Planning for water resources

Sanjay Gupta, Anne Chappuis, Paramita Sen

Irrigation Potential and Food Security

India's agricultural growth during the 50-year period of independence remains impressive at 2.7 per cent per annum. Around two-third of this growth in production was a resulth of the increase in crop productivity. With population growth at a sustained 2.1 per cent per annum, per capita availability of food grains during this period has grown at around 0.5 per cent per annum (GOI, 1997). The need based strategies followed during this period focused mainly on agricultural growth through intensive input based productivity for feeding the growing population and making the country self sufficient in food production. As a result, India's agricultural sector has made rapid strides in making India not only self sufficient in meeting food needs but also providing her with a small surplus in food. At the beginning of the millennium total annual food grain production exceeded 200 MT. The first major concern of providing food security during the post-independence era was, thus, achieved by matching supply with demand.

The future scenario of Indian agriculture is different from what has been experienced so far.

- Firstly, with continuous growth in population, agricultural growth still has to balance between the pressing need to provide food and nutrition security to the country, the need to accelerate income growth to alleviate poverty and the need to quicken the pace of economic growth. For instance, latest estimations of foodgrain demand in India up to the year 2020 reveal that with an anticipated rise in the growth rate of India's per capita income from the current trend of 3.5 to 5.5 per cent, the total cereal demand will increase by around 140 per cent over 1990[1].
- Secondly, in tune with economic liberalization, imminent agricultural policy resolution and GATT agreements, agricultural technology management will have to become highly efficient in order to exploit the expanding production and marketing opportunities.
- Thirdly, with a shrinking resource base for supporting future production growth, the challenges are unprecedented as compared to the pre-green revolution era. For instance, in the past four decades ending with the 1990's, the resource base consisting of land and water for an average farm holding supporting eight persons has considerably declined. Reduced farm land for producing food, continuous decline in land area for meeting fuel and fodder needs, slowing of net irrigation expansion due to maintenance, insufficient investment, physical and environment related constraints, falling growth in total factor productivity and falling public investments in agricultural research in real terms make the future resource, production and technology management scenario quantitatively different from what was experienced during the later half of this century.
- Finally, improving the use efficiency of existing resources like land, water, fertilizers, infrastructure etc. will be crucial to relax the supply side constraints on future agricultural growth. The role of Irrigation water will remain crucial in the whole process of agricultural growth planning primarily in view of its complementarity with other yield enhancing and/or cost saving inputs.

[1] *Assessment made by the Ministry of Water Resources, Government of India*

Continued physical expansion of irrigation remains a short-term option in a number of basins. The past basis of irrigation's growth contribution, i.e, rapid expansion of irrigated area, is becoming progressively less feasible. Many issues confronting the irrigation sector have held back its real potential and the possibilities for a much larger contribution to agricultural growth.

Improvement in the productivity of existing irrigation, already the base for over two thirds of agricultural production, could be a major source of future agriculture growth. The opportunity available would be to **realize the hidden irrigation and agricultural potential prevalent in existing irrigation projects**: better water utilization and a larger area actually irrigated in the irrigation commands, and higher crop productivity per unit of land and water. This opportunity is relevant to both surface and groundwater irrigation, and concerns both major and minor irrigation systems However in the case of minor irrigation and ground water such a step will assume the nature of livelihoods promotion of small and marginal farmers who are also investing personal financial resources in the creation and sustenance of these resources.

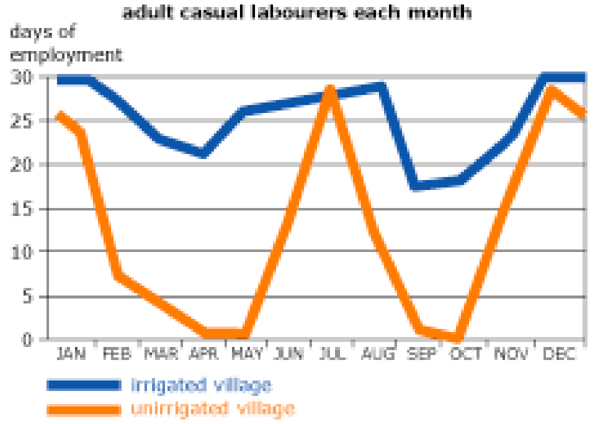
The Potential

It is estimated at all India level that a concurrent 25% improvement in both crop yields and water use efficiency (WUE from 35% to 43%) could yield an additional food grain output of 88 MT. This would represent some 44% of current food grain (Mt) 200 or 55% of the additional 159 MT of food grain estimated by GOI to be needed by 2025.

Water and Equity

Generally, criticism of large irrigation structures is concerned with problems of equity of access and opportunity. Various studies indicate the widespread coverage of the population both land owning and labor. The most recent one amongst these is the report titled *"India's Water Economy"* published by the World Bank in 2005. According to this report the central factor is not who gets the water, but how that water transforms the demand for inputs, most strikingly labor (which is provided primarily by the landless and marginal farmers). It indicates that the demand for agricultural labor is 50% to 100% higher on irrigated land. The report also quotes from Robert Chambers' study that at the village-level, irrigation has meant higher and much more stable employment, with the poor being the major beneficiaries[2].

Figure 1: Average number of days of employment for adult casual labourers each month



Source: Robert Chambers. Managing Canal Irrigation, New Delhi 1998

[2] From *World Bank – India's Water Economy, 2005*

There have also been numerous analyses at the project level, showing similar results. *Figure 2*, for example, compares the actual situation of farmers and agricultural laborers within the massive Nagarjunasagar Project on the Krishna River with that of similar groups who did not get water from the scheme. It shows that "the poor" – small and marginal farmers and agricultural laborers, benefited proportionately about as much as did the larger farmers.

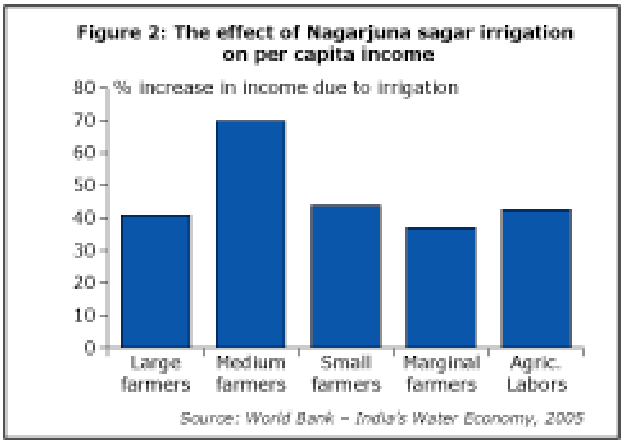


Figure 2: The effect of Nagarjuna sagar irrigation on per capita income

To quote further from the report, two recent, much more sophisticated analyses (which used input-output matrices and using Social Accounting Matrix methods) have shown similar results.

The study by the International Food Policy Research Institute on the impact of the green revolution in the North Arcot region of Tamil Nadu showed *(Figure 3)* that the biggest winners those who gained the most from the Green Revolution were the landless, whose incomes increased by 125 percent as a result of the large increase in demand for their labour.

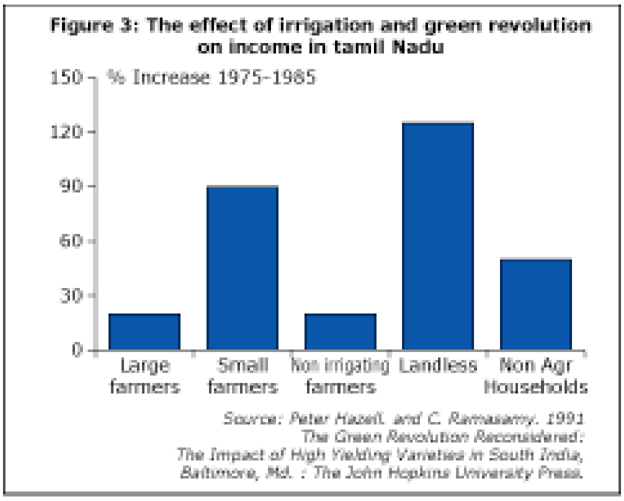


Figure 3: The effect of irrigation and green revolution on income in tamil Nadu

Critical issue to referred some time is the availability of per capita water. Less than 2000 cum per capita availability is defined as water stressed & less than 1000 cum per capita is classified as water scarce. Of course population & rainfall play a vital role in deciding this figure. Still the question remains that of fulfilling human need of food, drinking water, sanitation etc. Planners probably need to look into the optimum returns possible from the available water & then negotiate the demands of different sectors.

Irrigation and its impact in Andhra Pradesh

We will now be examining the status of water within the framework of agriculture and livelihoods in the southern Indian state of Andhra Pradesh. The brief profile of this state is attached to this paper as an annexure. This state lies along the eastern coast in the deccan plateau of the Indian sub continent. The state has invested huge amounts in the creation and maintenance of its irrigation infrastructure

The area under agriculture is almost constant despite the creation of new potential through an increase in ayacut and the launching of a massive watershed treatment program in the last decade. The contribution of agriculture to the gross state domestic product was Rs 142,470 millions during 1993-94 and Rs 129,870 millions during 2003-04 at the constant prices of 1993–94[3]. During this period, investments running into thousands of crores of rupees have been made in the irrigation and land development sectors.

It would be pertinent to ask where this investment has gone. One of the answers usually put forward is that the investment has gone toward the maintenance of the irrigation system and that the output from the agricultural sector would have gone down further but for this investment. This explanation could indeed go some way to accounting for the situation, but it would also serve to camouflage the real issue of system efficiency, presuming its steep and rapid decline as a natural and inevitable phenomenon. Let us examine the system efficiencies of certain projects and the ayacut under various sources.

The area under tank irrigation has fallen drastically. In 1955, tanks irrigated an area of 1,068,000 ha out of a total irrigated area of 2,747,000 ha. This was reduced to 727,000 ha in the year 2000, out of 4,528,000 ha of total area under irrigation. **The percentage of area dependent on tanks for irrigation was reduced to less than half in these 45 years (from 38.88 % in 1955 to 16.06 % in 2000).** The area under major and medium irrigation projects during this period was either more or less stagnant or showed a declining trend despite the creation of new potential and investment in modernization of the projects. The private investment during this period went up, almost exponentially from the eighties onward *(figure 5)*.

Figure 4: Share of agriculture and livestock in Gross Domestic Product

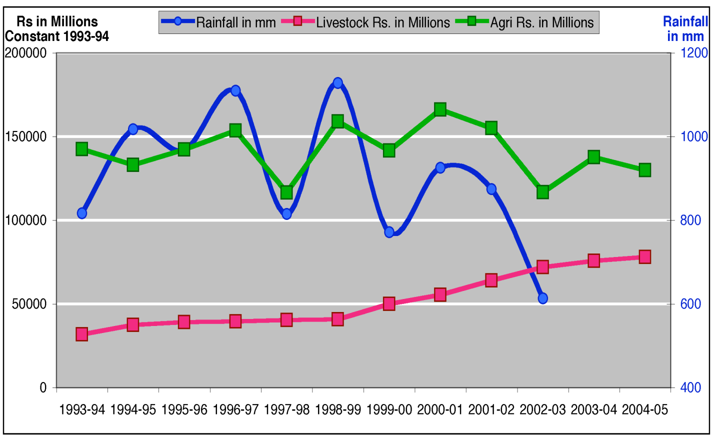
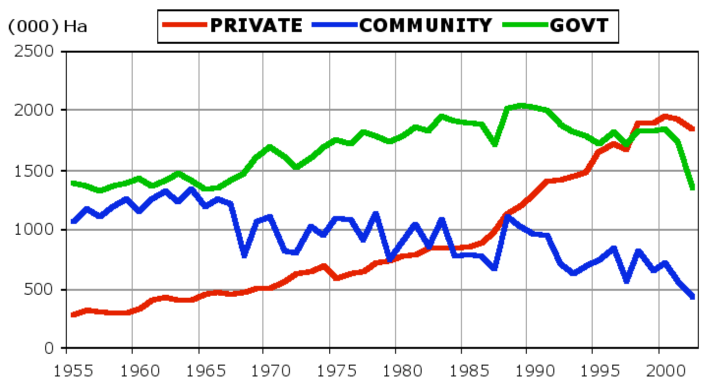


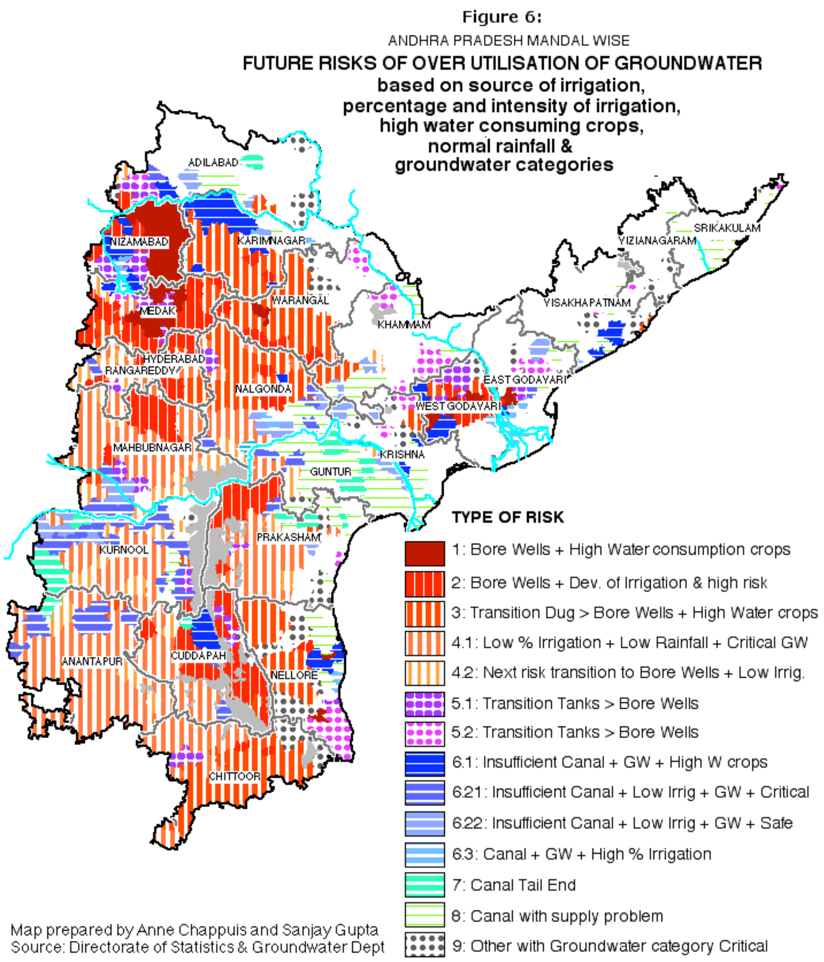
Figure 5: Area irrigated under private (wells), community (tanks) and government sources



[3] Directorate of Economics and Statistics, Government of Andhra Pradesh

It will also be observed that the area under irrigation through private investment has overtaken the area under the sources created by the government.

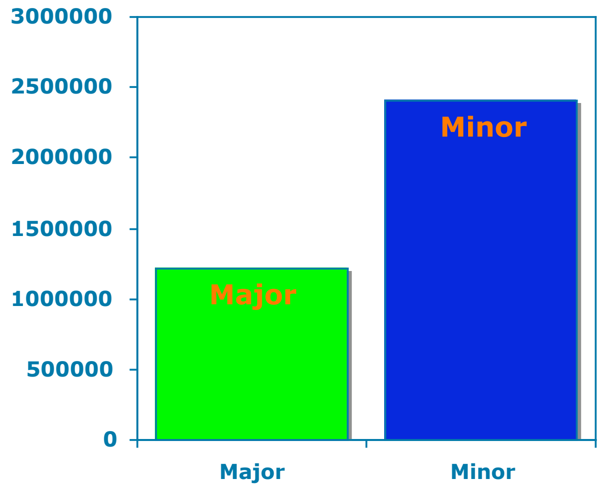
It is evident that the investment in bore wells and consequently area irrigated under ground water has increased. Ground water resources are fast depleting and their quality is worsening causing serious environmental concerns. There are certain disturbing trends as well such as the cultivation of high water consuming crops through the use of ground water. The present status of ground water and the areas of risk are highlighted in *figure 6.*



The areas shown in red indicate the highest risk areas. The next, lighter, shade, in adjacent areas, indicate the spreading risk. Those familiar with Andhra Pradesh would know that this area produces turmeric, tobacco and sugarcane, all irrigated using ground water.

High irrigation intensity and raising of high water consuming crops under ground water irrigation is a cause of serious concern for sustainability.

Figure 7: The classification of irrigation structures

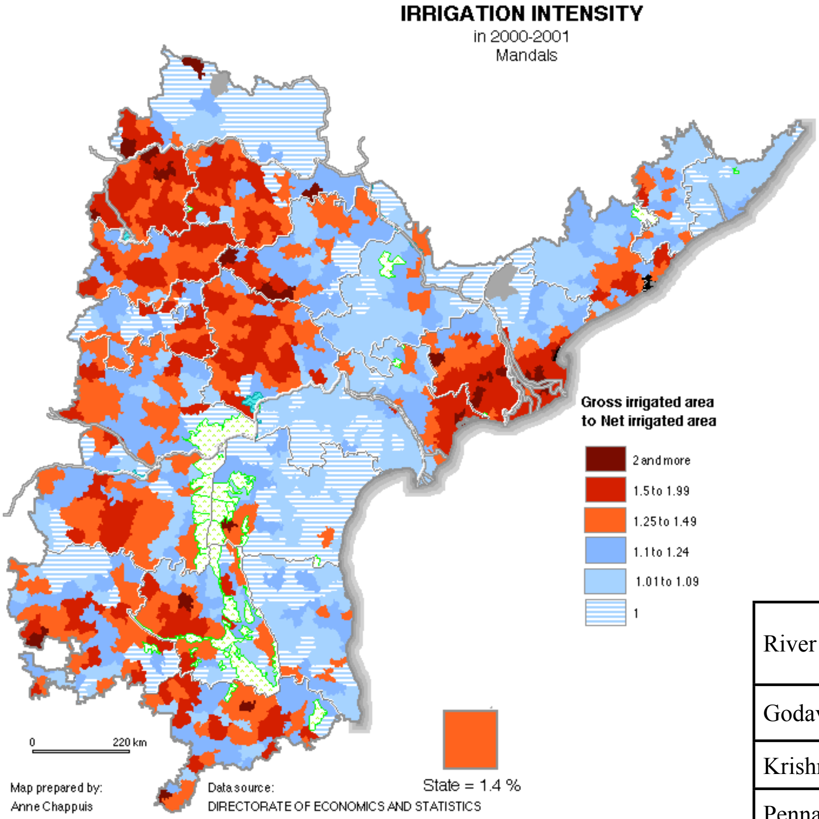


Irrigation planning and strategy is based on the classification of sources in Major, Medium and Minor irrigation projects depending upon the areas irrigated by these projects. The classification is on the basis of the area under irrigation, more than 10,000 ha, 2,000 to 10,000 ha and below 2,000 ha respectively.

The minor irrigation sector is comprised of tanks, lift irrigation and ground water irrigation. This "minor" sector now covers more than two third of the total irrigation in Andhra Pradesh. *(figure 7).* The investment in the creation and maintenance of these sources in the past decade reveals a skewed pattern *(table1).*

The minor irrigation sector has thus suffered from lack of investment and, consequently, the monitoring of this sector has been entirely insufficient. The label of "minor" has led the thinking and the policy. The uncontrolled tapping of ground water, which form part of minor irrigation irrigation sector policy, has not only caused serious environmental concerns but also led the farmers in to a vicious cycle of borrowing in order to gain access to more ground water. The lack of regulation and investment in this area has affected the livelihoods of millions amongst the rural poor, in primarily rain-fed areas.

Figure 8



Areas irrigated through ground water tend to have a high irrigation intensity (area irrigated more than once during one year). The average irrigation intensity in areas irrigated through canal water is 1.33 in areas where canal is the main source, 1.19 in areas where canal water is used in conjunction with other surface water but 1.36 when it is used with ground water, and it is 1.33 in areas irrigated mainly by ground water. Another disturbing trend is that of cultivating high-water consuming crops under ground water even during the rabi (winter) season. Policy support and future regulation are the key requirements here.

Where is the water and what it means to the poor

Surface water

The Krishna, Godavari and Pennar are three major river basins that run through Andhra Pradesh. These rivers carry a potential of 2746 tmc. Utilizable potential is now available only in Godavari.

The balance 993 tmc is capable of irrigating another 1.2 mha. The potential in Godavari also lies all along the tribal belt and also the high rainfall area of Andhra Pradesh. Creation of further structures will immediately benefit the tribal but this area is also covered with the only patch of good forest in Andhra Pradesh. Future exploitation and utilisation will therefore require careful planning and a balancing of the two natural resources, the forest and water.

River	Available (tmc)	Utilised (tmc)	Ayacut (mha)	Balance (tmc)	Balance (mha)
Godavari	1480	720		760	
Krishna	811	811		0	
Pennar	98	98		0	
Others	357	124		233	
Total	2746	1753	2.2	993	1.2

These three basins are further subdivided in to 81 sub-basins. The yields and utilisation of these basins indicate the potential in 48 sub-basins and the deficit in 33 basins. The deficit basins indicate that the created capacity cannot be used to fullest for want of water itself. Any further investment in these sub-basins will only shift the ayacut from one place to another and will not add to the total ayacut.

Minor irrigation comprising both, surface and ground water, functions in a policy vacuum leading to dysfunctional rural irrigation management.

Ground water

Ground water resources in the state are assessed on the basis of 1229 units, which follow the 81 surface water sub-basins. These assessment units are divided into command and non-command areas.

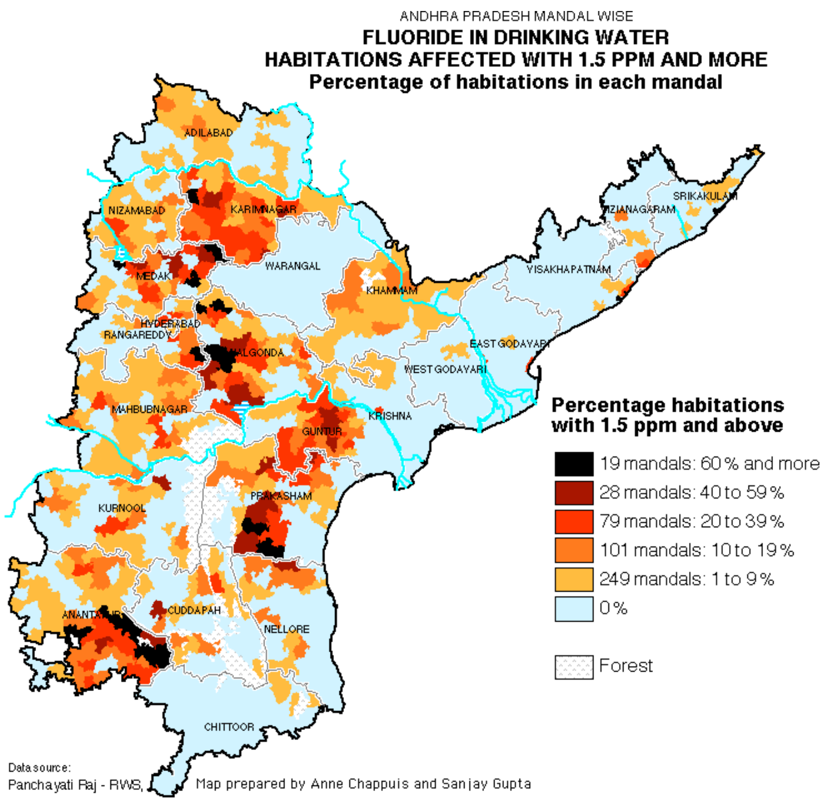
The ground water estimation of the 1229 units in Andhra Pradesh indicates that about 700 units have further potential for future development. Conservative exploitation norms can be applied to about 255 units that utilize less than 30 % of their ground water potential. Another 148 units with utilization between 30 and 50 % have large untapped potentials of ground water. This potential will require systematic planning with the community for maximum water use efficiency. Realistic estimation indicate that another 0.3 million ha is possible to be added through remaining potential of ground water.

The surface water potential and ground water potential are mapped and superimposed for identification of areas for creation of new sources both under ground and surface water. It is expected that only about 600 tmc of leftover surface water is available for future use which will mean about 0.7 million ha additionally as against the estimates made in some quarters projecting more than 2 million ha. Creation of additional capacity anticipating this ayacut may not fulfill the expectations. The additional capacity of 1 million ha (0.7 and 0.3 million ha) will convert to Rs 3000 million per annum at the present rate of water use efficiency.

These estimations are based on appreciation of the fact that most of the untapped ground water potential lies in the command area, forest, upland areas etc. It is therefore presumed that theoretical availability cannot be used for ground water exploitation.

The continued free power for ground water extraction & government support for pumpsets during eighties and nineties of 20th century have led the over exploitation of ground water. This continued over exploitation have led to un-sustainability of agriculture under ground water irrigation. Another serious concern, as a result of over exploitation, is the surfacing of excessive fluoride (beyond permissible limits) in drinking water. These higher concentrations were never reported about 20 years back and even the clinical symptoms were not visible. The extent of problem in Andhra Pradesh is best understood from the map below.

Figure 9

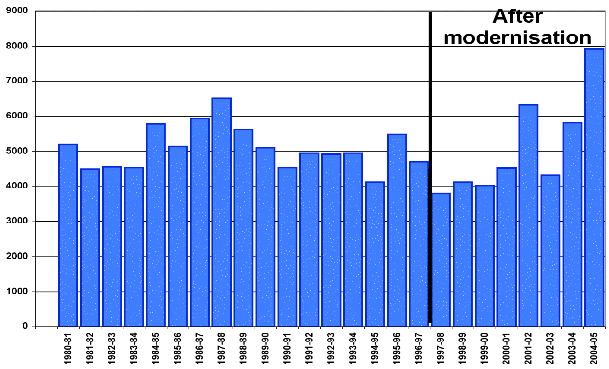


Case study of a major project - K.C. canal

Water use efficiency will be a major issue in the future because of increasing constraints on the availability of water and the huge resources required for investment. The conflicting sectoral demands will further put pressure on water availability for irrigation. Increasing food security and the reduced contribution of agriculture to Gross State Domestic Products will further weaken the irrigation's claim on water[4]. There is also the phenomenon of the industrial base shifting from urban to rural areas. Rural India now contributes more than 40 % of the country's industrial output and also provides employment to roughly the same extent. Shifting the knowledge-based industry to rural areas will serve to further marginalize the role of agriculture in rural India. This will create a stronger lobby for the use of water for purposes other than agriculture. Energy security is emerging as a critical issue for countries, that have achieved food security. In such a situation water demand for hydro electricity will gain importance over agriculture.

All these factors will force planners to invest in improving the efficiency of water use and achieving better returns on investments. A detailed study of a major irrigation project in the southern Indian state of Andhra Pradesh was taken up. The project is known as the Kurnool Cuddappah Project (K.C. canal Project). Constructed during 1863-70 and located in the Tungabhadra river sub-basin of the Krishna river basin, the project is comprised of an anicut across the Tungabhadra river at Sunkesula in Kurnool district, and a 305.65 km long canal across Kurnool and Cuddapah districts of the Indian State of Andhra Pradesh. The command area of K.C. Canal falls in a drought prone area. The created irrigation potential is 70,000 ha in Kurnool district and 37,000 ha in Cuddapah district. Over the decades, the anicut of the K.C. Canal became dilapidated, and the canal system fell into a state of disrepair, resulting in a severe reduction of the conveyance capacity, as well a chronic shortage of water to the tail-ends of the ayacut. This led to conflicts and an extremely difficult situation for water management. The Japan Bank for International Cooperation supported the modernization of the anicut and the lining of the main-canal. This has resulted in the increase of irrigated area from 1600 ha per mcft water to about 3000 ha per mcft. Strengthening of farmers organizations for irrigation management will sustain these efforts and create more livelihood opportunities.

Figure 10: K.C. canal (acres per MCFT)



The K.C. canal system runs over 306 km in two districts and is managed by 94 farmers organizations, better known as Water User Associations (WUA). These WUAs have different areas irrigated under the canals and distributaries. The following map indicates the location of these WUAs along the reach of the canal.

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4 The contribution of agriculture to the gross state domestic product of Andhra Pradesh fell from 30.11 % in 1993-94 to 22.23 % in 2003-04. At an all-India level the contribution slid from 28.39 % to 20.70 % in the same period.

Figure 11

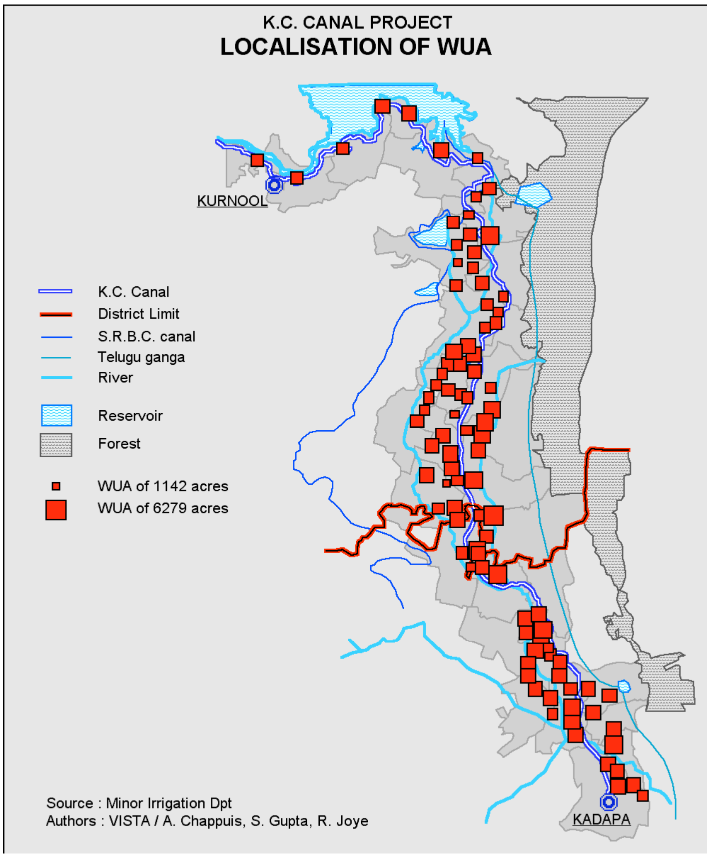
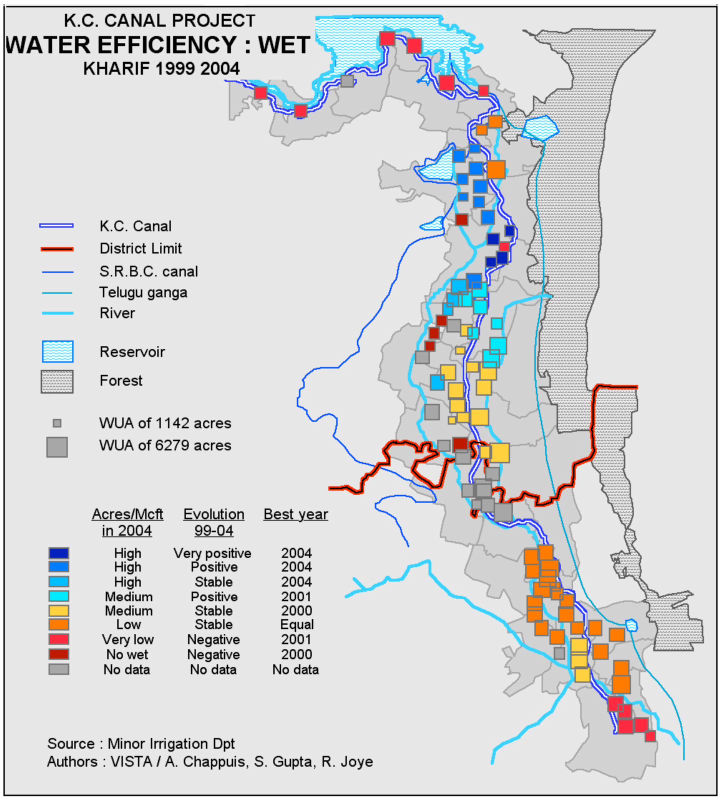


Figure 12



These WUAs have been assigned areas to be irrigated under various kinds of crops during the monsoons (Kharif) and then the winter season (Rabi). The areas authorized, the actual crops raised, and the quantity of water released for the last five years were analysed for two parameters.

- The area irrigated for each unit of water and
- The shift in cropping pattern from wet crops to less water consuming crops

The results are plotted for each WUA on the basis of performance level and evolution over the years. The critical findings are:

- That 14 WUAs are working at a high level of water efficiency and further improving their performance.
- Some of the WUAs are able to maintain a good performance
- Some WUAs, particularly in the upper reaches and in tail-end, are the worst in terms of water-use efficiency.
- There is a shift from wet crops to more water-efficient crops in a number of WUAs.

The results have been shared with project functionaries, and three NGOs are now involved in understanding the differential water use efficiency of different WUAs and are working with farmers on agricultural productivity for optimizing agricultural returns.

A concept of model Farms & Farmer Field school is introduced. Four to five WUAs are loosely federated at Farmer Field School (FFS). These FFS are facilitated by NGOs and provide critical support on technology, marketing and credit linkage, etc. Model Farms cover three or four FFS & demonstrate technological options, farm mechanization and other innovation through information technology linkage.

The Future Options

The increasing limitation on expansion in the irrigation sector and under-performing assets created provides a strategic opportunity to assess the prospects for improving the performance of the existing irrigation infrastructure. The introduction of institutional and agricultural reforms could, if properly implemented, provide generous returns. This would require the participation of primary stakeholders for the mobilization of resources for operation and management of the systems. Simultaneously, the capacity of departmental officials in this changed institutional setup would have to be developed. This is a broad policy issue that needs to be followed up through detailed processes at the field level.

Policy for the entire minor irrigation sector as a whole, both minor irrigation tanks and ground water, is a primary requirement. The coordinated planning and management of ground water and surface water is an imperative for the restoration and creation of new sources, as we will point out further on in this article. In-depth analysis of the availability and exploitation of surface and ground water reveals the regional imbalances that exist in nature. These imbalances are also a consequence of poor social and political empowerment and of private investment and lack of entrepreneurship.

Rough calculations provide us with an idea of the potential of water in Andhra Pradesh available for the agricultural sector. The present usage of 1753 tmc water by the major, medium and minor irrigation sectors provides an ayacut of 2.2 mha. This works out to an area of 1259 ha per tmc of water. This loss, due to inefficiency of water use, is practically equal to the annual investment and is, therefore, a significant amount and serious cause for concern. Opportunity and obsolescence make these losses much more significant. **Improving system efficiencies is therefore a crucial requirement preceding any other investment**. This improvement may require a major structural change of institutions and supporting policies among others like the management turnover etc.

Investment in deficit basins for the creation of new storage structures will not add to the total ayacut in the state and will merely shift the ayacut from one place to other.

Political intervention and decision making in the absence of a proper understanding of all the facts may lead to unproductive investment in new structures and the creation of potential far beyond actual capacity or water availability. Evolution of irrigation sources indicates a trend in the southern Indian plateau. Historically, water was harvested through tanks and tanks were the major source of irrigation. Big dams became the temples of modern India after independence. This led to the decline of tank based irrigation systems. The bore-well technology of the late seventies revolutionized the face of rural India through the creation of irrigation opportunities in hitherto impossible areas. Government support for energy and hardware facilitated the exponential growth of bore-well based ground water irrigation. This also broke down the community based management systems of the tanks, and groundwater took over from tanks as the source of irrigation. Irrigation through ground now accounts for more than 2.5 million ha as opposed to the 2.2 million ha from all the other projects put together. Free power and easily accessible technology led to the spread of ground water irrigation beyond anything that could be considered sustainable. A number of regions became "dark" meaning thereby that the extraction was, and still is, more than the recharge.

Figure 13

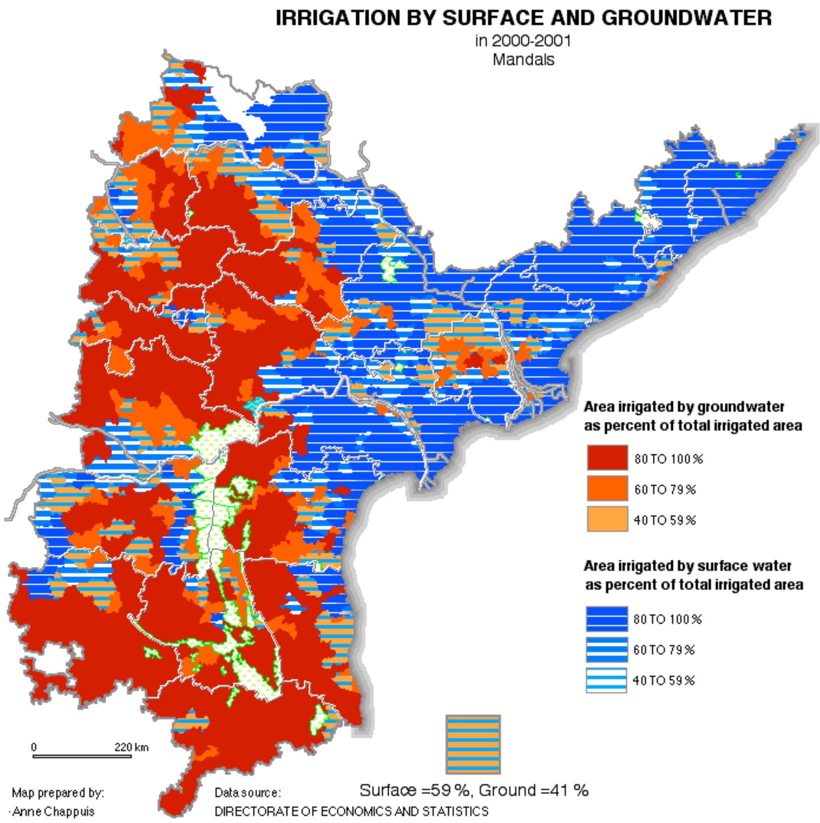
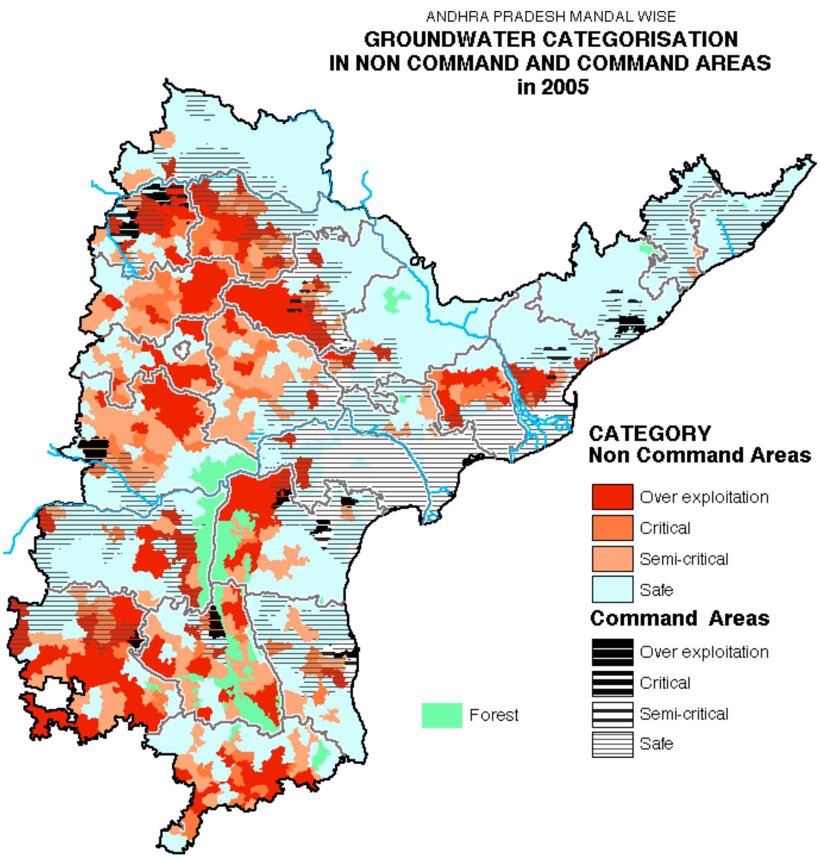


Figure 14



Figures 13 and 14 show source wise irrigation and areas with ground water concerns. The overall picture of ground water availability and utilization at the state level indicates availability of ground water for future utilization. However, closer analysis reveals that the so-called potential exists only in the command areas of major irrigation projects, forest areas, upland areas or other unsuitable areas. Therefore, planners need to be careful in projecting future demands, supplies and resource mobilization.

Future Tasks

1. Water sector institutions and support mechanism
2. Priortisation of areas and convergence with other departments
3. Sub-Mission for water use efficiency and agriculture productivity
4. Community participation and management transfer.

The Government of Andhra Pradesh has prioritized reforms and investments in the water sector, particularly irrigation, as one of the main development issues. The reforms cut across the various issues in the sector and are broad based in order to be effective. The ultimate objective will be to maximize the gain from water and agriculture. The main reform agenda covers the following issues:

1. Action Research, Piloting and Inter/ Intra Departmental convergence (including agriculture universities and research institutes) leading to governance reforms in irrigation.
2. Irrigation Department as a driver/ manager of water policy and concentrating on water as a platform of convergence for poverty eradication, with a focus on Livelihoods approaches.

3. Information technology-based network for information dissemination and a network of Farmers Field School, Model Farms, NGOs for better market access to farmers

Specific activities for reform in the irrigation sector include:

1. Community Mobilisation and emerging existing Water Users Associations, Self-help Groups and other Community Based Organisations (CBO), their networks, building new CBO, where they are absent, synergizing various CBO on water platform.
2. Capacity Building for social capital, consolidating Common Property Resources, NRM and water resources as focuses of social convergence, development and poverty eradication.
3. Creating spaces, roles and rights for marginal farmers, the landless and poor with a stress on gender issues.
4. Institutionalising community level management of Water resources and creating awareness about Water Use Efficiency, Productivity, Water Quality and managing conflicts.
5. Establishment of model/pilot farm and coordination of exposure visits.
6. Creation of Farmers Field School with farmers as trainers for other farmers and creation of a network of farmer learning centers for pooling experiences and consolidating learning
7. New agricultural practices, cropping patterns and value additions including post-harvest processing.
8. Aproject area convergence centre for coordinating inputs of different departments and agencies, and facilitating the evolution of 'Irrigation Engineers' into 'Water Resources Managers'.
9. Linking all of the above with nodal organisations such as those in water and land management, as well as with sectoral and Departmental stakeholders in water resources to enable 'Bottom-up' policy components. It would also be important to benchmark the best and most effective practices for the state's water security.
10. A Sub-project for Livelihoods, focusing on the landless, poor and women.

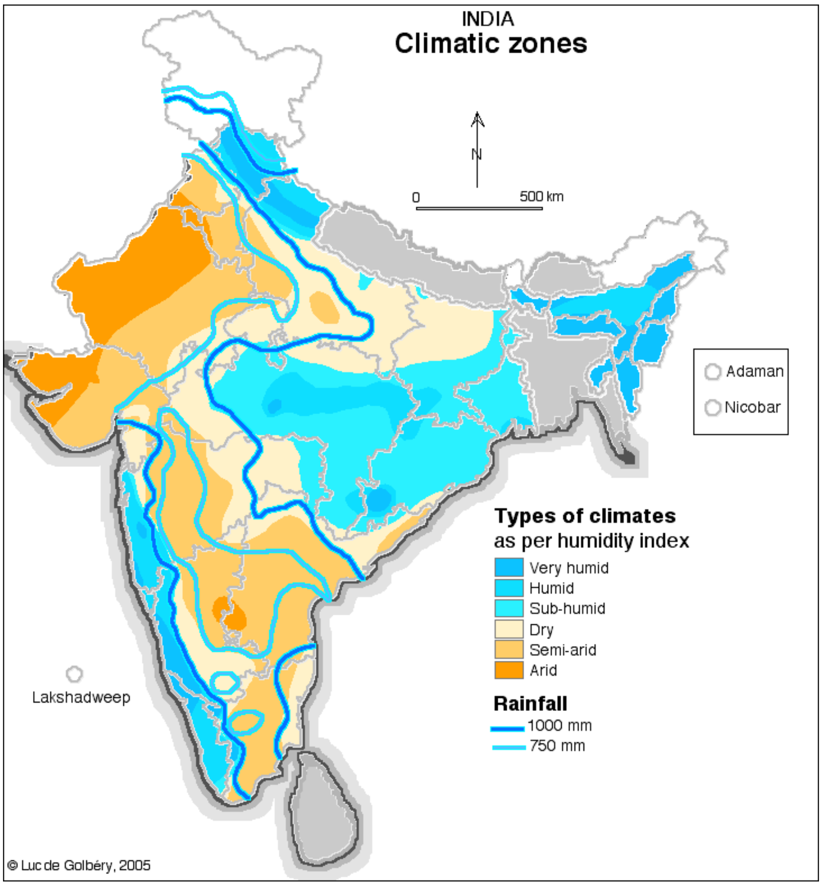
Poor irrigation system efficiencies translates into a loss of potential income comparable to present investment.

The depletion of ground water sources has reverted the attention back to tanks and community management system. Planners need to identify and support these traditional community based systems rather than invest in new structures without assessing resources, or create new sources only without community based management system in place. Similarly an equal priority need to be accorded to the revival and restoration of traditional structures along with the traditional management system.

Annexes

I. ANDHRA PRADESH: POPULATION (2001 CENSUS)

Sl. No	Particulars	Persons/ Male/ Female	Total	Rural	Urban
1	Population (No.in Lakhs)	Persons/	762.10	554.01	208.09
		Male/	385.27	279.37	105.90
		Female	376.83	274.64	102.19
2	Decennial Growth Rate (1991 -2001)		14.59	13.94	16.34
3	0-6 Population (In Lakhs)	Persons/	101.72	76.22	25.50
		Male/	51.87	38.83	13.04
		Female	49.85	37.39	12.46
4	Literates (7 yrs & above) (in lakhs)	Persons/	399.35	260.42	138.93
		Male/	234.45	157.20	77.25
		Female	164.90	103.22	61.68
5	Sex Ratio (Females per 1000 Males)		978	983	965
6	Density (Persons per Sq.Km)		277	205	4645
7	Proportion of Urban/Rural Population to the total population	%		72.7	27.3
8	Area in Sq.Kms		275069	270589	4480
9	Proportion of Urban Population to the total area of the State			98.37	1.63
10	Number of Districts	No	23	-	-
11	Number of Towns	No	210	-	-
12	No.of Urban Agglomerations	No	37	-	-
13	Number of Mandals	No	1127	-	-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as per humidity index
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Dry
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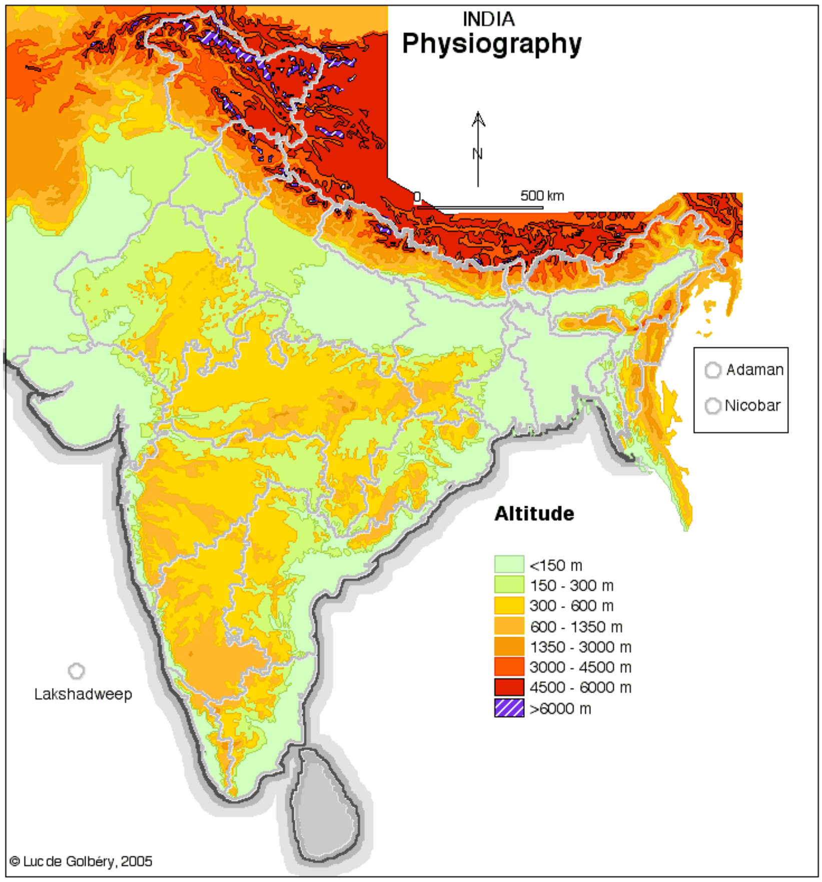
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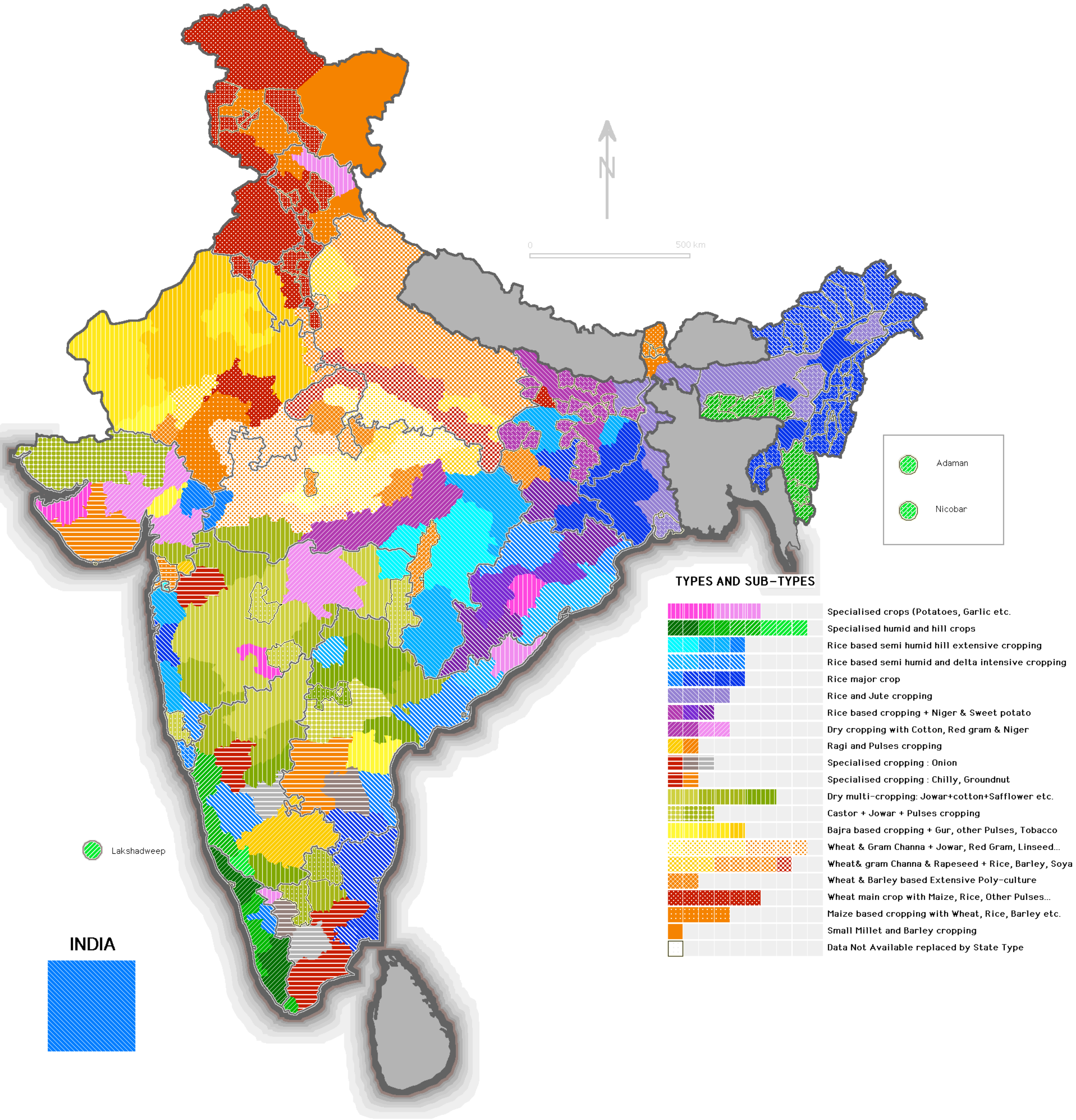
0
500 km
Adaman
Nicobar
Altitude
<150 m
150 - 300 m
300 - 600 m
600 - 1350 m
1350 - 3000 m
3000 - 4500 m
4500 - 6000 m
>6000 m
Lakshadweep
© Luc de Golbéry, 2005

INDIA'S AGRICULTURE 1982

THE MAJOR TYPES OF CROPPING PATTERN

DISTRICT WISE



L. de Golbéry, 2005

Source: CSO 1997

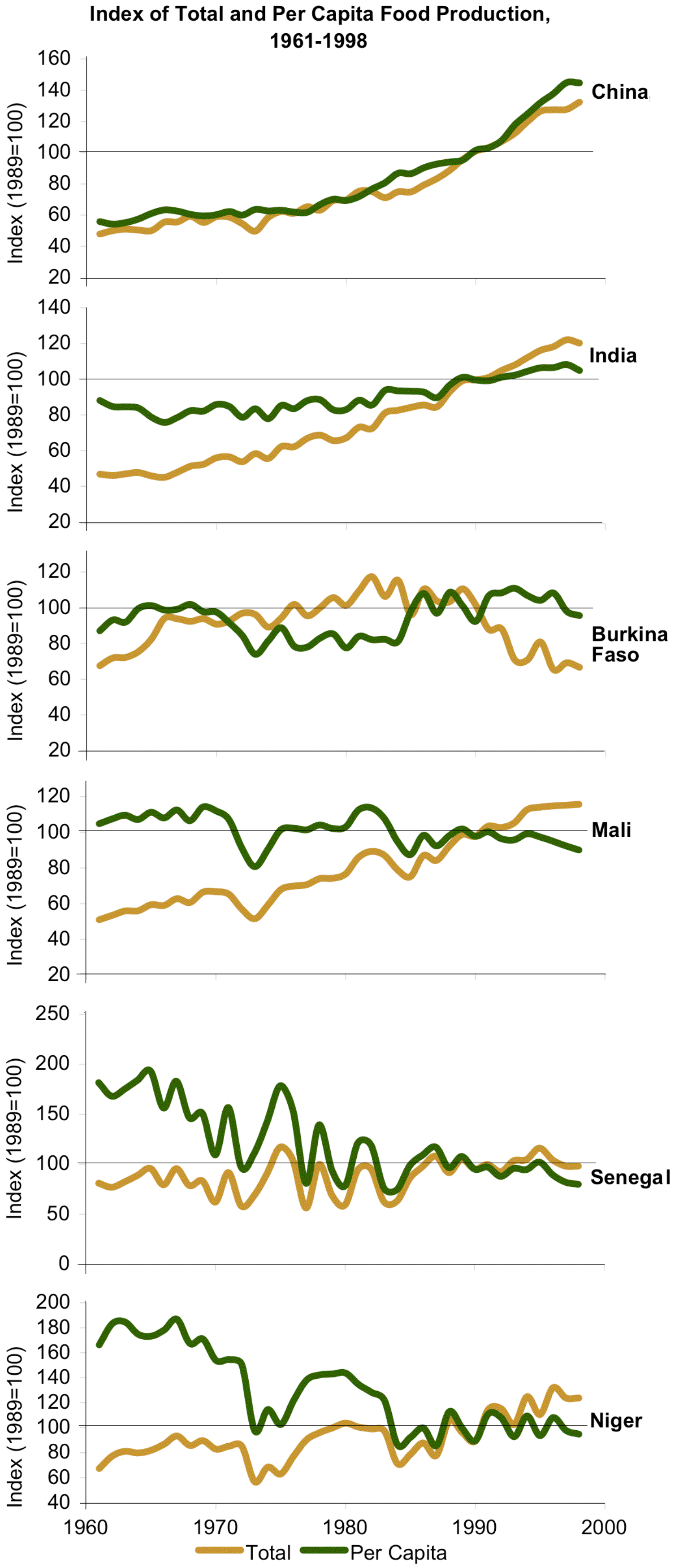
II. ANDHRA PRADESH: AGRICULTURE, 2003-2004

Sl.No	Particulars	Production in '000 tonnes	Area in '000 Ha.
1	Rice	8943	2975
2	Jowar	743	648
3	Redgram	218	521
4	Groundnut	986	1493
5	Cotton	1890*	837
6	Sugarcane	1504	209
7	Tobacco	196	133
8	Chillies	797	250

*(Bales of 170 Kgs. Lint)

III. ANDHRA PRADESH: Yields of Principal Crops

Sl.No	Particulars	Units	2003-04
1	Rice	in Kgs/Ha	3011
2	Jowar	in Kgs/Ha	1145
3	Groundnut	in Kgs/Ha	418
4	Cotton	in Kgs/Ha	660
5	Sugarcane	in Kgs/Ha	72115
6	Tobacco	in Kgs/Ha	1475



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