase to 15% in 2025 from 5% in 1995 where as the share of agriculture sector is expected to fall to the level of 77% of total depletion in 2025 from base year level 90%.

Fig. 4: Primary withdrawal in AER 12.0

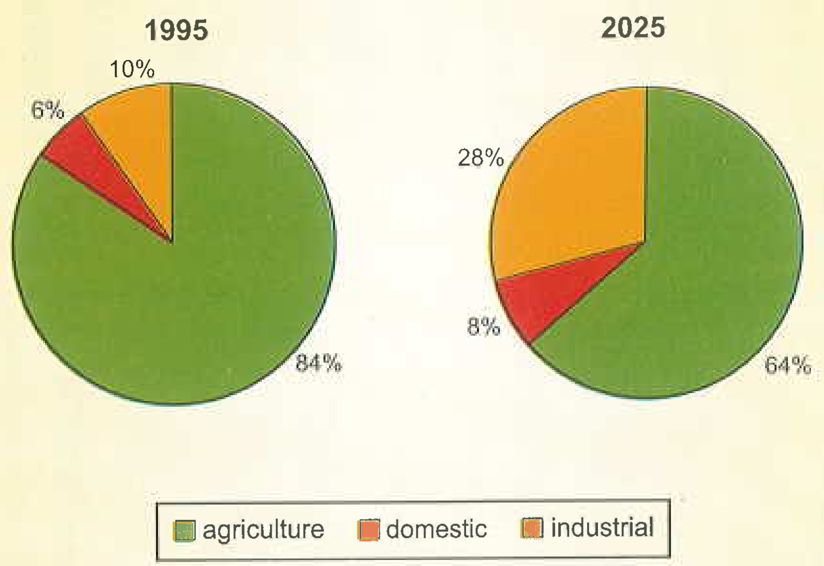
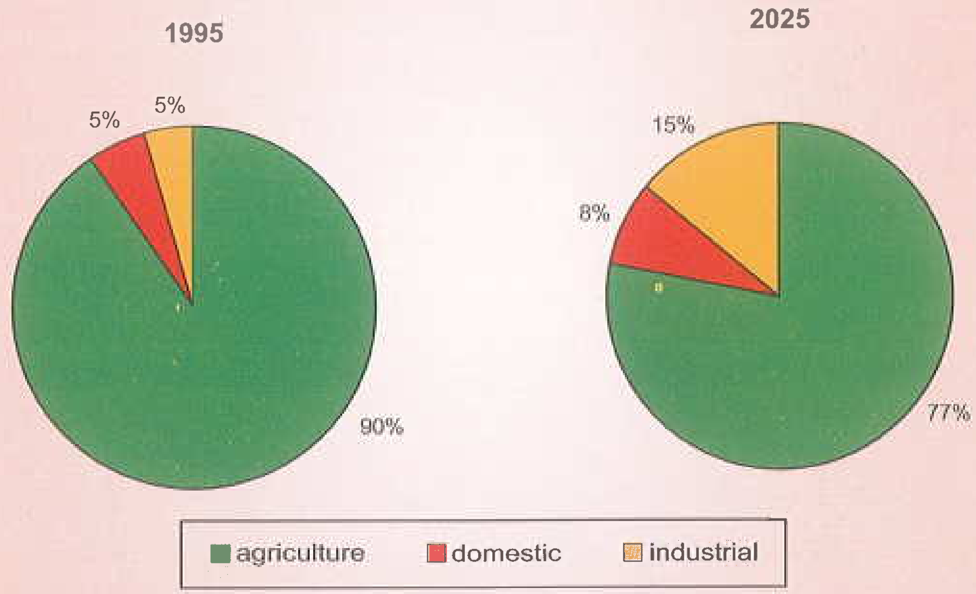


Fig. 5: Depletion per sector in AER 12.0



3.3.4 Cereal Production, Irrigation Requirements and Water Scarcity

The major task remains to understand the inter linkages of food demand –supply scenarios with water scenarios. PODIUM provides unique framework to study these inter linkages. As the basis of analysing these alternative scenarios it may be noted that under BAU scenario, all the AESRs of the AER 12 are projected to face potential food deficit of different magnitudes if the past trend continues without any fresh interventions. AER 12 may experience the deficit of 7.46 million tonnes of cereal production by 2025 (Table 12). Under BAU scenario, though the country consumptive use and change in ground water level is okay in AER 12, the projected growth in total diversions is crossing threshold level (82%). To address such issues and to feed the burgeoning population with daily calorie per capita of 2396 k cal along with fulfilling other domestic and industrial requirements, different policy options have to be picked up those are analysed through alternative scenarios analysis in next section onwards in details.

Table 12 : Cereal production, irrigation and water requirement in AER 12

Cereal production	Unit	1995	2025 target	Projected production	Deficit / surplus
Daily calories intake	kcal	1825.9	2396.0		
Cereal production	m t	15.99	26.56	19.10	-7.46
Production from irrigated area	%	15	21		Food deficit
Implications for irrigation		**1995**	**2025 target**	**Growth**	**Annual growth**
Net area surface irrigation	m ha	3.1	4.2	34.8	1.0
Net area tube well irrigation	m ha	0.2	0.3	34.8	1.0
Irrigation intensity	%	116	116	0.0	0.0
Surface total diversions	km^3	11.72	15.3	31	0.9
Groundwater total pumped	km^3	0.5	0.7	32	0.9
Crop per drop	kg/m^3 ET	0.3	0.4	29	0.9
Water scarcity indicators		**1995**	**2025 target**	**Indicators**	
Degree of development	%	35	60	**Absolute water scarce**	
Country Consumptive uses	%	28	25	**Okay**	
Growth in total diversions	%		82	**Economic water scarce**	
Change in groundwater	km^3	0.0	0.0	**Okay**	

3.4 Food Security Scenarios

As per the BAU scenario of AER 12, the region is projected to be a food insecure region by the year 2025 with food deficit of 7.26 million tonne. In this section some of the alternative scenarios with different options are explored on the basis of PODIUM projections and findings. The implications of each of these scenarios are aptly analysed. Future food deficit can be compensated in different ways. The options are either we need to increase production by a number of alternative methods, or we may curtail future consumption requirements, or by both increasing production and reducing future level of consumption etc. Table 13 reveals such type of future options.

3.4.1 *Enhancing production Possibilities*

The most viable policy option for tackling future food insecurity is by increasing future production levels through technological innovations, appropriate crop diversification and exploring possibilities of another green revolution. As per the PODIUM findings, we have indicated three possibilities. First one, it has been investigated that how much area expansion is required to achieve the food security situation assuming all other variables to remain as per the BAU level. It has been found that we need to increase the gross cropped area by 1.15% annually so as to stay food secure in 2025. As per this projection we need to expand the total area under the cereal upto 13.722 m ha from the existing level of 9.738 m ha. As per the future policy direction is concerned it is not going to happen, as it is completely unfeasible.

Anther option (option 2 of Table 13) for achieving future food security situation is to expand irrigation potential and to increase crop yield from both irrigated and unirrigated land. Third option also reveals similar possibility of adopting combination of strategies to increase the production levels. Third option stresses on raising productivity from both irrigated and unirrigated land so as to achieve the food secure situation by 2025. It may be noted that implication of all these options for future scenario of water resources is not positive. The first option leads to growth in total diversion to be at the situation of economic water scarce level, where as rest two options also lead to situation of negative ground water balance along with diversion at the economic water scarce level.

3.4.2 *Consumption Adjustment*

Second theoretical possibility is to anticipate the lower level of per capita consumption compared to BAU projection level. This is the consumption adjustment possibility. As per BAU scenario, per capita calorie consumption is projected to increase to 2396 k cal in 2025 from the base year level of 1825.9 k cal. One of the options is to anticipate the per capita consumption to remain at little higher than the existing level. This is shown by the option 1 of Table 14. In this case it is assumed that all the production parameters to be same as BAU level. Three options of consumption adjustments have been indicated in this table with different combination of cereal products, animal products and calorie requirements so as to achieve self-sufficient level in terms of food demand and supply. It may be indicated

Table 13: Food Security Situation by Variation in Area-Yield-Production in AER 12

Options by changing production parameters only												
Parameters	Units	BAU Level		Option 1			Option 2			Option 3		
		1995	2025	2025	Total change (%)	Annual change (%)	2025	Total change (%)	Annual change (%)	2025	Total change (%)	Annual change (%)
Production Variables												
Total cereal area	m ha	9.7	9.7	13.7	40	1.15	12.18	25.1	0.75	10.5	7.80	0.25
Net irrigated area	m ha	3.34	4.5	4.49	34.8	1.0	6.99	110	2.5	6.0	56.3	2
Irrigation intensity	%	116	116	116	0.0	0.0	145	24.8	0.7	1.45	25.1	0.8
Irrigated yield	t/ha	1.7	2.3	2.36	34.8	1.0	2.36	34.8	1.0	3.17	81.1	2.0
Rainfed yield	t/ha	1.616	1.87	1.87	16.1	0.5	2.1	30.8	0.9	2.29	41.8	1.2
Production from irrigated area	%	15	21	21			30		-	35		
Consumption Variables												
Daily calorie intake	k cal	1826	2396	2396	31.2	0.91	2396	31.2	0.9	2396	31.2	0.91
Cereal products	%	71.5	67.0	67.0	-6.3	-0.22	67.0	-6.3	-0.2	67.0	-6.3	-0.22
Animal products	%	6.5	7.7	7.7	18.2	0.56	7.7	18.2	0.56	7.7	18.2	0.56

Resulting Scenarios	Unit	1995		2025	Results	2025	Results	2025	Results
Total production level	m t	15.9	19.1	26.58		26.56		26.58	
Total consumption level	m t		26.6	26.56		26.57		26.56	
Deficit/surplus	m t		-7.46	0.014	Surplus	0.01	Surplus	0.02	Surplus
Degree of development	%	15	34	34.1	Okay	148	Absolute water scarce	132.1	Absolute water scarce
Consumptive use	%	24	19	19.1	Okay	29	Okay	28.9	Okay
Growth in total diversions	%		143	143	Economic water scarce	827	Economic water scarce	732	Economic water scarce
Change in groundwater	km^3	0.0	0.0	0.0	Okay	-0.8	Ground water decline	-0.4	Ground water decline

Source: Computed from PODIUM model for AER 12. Note: 1.Bold and underlined figures have been changed to get desired scenarios

Table 14: Food Security Situation by Variation in Cereal Requirements in AER 12

Parameters	Units	Options by changing consumption parameters only										
		BAU Level		Option 1			Option 2			Option 3		
		1995	2025	2025	Total change (%)	Annual change (%)	2025	Total change (%)	Annual change (%)	2025	Total change (%)	Annual change (%)
Consumption Variables												
Daily calorie intake	k cal	1826	2396	**1896**	**3.8**	**0.13**	**1946**	**6.58**	**0.21**	**1846**	**1.10**	**0.04**
Cereal products	%	71.5	67.0	**60.0**	**-16.1**	**-0.6**	**59.0**	**-17.5**	**-0.6**	**60.0**	**-16.1**	**-0.6**
Animal Products	%	6.5	7.7	**7.7**	**18.2**	**0.6**	**7.7**	**18.2**	**0.6**	**12.7**	**95.0**	**2.3**
Production Variables												
Total cereal area	m ha	9.7	9.7	9.7	0	0.00	9.75	0	0.00	9.7	0	0.00
Net irrigated area	m ha	3.3	4.5	4.5	1.0	34.78	4.52	1.0	34.78	4.5	1.0	34.78
Irrigation intensity	%	116	116	116	0	0.00	116	0	0.00	116	0	0.00
Irrigated yield	t/ha	1.7	2.4	2.4	1.0	34.78	2.36	1.0	34.78	2.4	1.0	34.78
Rainfed yield	t/ha	1.6	1.9	1.9	0.5	16.14	1.88	0.5	16.14	1.9	0.5	16.14
Production from irrigated area	%	15	21	21			21			21		
Resulting Scenarios	**Unit**	**1995**	**2025**	**2025**	**Results**		**2025**	**Results**		**2025**	**Results**	
Total production level	m t	15.98	19.1	19.1			19.1			19.1		
Total consumption level	m t		26.6	18.9			19.1			18.9		
Deficit/surplus	m t		-7.46	0.2	Surplus		0.02	Surplus		0.25	Surplus	
Degree of development	%	15.0	34.1	34.1	Okay		34.1	Okay		34.1	Okay	
Consumptive use	%	24.4	19.1	19.1	Okay		19.1	Okay		19.1	Okay	
Growth in total diversions	%		142.8	143	Economic water scarce		143	Economic water scarce		143	Economic water scarce	
Change in groundwater	km^3	0.0	0.0	0.0	Okay		0.0	Okay		0.0	Okay	

Note: 1.Bold and underlined figures have been changed to get desired scenarios
Source: PODIUM model for AER 12

that only varying the consumption module without altering cereal production and water requirements doesn't affect the water situation in any way as shown in the Table 14. It also shows that it is possible to achieve the secure food grain level without any change in BAU production scenario if consumption requirements don't rise at the rapid rate as projected in BAU scenario.

3.4.3 Adjustment in Production & Consumption Requirements

It is feasible to achieve the food security level by combination of methods of production and consumption adjustments. As indicated in option 1 of Table 15, we can do so by increasing gross cropped area under cereal by0.3% annually with increasing net area under irrigation to 4.843 by annual growth rate of 1.25%; raising irrigated yield and rainfed yield by 1.15% and 0.75% respectively along with anticipating little lower rate of growth of consumption. Option 2 and option 3 also provide some other possibilities by which AER 12 can be at food secure position in 2025. However all these combinations are proved to be detrimental to water security scenarios. Hence it is very urgent that we must address the food and water security issues simultaneously so as to facilitate sustainable resource utilisation.

3.5 Water Security Scenarios (WSS)

3.5.1 WSS in AER 12

The degree of development was absolute scarce (60%) during predicted year 2025 as per the BAU scenario. At this level, the crop consumption through surface was 30% in both seasons and through ground water it was 41% with area under tube well was 7%. We can bring degree of development to 59% (okay) by changing area under tube well from 7 to 8% or by changing crop consumptive use of surface water from 30% to 31%

To achieve degree of development, consumptive use of water, growth in total water diversion at satisfactory level (okay) i.e. 38, 40 and 25 %, respectively, the surface irrigation efficiency during dry season (rabi season) has to be increased from 30 % to 71 % and area under tube well from 7 to 11%, keeping other indicators level constant. The surface irrigation efficiency can be improved by lining of irrigation system, proper land levelling, adoption of pressurised irrigation with high value cash crops in this AER.

Table 15: Food Security Situation by Variation in Area-Yield-Production and Cereal Requirements in AER 12

Parameters	Units	Options by changing both production and consumption parameters										
		BAU Level		Option 1			Option 2			Option 3		
		1995	2025	2025	Total change (%)	Annual change (%)	2025	Total change (%)	Annual change (%)	2025	Total change (%)	Annual change (%)
Production Variables												
Total cereal area	m ha	9.74	9.74	10.34	6.18	0	9.8	0.90	0.03	9.6	0.90	0.03
Net irrigated area	m ha	3.34	4.45	5.61	68.28	1.8	4.8	45	1.3	3.6	7.78	0.25
Irrigation intensity	%	116	116	131	12.72	0.4	1.23	0.2	6.2	116	0	0.00
Irrigated yield	t/ha	1.75	2.36	2.73	56.31	1.5	2.463	40.92	1.15	3.2	81.1	2.0
Rainfed yield	t/ha	1.616	1.876	2.17	34.78	1.0	2.022	25.13	0.75	2.1	25.1	0.8
Production from irrigated	%	15	21	28			23			20		
Consumption Variables												
Daily calorie Intake	k cal	1826	2396	**2396**	**31.2**	**0.91**	**1896**	**3.84**	**0.13**	**2196**	**20.27**	**0.62**
Cereal products	%	71.5	67.0	**59.0**	**-17.5**	**-0.64**	**65.0**	**-9.10**	**-0.3**	**57.0**	**-20.3**	**-0.75**
Animal products	%	6.5	7.7	**9.7**	**48.9**	**1.34**	**10.7**	**64.29**	**1.67**	**11.7**	**79.64**	**1.97**
Resulting Scenarios	**Unit**	**1995**	**2025**	**2025**	**Results**		**2025**	**Results**		**2025**	**Results**	
Total production level	m t	15.99	19.10	23.86			20.73			21.44		
Total consumption level	m t		26.56	23.73			20.69			21.26		
Deficit/surplus	m t		-7.46	0.13	Surplus		0.04	Surplus		0.18	Surplus	
Degree of development	%	15.0	34.1	0.8	Absolute water scarce		54	Okay		0.32	Okay	
Consumptive use	%	24.4	19.1	0.3	Okay		24	Okay		0.18	Okay	
Growth in total diversions	%		143	4.3	Economic water scarce		260	Economic water scarce		1.28	Economic water scarce	
Change in groundwater	km^3	0.0	0.0	-0.23			0	Okay		0	Okay	

Note: 1.Bold and underlined figures (compared to BAU level) have been changed to get desired scenarios

Source: Computed from PODIUM model for AER 12

3.5.2 WSS in AESR 12.1

The degree of development, country consumptive use, ground water balance are projected to be okay and the values were 53%, 23%, and non-negative respectively as per the BAU scenario. By decreasing country consumptive use surface water from 30 to 25%, by keeping other parameters constant we can reach the degree of development to the maximum of 59%. The leftover 5 % surface water can be recharged in to the ground water aquifer by various recharge methods wherever it is feasible.

To maintain degree of development, country consumptive use of water, growth in total diversion to the extent of 32%, 36% and 24% which is considered to the optimum, the withdrawal of water should be reduced from 6.084 km^3 to 3.884 km^3, the surface irrigation efficiency during dry season should be increased to 55 % as against original level of 30 %, and the area under ground water utilization should be 9%.

3.5.3 WSS in AESR 12.2

The degree of development is projected to be 73% in this AESR as per the BAU scenario, which is not desirable for optimum utilisation of water resources. Rest parameters namely country consumptive use and ground water balance were at desirable level (okay). To make the degree of development to the extent of desirable level (i.e. to bring down to 59% which is considered as threshold level for acceptance), the surface water utilisation rate can be increased up to 40% during season 2.

Keeping other things constant, changing total industrial withdrawal from 1. 311 km^3 to 0.811km^3 (193%), and surface irrigation efficiency during dry season from 30% to 37% will lead to the water scarcity indicator viz. degree of development, country consumptive use and ground water changes to remain at the satisfactory level of 59%, 35%, 23% and nil respectively in AESR 12.2.

3.5.4 WSS in AESR 12.3

The degree of development, country consumptive use, ground water balance are projected to be 46%, 21% and 0.0% respectively which were at sub optimal level in AESR 12.3 as per the BAU. When the utilization of surface water is reduced from 30% to 18% during rabi season, the degree of development reaches the maximum of 59%. The excess surface water which is available after adjusting degree of development, can bring more area under irrigation during rabi season as well as some quantity of surface water can recharge ground water in the specific area where it is feasible.

For achieving satisfactory level of degree of development, country consumptive use, total water diversion in industries and ground water development at 25%, 34%, 24% and nil respectively, we have to reduce industrial water use from 2.050 km^3 to 0.95 km^3, per capita water consumption from 76.5 lit/day to 70.5 lit/day. At the same time we need to increase surface irrigation efficiency during dry season from 30% to 70%, keeping other indicators constant.

3.6 Water and Food Security Scenarios

The projected scenario for 2025 of AER 12 with respect to food supply and water resources reveals that the overall food supply is deficit to the extent of -7.46 million tonne when intake of food in terms of calories increased from 1826 k calories in 1995 to 2396 k calories in 2025, keeping total area under cereal intact (Table 16). If the problem of food insecurity is to be solved by 2025, the irrigated area has to be increased from 3.34 m ha to 4.5 m ha. The productivity of irrigated as well as rainfed area has to be increased from 1.75 t/ha to 2.36 t/ha and from 1.62 t/ha to 1.88 t/ha respectively. Irrigated area can be increased by 2025 by decreasing the country consumptive use of available water from 24.4% to 19.1% with diversion of total water to the maximum of 142.8%.

Under this BAU scenario, the ground water level remained stable across AESRs of AER 12. If the exploitation of ground water is to be increased during rabi and summer season, the depletion of ground water can lead to water scarce. But it never happened in predicted BAU scenario since the water supply through rains was adequate during rainy season in all AESRs. This surplus rainwater of kharif season can be harvested in reservoirs and effectively utilised in dry seasons. But in AER 12, the major irrigation projects are limited in numbers. To make certain provision for storing excess water, small reservoirs could be the alternative approach since the land holdings is very small and the farmers of the region can neither spare their land for construction of medium and major irrigation projects nor wait for long gestation period.

It is a matter of grave concern to find out the feasible ways to make the region secure and sustainable with comfortable levels of food and water situations by the

Table 16: Food & Water Security Scenario in AER 12 by Variation in all Modules

Parameters	Unit	Options by changing production, consumption and water requirements							
		BAU Level		Option 1			Option 2		
		1995	2025	2025	Total change (%)	Annual growth (%)	2025	Total change (%)	Annual growth (%)
Area-Yield-Production									
Total cereal area	m ha	9.74	9.74	10.03	3	0.1	10.03	3	0.1
Net irrigated area	m ha	3.34	4.50	5.22	56	1.5	5.22	56	1.5
Irrigation intensity	%	116	116	120	3.4	0.11	120	3.4	0.11
Irrigated yield	t/ha	1.75	2.38	3.03	73.3	1.85	2.73	56	1.5
Rainfed yield	t/ha	1.62	1.88	2.56	58.2	1.54	2.18	34.8%	1.0
Cereal Requirements									
Daily calorie intake	k cal	1826	2396	2396	31.2	0.1	2046	12	0.38
Cereal products	%	71.5	67.0	67.0	-6.3	0.001	67	6	0.22
Animal products	%	6.5	7.7	7.7	18	0.56	7.7	18	0.56
Water requirements									
Efficiency surface irrigation (wet season)	%	30	30	30	0.0	0.0	30	0.0	0.0
Efficiency surface irrigation (dry season)	%	30	30	30	0.0	0.0	30	0.0	0.0
Area with ground water (wet season)	%	7	7	7	0.0	0.0	7	0.0	0.0
Area with ground water (dry season)	%	7	7	7	0.0	0.0	7	0.0	0.0
Access to piped water	%	81	81	81	0.0	0.0	81	0.0	0.0
Daily use per capita	L	50.3	76.5	76.5	52.1	1.74	76.5	52.1	1.74
Industrial water use	km^3	1.99	9.44	9.44	374.4	12.5	9.44	374.4	12.5
Area with tube well									
(a) Season 1	%	7	30	30	0.0	0.0	30	0.0	0.0
(b) Season 2	%	7	30	30	0.0	0.0	30	0.0	0.0
Crop consumptive use GW									
(a) Season 1	%	40	41	41	2.5	0.001	41	2.5	0.001
(b) Season 2	%	40	41	84	110	3.7	84	110	3.7
Crop consumptive use Surface Water									
(a) Season 1	%	29	30	30	3.4	0.11	30	3.4	0.11
(b) Season 2	%	29	30	39	34.5	1.15	39	34.5	1.15

Parameters	Unit	BAU Level		Option 1		Option 2	
		1995	2025	2025	Results	2025	Results
Resulting Scenarios							
Total Production level	m t	15.99	19.1	26.6		23.0	
Total consumption requirements	m t		26.56	26.56		22.68	
Deficit/surplus	m t		-7.46	0.06	Surplus	0.31	Surplus
Degree of development	%	15.0	34.1	38	Okay	38	Okay
Consumptive use	%	24.4	19.1	50	Okay	50	Okay
Growth in total diversions	%		142.8	25	Okay	25	Okay
Change in groundwater	km^3	0.0	0.0	0.0	Okay	0.0	Okay

year 2025. Some of the alternative options have been explored through PODIUM model by altering its drivers, which is indicated in Table 16. In case of each of the options, it is attempted to make the region both food and water secure simultaneously.

First option assume that consumption requirements to remain at BAU projection level in 2025. If the per capita daily calorie intake remains at the level of 2396 k cal with total cereal requirement of 67% and animal product consumption at 7.7%, we need to increase the total cereal area upto 10.03 m ha in 2025 from 9.74 m ha in 1995 along with increasing net irrigated area from 3.34 m ha to 5.22 m ha. At the same time irrigation intensity has to be raised from 116% of BAU level to 120% in 2025 with annual growth requirement of 0.11%. The productivity of irrigated area and rainfed area has to be increased from 1.75 t/ha to 3.03 t/ha and from 1.62 t/ha to 2.56 t/ha respectively. For achieving water security at acceptable limit, the crop consumptive use through ground water and surface water during season 2 has to be increased to 84% by 2025 from 40% in 1995 with annual growth rate of 3.7% and from 29% in 1995 to 39% in 2025 with annual growth rate of 1.15%. The resulting scenario of this combination of driver parameters of all the three modules may be seen from the Table 16, which shows that the region is both food and water secure.

Another alternative scenario is more realistic scenario as it allows changing the required drivers of all the modules so as to get the state of both water and food secure scenario in the region AER 12. Unlike option 1, we have assumed that the consumption requirement is also expected to be at lower level compared to BAU projection. We have set the per capita daily intake to be 2046 k cal in 2025(which is less than what has been projected figure in option 1) compared to 1826 k cal in 1995 with annual growth rate of 0.38%.

We need to increase the both irrigated and rainfed yield to 2.73 t/ha and 2.18 t/ha in 2025 from the BAU level so as to achieve the food secure scenario in 2025. In order to achieve water secure level at the same time we need to increase the crop consumptive use through ground water and surface water during season 2 from 40% in 1995 to 84% by 2025 with annual growth rate of 3.7% and from 29% in 1995 to 39% in 2025 with annual growth rate of 1.15% respectively. The resulting scenario shows that total food grain surplus of 0.31 m t with degree of development of 38%, country consumptive use of 50% and growth in total diversion of 25%.

4.0 SUGGESTED OPTIONS

The policy options are suggested in following three sections. The first section suggests the options for achieving the food security levels without addressing water security issues of AER 12. The second section suggests the alternative options for making the region water secure without considering the food security situations. The last section suggests the options for achieving both water and food security situations simultaneously, hence, contains more realistic suggestions with respect to AER 12.

4.1 Making the Region Food Secure

Option 1: This option reveals the possibility of adopting combination of strategies to increase the production levels. It is suggested to expand irrigation potential by 2.5% annually along with annual area expansion by 0.75%; irrigation intensity by 0.74%; and yield growth by 0.9% so as to achieve food secure situation in 2025 (Table 13).

Option 2: Another option, a more realistic than previous one, stresses on raising productivity from both irrigated and unirrigated land so as to achieve the food secure situation by 2025. It requires to increase irrigated yield by 2% and rainfed yield by 1.2% annually along with raising irrigation intensity by 0.8% and cereal area by 0.25% for achieving food secure scenario in 2025.

4.2 Making the Region Water Secure

Options for AESR 12.1

Option 1: Under the BAU scenario, the degree of development, country consumptive use, ground water balance are projected to be okay in 2025 and the values were 53%, 23%, and non-negative respectively. By decreasing country consumptive use (surface water) from 30 to 25%, along with keeping other parameters as such we can reach the degree of development to the maximum of 59%. The leftover 5 % surface water can be recharged in to the ground water aquifer by various recharge methods wherever it is feasible.

Option 2: To maintain degree of development, country consumptive use of water, growth in total diversion to the extent of 32%, 36% and 24% which is considered to the optimum, the withdrawal of water should be reduced from 6.084 km^3 to 3.884 km^3, the surface irrigation efficiency during dry season should be increased to 55 % as against original level of 30 %, and the area under ground water utilization should be 9%.

Options for AESR 12.2

Option 1: Under BAU, the degree of development is projected to be 73%, which is not desirable for optimum utilisation of water resources. Rest parameters namely country consumptive use and ground water balance were at desirable level (okay). To make the degree of development to the extent of desirable level (i.e. to bring down to 59% which is considered as threshold level for acceptance), the surface water utilisation rate can be increased up to 40% during season 2.

Option 2: Keeping other things constant, changing total industrial withdrawal from 1. 311 km^3 to 0.811km^3 (193%), and surface irrigation efficiency during dry season from 30% to 37% will lead to the water scarcity indicator viz. degree of development, country consumptive use and ground water changes to remain at the satisfactory level of 59%, 35%, 23% and nil respectively.

Options for AESR 12.3

Option 1: As per the BAU the degree of development, country consumptive use, ground water balance are projected to be 46%, 21% and 0.0% which were at sub optimal level. When the utilization of surface water is reduced from 30% to 18% during rabi season, the degree of development reaches the maximum of 59%. The excess surface water which is available after adjusting degree of development, can bring more area under irrigation during rabi season as well as some quantity of surface water can recharge ground water in the specific area where it is feasible.

Option 2: To achieve satisfactory level of degree of development, country consumptive use, total water diversion in industries and ground water development at 25%, 34%, 24% and nil respectively, we have to reduce industrial water use from 2.050 km^3 to 0.95 km^3, per capita water consumption from 76.5 l/day to 70.5 l/day. At the same time we need to increase surface irrigation efficiency during dry season from 30% to 70%, keeping other indicators as such.

Options for AER 12

Option 1: Under BAU scenario the degree of development is projected to be absolute scarce (60%) during 2025. At this level, the crop consumption through surface water and ground water is 30% and 41% in both the seasons respectively with area under tube well at 7%. We can bring degree of development to 59% (okay level) by changing area under tube well from 7% to 8% or by changing crop consumptive use of surface water from 30% to 31%.

Option 2: To achieve degree of development, consumptive use of water, growth in total water diversion at satisfactory level (okay) i.e. 38%, 40% and 25% respectively, the surface irrigation efficiency during dry season (rabi season) has to be increased from 30% to 71% and area under tube well from 7% to 11%, keeping other drivers at the BAU levels. The surface irrigation efficiency can be improved by lining of irrigation system, proper land levelling, and adoption of pressurised irrigation system with high value cash crops.

4.3 Making the Region both Food and Water Secure

Option 1: First option assume that consumption requirements to remain at BAU projection level in 2025. If the per capita daily calorie intake remains at the level of 2396 k cal with total cereal requirement of 67% and animal product consumption at 7.7%, we need to increase the total cereal area upto 10.03 m ha in 2025 from

9.74 m ha in 1995 along with increasing net irrigated area from 3.34 m ha to 5.22 m ha. At the same time irrigation intensity has to be raised from 116% of BAU level to 120% in 2025 with annual growth rate of 0.11%. The productivity of irrigated area and rainfed area has to be increased from 1.75 t/ha to 3.03 t/ha and from 1.62 t/ha to 2.56 t/ha respectively. For achieving water security at acceptable limit, the crop consumptive use through ground water and surface water during season 2 has to be increased to 84% by 2025 from 40% in 1995 with annual growth rate of 3.7% and from 29% in 1995 to 39% in 2025 with annual growth rate of 1.15%. The resulting scenario shows that the region is both food and water secure.

Option 2: This alternative scenario is more realistic scenario as it allows to change the required drivers of all the modules so as to get the state of both water and food secure scenario in the region AER 12. Unlike option 1, we have assumed that the consumption requirement is also expected to be at lower level compared to BAU projection. We have set the per capita daily intake to be 2046 k cal in 2025(which is less than what has been projected figure in option 1) compared to 1826 k cal in 1995 with annual growth rate of 0.38%. We need to increase the both irrigated and rainfed yield to 2.73t/ha and 2.18t/ha in 2025 from the BAU level so as to achieve the food secure scenario in 2025. In order to achieve water secure level at the same time we need to increase the crop consumptive use through ground water and surface water during season 2 from 40% in 1995 to 84% by 2025 with annual growth rate of 3.7% and from 29% in 1995 to 39% in 2025 with annual growth rate of 1.15% respectively. The resulting scenario shows that total foodgrain surplus of 0.31 million tonne with degree of development of 38%, country consumptive use of 50% and growth in total diversion of 25%.

To make availability of food supply in ample amount without any significant depletion of available water, the combination of various parameters of Area Yield Production Modules and Water Modules were adjusted. To compensate the increased daily calorie intake of 2396 k calorie in 2025 over 1825.9 kcal in 1995 as per the BAU scenario, the production level has to increase from 15.99 m t in 1995 to 19.1 m t in 2025. The irrigated yield and rain fed yield need to be raised from 1.75 to 2.36 t/ha and from 1.61 to 1.88 t/ha, respectively. To meet desired calorie requirement, preference should be given to take animal products than cereal product as the later is known for high nutrition value.

5.0 SUGGESTED FUTURE COURSE OF ACTION

In order to counter balance the projected food deficit of 7.46 m t of food grain towards 2025 in AER 12, the net irrigated area, irrigation intensity, and yield of cereal crops grown under irrigated and rain fed area is to be increased.

To bring more area under irrigation, the proposal is made to use part of excess surface water of kharif season and exploitation of ground water during rabi season (season 2). Because utilisation of ground water during rabi season is highly feasible in all districts of AER 12. the region being a coastal region with good record of average annual rainfall, the development of ground water has not reached to the minimum development stage of 65%. The ground water development is 11.4 % in AESR 12.1, 12.7 % in AESR 12.2, and 10.6 % in AESR 12.3 with substantial variation within districts (CV of 40.4%, 28.7% and 119% in AESR 12.1, 12.2 and 12.3 respectively). The low developments of ground water in these regions are mainly due to smaller size of land holdings and poor economic conditions of farmers those are unable to invest for creating irrigation facilities.

To increase cropping intensity and irrigation intensity, there should be well established cooperative sector or association who can invest huge amount for opening bore wells/open wells and on the basis of irrigated area or on volume of water exploited, the association can collect money from the users (farmers). The government can also create such facilities to the farmer by exploring ground water and hand over to them for their use.

The other option is to conserve rainwater during rainy season or recharge into aquifer, wherever it is feasible, which is always excess than requirements in most of districts except East Godavari of AP, Chandrapur and Gadchirolli of Maharashtra, and Dhenkanal of Orissa in AESR 12.1; Vishakapatnam and Vijayanagram of AP and Ganjam district of Orissa in AESR12.2 and Dhanbad, Dumka (Jharkhand), Purulia (West Bengal) in AESR12.3. In all the remaining districts the NET is higher than rainfall at 75% probability level. Once irrigation facility is created, the farmers should select a crop or cropping pattern, which can fit in to the land and climatic condition, that in turn, will raise the agricultural productivity and prosperity in the region.

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Annexure

Annexure 1: Water requirements under BAU scenario in AESR 12.1

Parameters	Unit	1995		2025	
		Season 1	Season 2	Season 1	Season 2
Gross irrigated area	m ha	1.06	0.23	1.43	0.31
Area with tube wells	%	8.56	8.56	8.56	8.56
NET (beneficial ET)	mm	0	523.0	0	523.0
Non-beneficial ET (% of NET)	%	30	30	30	30
Recycling drainage water	%	0	0	0	0
Crop consumptive use ground water	%	40	40	41	41
Crop consumptive use surface water	%	29	29	30	30
Recharge of ground water	%	33	33	33	33
Annual diversions (all)		**1995**	**2025**	**Growth (%)**	**Annual growth (%)**
Potential utilizable water resources	km^3	21.74	21.74		
Agricultural primary diversions	km^3	4.93	6.43	30	0.89
Agricultural total diversions	km^3	5.19	6.77	30	0.89
Domestic total diversion	km^3	0.40	0.83	108	2.47
Industrial total diversion	km^3	1.29	6.08	373	5.32
Primary diversions all sectors	km^3	6.20	11.61	87	2.12
Total diversion all sectors	km^3	6.88	13.68	99	2.32
Total consumptive use	km^3	1.72	2.69	56	1.50
Water use indicators		**1995**	**2025**	**indicator**	
Degree of development (%)		29	53	okay	
Country consumptive use (%)		28	23	okay	
Ground water balance		0.0	0.0	okay	
Total recycling factor all sectors	(%)	11	18		
Agricultural use	**Unit**	**Season 1**	**Season 2**	**Season 1**	**Season 2**
Withdrawal for surface irrigation	km^3	0	4.93	0	6.43
Primary withdrawal surface	km^3	0	4.93	0	6.43
Volume pumped	km^3	0	0.26	0	0.34
total NET surface	km^3	0	1.10	0	1.48
total NET groundwater	km^3	0	0.10	0	0.14
Recharge aquifers	km^3	0	1.21	0	1.55
Surface outflow	km^3	0	3.73	0	4.81
Ground water balance	km^3	0	0.95	0	1.21
Country consumptive use	%	0	24	0	25
Non beneficial ET	%	0	0.36	0	0.49
Productivity per unit ETa	kg/m^3	0.22	0.30	0.30	0.35
Water productivity annual	kg/m^3	0.24	0.31		

Annexure 2: Water requirements under BAU scenario in AESR 12.2

Parameters	Unit	1995		2025	
		Season 1	Season 2	Season 1	Season 2
Gross irrigated area	m ha	0.84	0.18	1.14	0.25
Area with tubewells	%	5.69	5.69	5.69	5.69
NET (beneficial ET)	mm	-8.75	599.62	-8.75	599.62
non-beneficial ET (% of NET)	%	30	30	30	30
Recycling drainage water	%	0	0	0	0
Crop consumptive use GW	%	40	40	41	41
Crop consumptive use surface	%	29	29	30	30
Recharge of ground water	%	33	33	33	33
Annual diversions (all)		**1995**	**2025**	**Growth %)**	**Annual growth(%**
Potential utilizable water resources	km³	10.22	10.22		
Agricultural primary diversions	km³	4.62	6.02	30	0.89
Agricultural total diversions	km³	4.78	6.23	30	0.89
Domestic total diversion	km³	0.31	0.68	117	2.62
Industrial total diversion	km³	0.28	1.31	373	5.32
Primary diversions all sectors	km³	5.06	7.51	48	1.32
Total diversion all sectors	km³	5.37	8.21	53	1.43
Total consumptive use	km³	1.49	2.12	42	1.18
Water use indicators		**1995**	**2025**	**Indicator**	
Degree of development		50%	73%	Absolute scarce	
Country consumptive use		29%	28%	Okay	
Ground water balance		0.0	0.0	Okay	
Total recycling factor all sectors		6%	9%		
Agricultural Use	**Unit**	**Season 1**	**Season 2**	**Season 1**	**Season 2**
Withdrawal for surface irrigation	km³	0.00	4.62	0.00	6.02
Primary withdrawals surface	km³	0.00	4.62	0.00	6.02
Volume pumped	km³	0.00	0.16	0.00	0.20
Total NET surface	km³	0.00	1.03	0.00	1.39
Total NET groundwater	km³	0.00	0.06	0.00	0.08
Recharge Aquifer	km³	0.00	1.11	0.00	1.43
Surface outflow	km³	0.00	3.53	0.00	4.55
Groundwater balance	km³	0.00	0.96	0.00	1.23
Country consumptive use	%	0.00	24	0.00	24
Non beneficial ET(% of NET)	%	0.00	0.33	0.00	0.44
Productivity per unit ETa	kg/m³	0.22	0.37	0.30	0.32
Water productivity annual	kg/m³	0.25	0.30		

Annexure 3: Water requirements under BAU scenario in AESR 12.3

Parameters	Unit	1995		2025	
		Season 1	Season 2	Season 1	Season 2
Gross irrigated area	m ha	1.43	0.06	1.93	0.08
Area with tube wells	%	6.91	6.91	6.91	6.91
NET (beneficial ET)	mm	0	476	0	476
Non-beneficial ET (% of NET)	%	30	30	30	30
Recycling drainage water	%	0	0	0	0
Crop consumptive use GW	%	40	40	41	41
Crop consumtive use surface	%	29	29	30	30
Recharga of ground water	%	33	33	33	33
Annual diversions (all)		**1995**	**2025**	**Growth (%)**	**Annual growth (%)**
Potential utilizable water resources	km^3	8.33	8.33		
Agricultural primary diversions	km^3	1.17	1.54	31	0.91
Agricultural total diversions	km^3	1.22	1.60	31	0.91
Domestic total diversion	km^3	0.44	1.00	129	2.80
Industrial total diversion	km^3	0.43	2.05	373	5.32
Primary diversions all sectors	km^3	1.83	3.82	110	2.50
Total diversion all sectors	km^3	2.09	4.65	122	2.70
Total consumptive use	km^3	0.46	0.80	72	1.83
Water use indicators		**1995**	**2025**	**Indicator**	
Degree of development	%	22	46	Okay	
Country consumptive use	%	25	21	Okay	
Ground water balance	km^3	0.0	0.0	Okay	
Total recycling factor all sectors	%	15	22		
Agricultural Use	**Unit**	**Season 1**	**Season 2**	**Season 1**	**Season 2**
Withd for surface irrigation	km^3	0.00	1.17	0.00	1.54
Primary withdrawals surface	km^3	0.00	1.17	0.00	1.54
Volume pumped	km^3	0.00	0.05	0.00	0.06
Total NET surface	km^3	0.00	0.26	0.00	0.35
Total NET groundwater	km^3	0.00	0.02	0.00	0.03
Recharge aquifers	km^3	0.00	0.28	0.00	0.37
Surface outflow	km^3	0.00	0.89	0.00	1.16
Groundwater balance	km^3	0.00	0.24	0.00	0.30
Country consumptive use	%	0.00	24	0.00	25
Non beneficial ET(% of NET)	%	0.00	0.08	0.00	0.11
Productivity per unit ETa	kg/m^3	0.38	0.52	0.52	0.63
Water productivity annual	kg/m^3	0.39	0.52		

Annexure 4: Cereal production and water requirement under BAU in AESR 12.1

Cereal production	**Unit**	**1995**	**2025**	**Projected production**	**Deficit / surplus**
Daily calories intake	kcal	1908.68	2407.00	6.93	-3.28 Food deficit
Cereal production	mt	5.88	10.21		
% Production from irrigated	%	8	12		
Implications for irrigation		**1995**	**2025**	**Growth (%)**	**Annual growth (%)**
Net area surface irrigation	mha	0.97	1.30	34.78	1.00
Net area tube well irrigation	m ha	0.09	0.12	34.78	1.00
Irrigation intensity	%	1.22	1.22	0.00	0.00
Surface total diversions	km³	0.34	0.44	30.29	0.89
Groundwater total pumped	km³	0.02	0.02	31.50	0.92
Crop per drop	kg/m³ ET	0.33	0.42	26.80	0.79
Water scarcity indicators		**1995**	**2025**	**Indicators**	
Degree of development	%	29	53	Okay Economic water scarce Okay	
Country consumptive uses	%	28	23		
Growth in total diversions	%		99		
Change in groundwater	km³	0.0	0.0		

Annexure 5 : Cereal production and water requirement under BAU in AESR 12.2

Cereal production	**Unit**	**1995**	**2025**	**Projected production**	**Deficit / surplus**
Daily calories per capita	k cal	1822.33	2550.00	3.91 Food deficit	-2.88
Cereal production	m t	3.30	6.79		
% Production from irrigated	%	19	26		
Implications for irrigation		**1995**	**2025**	**Growth (%)**	**Annual growth(%)**
Net area surface irrigation	m ha	0.80	1.07	34.78	1.00
Net area tube well irrigation	m ha	0.05	0.06	34.78	1.00
Irrigation intensity	%	122	122	0.00	0.00
Surface total diversions	km³	4.31	5.61	30.29	0.89
Total groundwater pumped	km³	0.15	0.19	31.50	0.92
Crop per drop	kg/m³ ET	0.36	0.41	12.23	0.39
Water scarcity indicators		**1995**	**2025**	**Indicators**	
Degree of development	%	50	73	Absolute water scarce	
Country Consumptive uses	%	29	28	Okay	
Growth in total diversions	%		53	Economic water scarce	
Change in groundwater	km³	0.0	0.0	Okay	

Annexure 6 : Cereal production and water requirement under BAU in AESR 12.3

Cereal production	Unit	1995	2025	Projected production	Deficit / surplus
Daily calories intake	k cal	1746.69	2230.00		
Cereal production	m t	6.81	9.13	8.31	-0.83
% Production from irrigated	%	19	28		Food deficit
Implications for irrigation		**1995**	**2025**	**Growth (%)**	**Annual growth(%)**
Net area surface irrigation	m ha	1.34	1.80	35	1.00
Net area tube well irrigation	m ha	0.10	0.13	35	1.00
Irrigation intensity	%	104	104	0	0.00
Surface total diversions	km^3	1.17	1.54	31	0.91
Total groundwater pumped	km^3	0.05	0.06	32	0.94
Crop per drop	kg/m^3 ET	0.39	0.52	34	0.98
Water scarcity indicators		**1995**	**2025**	**Indicators**	
Degree of development	%	22	46		
Country Consumptive uses	%	25	21	Okay	
Growth in total diversions	%		122	Economic water scarce	
Change in groundwater	km^3	0.0	0.0	Okay	