

Green Accounting for Indian States Project

Monograph 2



Estimating the Value of Agricultural Cropland and Pastureland in India



Deutsche Bank



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GAISP (Green Accounting for Indian States Project)

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List of acronyms

CSO	Central Statistical Organization
EPIC	Erosion productivity index calculator
ESI	Environmental sustainability index
GAISP	Green Accounting for Indian States and Union Territories Project
GDP	Gross domestic product
GHG	Greenhouse gas
GSDP	Gross state domestic product
GCF	Gross capital formation
HDI	Human development index
NAEB	National Afforestation and Eco-development Board
NBSSLUP	National Bureau of Soil Survey and Land Use Planning
NRSA	National Remote Sensing Agency
NSDP	Net state domestic product
SEEA	System of Integrated Environmental and Economic Accounting
SNA	System of National Accounts
SPWD	Society for Promotion of Wastelands Development
USLE	Universal soil loss equation

Estimating the value of agricultural cropland and pastureland in India

Background

Like most developing nations, India faces many trade-offs in its attempts to reduce poverty and improve the living standards of its people. There is a need for an empirical basis on which to base policy decisions on the trade-offs between the many competing priorities of a developing nation, including intergenerational claims — trade-offs between the needs of present and future generations. Available mechanisms and measures of development, including the current SNA (system of national accounts) with its primary focus on GDP (gross domestic product) growth rates, do not capture many vital aspects of national wealth such as changes in the quality of health, changes in the extent of education, and changes in the quality and extent of India's environmental resources. All these aspects have a significant impact on the well-being of India's citizens generally, and most of them are critical to poverty alleviation in providing income opportunities and livelihood security to the poor. GDP accounts and their state-level equivalents GSDP (gross state domestic product) accounts are, therefore, inadequate for properly evaluating the trade-offs encountered by India's policy-makers.

The GAISP (Green Accounting for Indian States and Union Territories Project) was launched in 2004 largely in recognition of the reality that the available yardsticks (in particular, 'GDP growth percentages') are substantially misleading as measures of either growth or development, wealth or well-being, and nevertheless, they continue to be used extensively and often exclusively by planners, policy-makers, businesses, and the media. GAISP proposes to build a framework of adjusted national accounts that represents genuine net additions to national wealth. These are sometimes referred to in literature as 'Green Accounts'. Such a system of environmentally adjusted national income accounts will not only reflect, in economic terms, the depletion of natural resources and the health costs of pollution, but will also reward additions to the stock of human capital through education. Thus, we hope that 'Green Accounts' will provide a more holistic measure of development, welfare, and wealth than GDP (national income) and GSDP (state income) growth percentages. They will thus enable and encourage the emergence of sustainable development as a focus of economic policy at the operative state level. Other indicators and indexes such as HDI (human development index) and ESI (environmental sustainability index) provide qualitative measures of sustainability; however, only Green Accounting can quantitatively answer the question: 'is this economy sustainable or not?'

GAISP aims to set up 'top-down' economic models for state-wise annual estimates of adjusted GSDP for all major Indian state and union territory economies. A top-down or macroeconomic approach is adapted to model adjustments to GDP/GSDP accounts, for two reasons. Firstly, it

has the advantage of providing a consistent and impartial national framework to value hitherto unaccounted aspects of national and state wealth and production. Secondly, it optimizes existing research, which is already extensive, albeit not yet tied together in a manner that makes it useful for policy analysis. The publication of the results and methodology of GAISP will provide a much improved toolkit for India's policy-makers to evaluate in economic terms the trade-offs faced by the nation. They will also enable policy-makers and the public to engage in a debate on the sustainability of economic growth, both at the national level as well as through interstate comparisons.

The first phase of GAISP consists of eight monographs, each of which will evaluate a particular area or related set of areas of adjustments to GSDP accounts.

These eight monographs are as follows.

- 1 The value of timber, carbon, fuelwood, and non-timber forest produce in India's forests (published in February 2005)
- 2 Estimating the value of agricultural cropland and pastureland in India (the current paper)
- 3 The value of India's sub-soil assets
- 4 Eco-tourism and biodiversity values in India
- 5 Estimating the value of educational capital formation in India
- 6 Investments in health and pollution control and their value to India
- 7 Estimating the ecological values of India's forests: water augmentation, soil conservation, and flood prevention
- 8 Estimating the value of freshwater resources in India

All adjustments calculated in the above eight GAISP monographs apply to the same set of GSDP accounts (viz., for year ended March 2003) and they are all additive. The website of GAISP (<http://www.gistindia.org>) will carry a running record of cumulative state-wise adjustments to these GSDP accounts. To a first-order approximation, these adjustments may be added/subtracted, as indicated, to GSDP growth percentages for the year 2002/03.

The final report of GAISP will summarize and consolidate the work done on these eight monographs and will include 'adjusted GSDP' measures for the states and significant union territories in India, as well as a commentary on the policy implications of our results.

Estimating the value of agricultural cropland and pastureland in India

Introduction

Agricultural land, constituting 57% of the geographical area of India, contributed around 20% to the total GDP in India for the year 2002/03. In SNA, agricultural land is treated as a non-produced economic asset, which provides economic benefits to its users. This is one of the several uses to which land is put, and forms a significant part of the total wealth of the nation. The economic activities considered under 'agriculture' in SNA include (1) growing of field crops, fruits, nuts, seeds, and vegetables, (2) management of tea, coffee, and rubber plantations, (3) agricultural and horticultural services on a fee or contract basis, such as harvesting, baling and threshing, preparation of tobacco and other agro products for marketing, pest control, spraying, pruning, picking, and packing, and (4) ancillary activities of cultivators such as making *gur* (raw cane sugar), transportation of produce to primary markets, and activities yielding rental income from farm buildings and farm machinery and interest on agricultural loans.

The contribution of the agricultural sector¹ to India's GDP has decreased from 50% in 1951 to 20% in 2003, which largely reflects India's modernization and urbanization over this half century. During this period, the contribution of manufacturing and utilities grew from 15% to 24%, and the contribution of services (the so-called 'tertiary sector') grew from 29% to 51%. The agricultural sector has, however, seen considerable transformation during this period such as an increase in the use of fertilizers, pesticides, irrigation, better-quality seeds, etc. From Figures 1a and 1b, we can see that the quantity of pesticides and fertilizers consumed per tonne of food grain produced has increased manifold, whereas the gross area sown has increased at a very slow rate. However, the benefits of inputs such as fertilizers, pesticides, and irrigation often have more damaging off-farm effects (on the quality of downstream water, soil quality, groundwater potability, human health, and biodiversity) in the long run than the short-run on-farm benefits.

Fertilizers supplement the soil with nutrients but do not supply organic matter, thereby lowering its water-retention capacity. This leads to soil compaction, increased run-off, and loss of soil. Another major problem of fertilizer use is leakage/run-off into surface water and groundwater, which has serious environmental consequences such as eutrophication (nitrogen and phosphorus over-concentration due to fertilizer run-off / leaching). Eutrophication leads to explosive growth of algae, oxygen depletion, death of fish, and loss of biodiversity. Furthermore, the contamination of groundwater has serious health impacts because the

¹ Including the allied activities such as livestock and irrigation.

Figure 1a
Yield, fertilizer use, and
pesticide use over the last
50 years

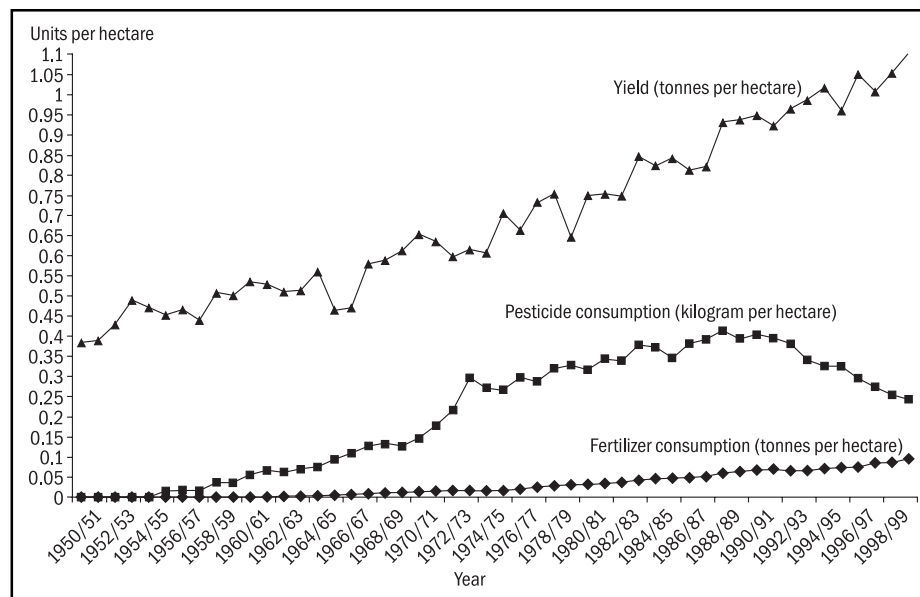
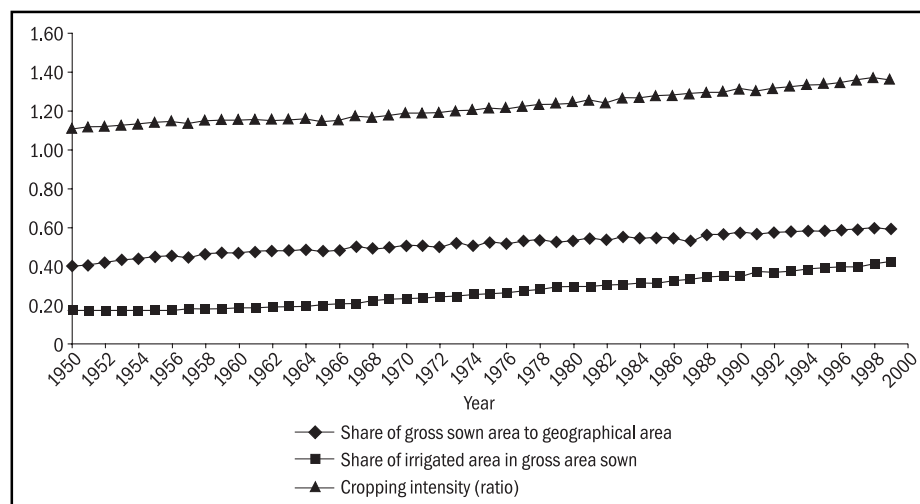


Figure 1b
Cropping Intensity, share
of irrigated area in gross
area sown, and share of
gross sown area to
geographical area



majority of India's population uses groundwater as a source of drinking water.

The most detrimental impact of pesticide use is on human health and ecology. Human beings indirectly consume pesticides either through the consumption of fish/shellfish/agricultural products that are contaminated with pesticides or through direct consumption of pesticide-contaminated water, which poses serious health hazards. The ecological effects of pesticides (and other organic contaminants) are varied and are often interrelated. Many of these effects are chronic and often go unnoticed, yet they can affect the entire food chain. Some of these effects range from the death of the organism to the thinning of eggshells and loss of biodiversity. In addition to the effects of fertilizers and pesticides, irrigation of agricultural lands also causes environmental problems.

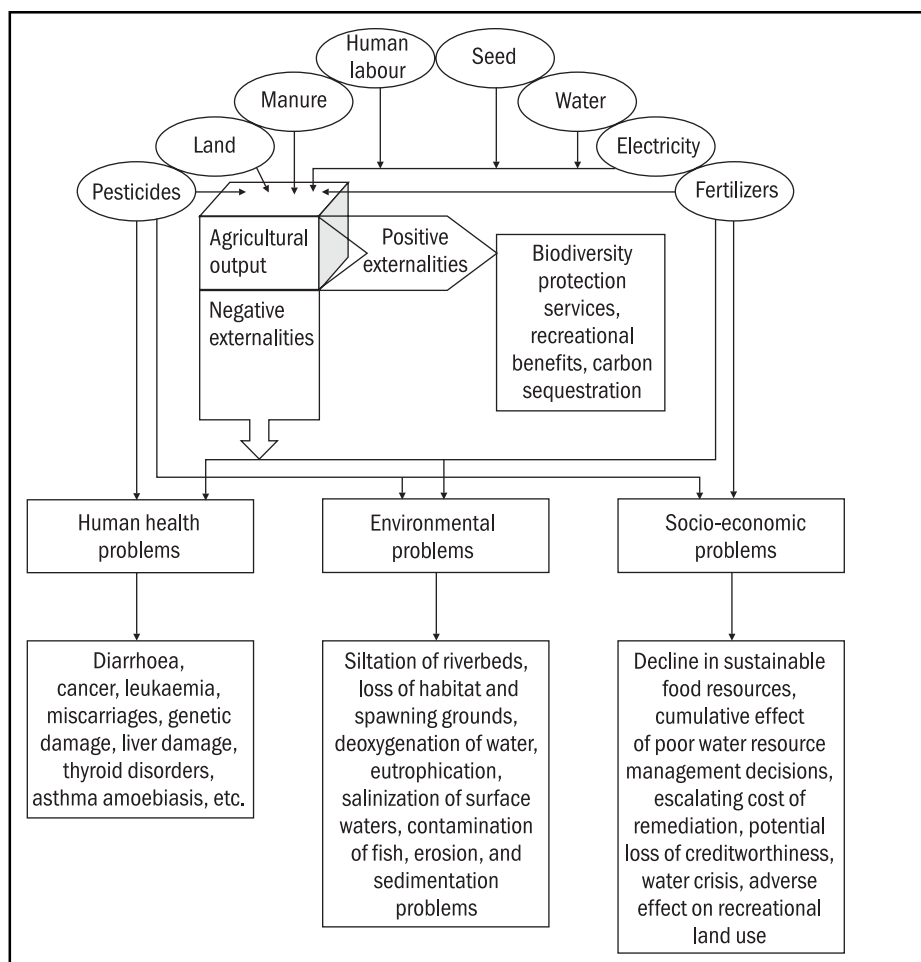


Figure 2

Agricultural impact on environment

Source Authors' compilation

Irrigation results in waterlogging, desertification, salinization, erosion, etc. and may also cause downstream degradation of water quality by salts, agrochemicals, and toxic leachates (Figure 2).

In addition to the impact of pesticides, fertilizers, and irrigation on the environment, agriculture can also have positive externalities (Figure 2). These generally include recreational and biodiversity benefits, although these may be questionable in the Indian context. In developed economies with temperate climates, the attraction of 'farm and field' living is widespread, both as a lifestyle choice and as a tourist destination. The same cannot be said for India, where lack of attendant amenities and infrastructure prevents agricultural locales from attracting either tourism or residential interest. Furthermore, biodiversity benefits of agriculture are offset by losses in forest biodiversity due to farming and grazing pressures. On the other hand, agricultural biomass and soil act as a sink for carbon dioxide, via carbon fixing in the biomass, and this type of carbon storage is a positive externality.

Thus, it is clear that economic use of land is often connected with short- or long-term processes of deterioration (or improvement). In order to get a better understanding of the relationship between economic activities and the environment, we need to consider both the use of land by different economic activities and the potential of land from an ecological point of view. This helps in assessing the sector's net contribution to the economy, analysing whether the sector is growing sustainably and identifying the corrective measures to be taken if growth is unsustainable. However, the aggregate statistics do not show any alarming signal because most of the problems relating to agriculture are micro-level and cannot be reflected at the macro level. Hence, there is a need for revising macro level estimates in order to have an improved understanding of the economic implications of the sector's impact on environment.

Objectives

The main aim of this study is to develop an accounting framework that reflects the real contribution of agricultural land and pastureland to society. The more specific objectives are to

- 1 estimate the value of the stocks and flows of agricultural land and pastureland;
- 2 incorporate the loss in value caused due to depletion of agricultural and pastoral resources into the national accounts; and
- 3 estimate the impact of the sector on the degradation of the environment and thereby estimate the sector's real contribution to the economy.

While estimating the degradation of the environment, we mainly considered the impact of agricultural production on land degradation, soil erosion, and sedimentation of waterways. Although we recognized the fact that agricultural activity has several other externalities such as chemical pollution and falling water tables, these are outside the scope of this monograph and will be dealt with in other monographs. Furthermore, we did not address the negative impact of the production of inputs like fertilizers/pesticides. Our study looks at various states in India and mainly relies on secondary data.

Literature review

Several studies exist in other countries on agricultural accounting. Adger and Whitby (1993) adjusted the national accounts of the UK (United Kingdom) for the 'land-use sector' as a whole. The study showed that the adjusted NDP (net domestic product) was larger than the conventional NDP due to net appreciation of natural capital outweighing degradation. Adger and Whitby (1996) estimated the value of asset changes in the UK agricultural sector in order to discuss the contribution of agriculture to net wealth creation. Another study by Pretty, Brett, Gee, *et al.* (2000) estimated the externalities without incorporating them into a set of revised accounts. Their study estimated the damage to natural capital

such as water, air, soil, biodiversity, and landscape, and to human health due to pesticides, nitrates, microorganisms, and other disease agents. The total damage due to agriculture was estimated to be in the range of 1149–3907 million pounds. Hartridge and Pearce (2001) adjusted the national accounts in the UK for the year 1998 (after adjusting for pre-vailing subsidies) for the negative and positive externalities of agriculture in the UK. They found that the negative externalities amounted to at least 1072 million pounds, while the positive externalities (due to the amenity value of agricultural countryside, excluding non-use values) offset approximately one-half of these negative effects. The study argued that if the subsidies were removed, the sector would contract and the configuration of externalities would differ. A study by Atkinson *et al.* (Eftec 2004) estimated the economic value of the positive environmental services provided by agriculture as well as the negative service flows resulting from depreciation of natural assets for the UK. The study systematically considered environmental services and sink functions impacted upon by agriculture according to key impact headings such as water, air, soil, landscape, habitats and species, waste, nuisance, resource use, etc. The study used the DPSIR (driving forces, pressures, state of the environment, impact on final end points, and policy responses) framework. The economic value of an environmental impact is estimated using data on household preferences for that impact. Preferences are measured by people's willingness to pay for environmental goods and services.

While all these studies were done for the UK, some studies exist for other countries as well. Some studies like Tiezzi (1999) for Italy; Bonnieux, Rainelli, and Vermersch (1998) and Le Goffe (2000) for France; and Hrubovcak, LeBlanc, and Eakin (2000), Smith (1992), and Steiner McLaughlin, Faeth *et al.* (1995) for the USA attempted to address this issue. However, not all the studies aimed at adjusting the national accounts.

Hrubovcak, LeBlanc, and Eakin (2000) developed a theoretically consistent framework to incorporate the environmental effects of agricultural production and the depletion of natural capital caused by agricultural production into the existing national accounts for the USA. Using theoretical framework, the study estimated the adjustments to the income attributed to agriculture to be 3.9 billion dollars in 1982, 4.2 billion dollars in 1987, and 4.4 billion dollars in 1992. These adjustments to net income attributed to agriculture range from six per cent to eight per cent of the total net income, and the relative share of adjustments to the net income attributed to agriculture decreased during 1987–92. Smith (1992) in his work on environmental costing considered the off-site effects of soil erosion, wetland erosion, and groundwater contamination caused due to agricultural activities in each of the 10 crop-producing regions in USA and estimated the environmental costs relative to the value of crops produced in 1984. His estimates ranged from 0.08% to 40% of the value of crops per acre on land deemed

responsible for these impacts. Tiezzi (1999) estimated the aggregate value of external effects from agriculture for three provinces in Italy for the period 1961–91. The negative external effects considered included emissions of chemical and organic fertilizers into the environment, determination of air pollution, ground and surface-water pollution, and oil contamination. The analysis was done for three regions in Italy. It was found that the value of external effects from the use of chemical and organic fertilizers amounted to around 0.4% of the total Italian value added nationally. Different studies followed different frameworks and there is no standardized framework. The United Nations SEEA (System of Integrated Environmental and Economic Accounting) has a suggested framework for land use accounting, of which agriculture is one. However, several issues were left unaddressed by SEEA like accounting for the damages caused to other sectors due to agriculture. In SEEA, five major types of land resources are distinguished: (1) land underlying buildings and structures, (2) agricultural land and associated surface water, (3) wooded land and associated surface water, (4) major water bodies, and (5) other land. However, we based our analysis on a nine-fold classification of land drawn from a standard system used by the Department of Agriculture, Government of India.

A study by Brekke, Iversen, and Aune (1999) estimated Tanzania's soil wealth, focusing extensively on soil mining. The estimates suggested that the value of the eroded soil amounted to 12%–17% of the value of the Hicksian income, and the savings required for maintaining consumption amounted to 13%–29% of the contribution to the GDP. The study indicates that the potential gains from change in agricultural management are considerable. A study by Francisco and de Los Angeles (1998) presented the results of the damage function for soil loss using a 20-year data projected through the application of EPIC (erosion productivity index calculator) in one soil conservation project site in the Philippines. A study by Reddy (2003) for India measured the extent of damage due to land degradation of various types and their expected trends. It also explored the linkages between degradation and policy and the institutional environment in the context of the agro-climatic regional planning.

Profile of agricultural land and pastureland in the study area

Agriculture in India is the means of livelihood for almost two-thirds of the work force in the country and it has always been India's most important economic sector. Based on the nine-fold classification of land use, of India's reported geographical area of 306.2 million ha (hectare) for land utilization statistics, about 22.6% of the land is forested, 46% is cultivated, 7.7% is put to non-agricultural uses, 6.2% falls under barren and uncultivable land, 3.6% is under permanent pastures and grazing lands, 1.2% is under miscellaneous tree crops and groves, 4.5% is cultivable waste, 3.3% is fallow land other than current fallow, and 4.8% land is under current fallow (Table 1). The nine-fold classification is primarily based on whether a particular area is cultivated, grazed, or forested and is based on actual use and not on how a particular piece of land can be potentially utilized (Annexure I).

Table 1

Land-use classification in different states (2000/01) ('000 hectares)

State	Geographical area	Reporting area for land utilization statistics	Land under forests	Area put to non-agricultural uses	Barren and uncultivable land	Permanent pastures and other grazing land	Land under misc. tree crops and groves	Cultivable waste land	Fallow lands, other than current fallow	Current fallow	Net area sown
Andhra Pradesh	27507	27440	6199	2624	2100	675	269	728	1417	2312	11115
Arunachal Pradesh	8374	5498	5154	5	21	4	36	37	47	30	164
Assam	7844	7850	1932	1070	1461	163	234	80	65	110	2734
Bihar	17388	17330	2949	2430	1010	105	344	321	922	1811	7437
Goa	370	361	125	37	—	1	1	55	—	—	141
Gujarat	19602	18812	1865	1141	2604	849	4	1982	13	911	9443
Haryana	4421	4402	115	368	102	34	7	19	—	232	3526
Himachal Pradesh	5567	4547	1094	314	807	1529	57	124	13	54	555
Jammu and Kashmir	22224	4505	2747	291	291	126	72	140	8	81	748
Karnataka	19179	19050	3068	1312	794	959	303	427	409	1367	10410
Kerala	3886	3885	1082	382	29	—	15	59	34	78	2206
Madhya Pradesh	44345	30755	8655	1889	1349	1585	20	1201	575	818	14664
Maharashtra	30771	30758	5296	1301	1696	1341	226	903	1171	1189	17636
Manipur	2233	2211	602	26	1419	—	24	—	—	—	140
Meghalaya	2243	2227	951	87	136	—	155	441	162	65	230
Mizoram	2108	2109	1626	—	16	23	31	127	156	36	94
Nagaland	1658	1589	863	66	—	—	125	65	79	91	300
Orissa	15571	15571	5813	999	843	443	482	392	430	340	5829
Punjab	5036	5033	305	327	55	7	10	25	4	38	4264
Rajasthan	34224	34265	2606	1740	2566	1707	14	4908	2444	2415	15865
Sikkim	710	710	257	97	173	69	5	1	9	4	95
Tamil Nadu	13006	12991	2134	1986	476	123	255	352	1228	1134	5303
Tripura	1049	1049	606	131	3	—	27	1	1	1	280
Uttar Pradesh	29441	29767	5155	2579	920	292	572	872	730	1034	17612
West Bengal	8875	8688	1190	1567	27	4	57	37	29	358	5417
Andaman and Nicobar Islands	825	793	695	22	2	4	16	12	3	1	38
Chandigarh	11	7	—	4	1	—	—	—	1	—	2
Daman and Diu	11	10	—	1	2	—	1	2	—	—	4
Dadra and Nagar Haveli	49	49	20	4	—	1	—	—	1	1	23
Delhi	148	147	1	77	13	—	1	10	7	4	34
Lakshadweep	3	3	—	—	—	—	—	—	—	—	3
Pondicherry	48	49	—	15	0	0	1	4	3	1	24
India	328726	306249	69407	23569	19259	10897	3366	13660	10191	14799	141101

Note For standard definitions of various categories of land use adopted in the land utilization statistics, refer to Annexure I.**Source** www.indiastat.com

The agricultural land resources in India suffer from indiscriminate conversions. As forestlands give way to agriculture, so do farm lands to industrial and urban expansion. These conversions are largely offshoots of the industrialization effort in India. With commercial and industrial development offering immediate and more profitable returns, converting agricultural lands to industrial uses has escalated. In terms of per capita availability, the availability of land has declined from 0.89 ha in 1951 to 0.3 ha in 2001; the per capita availability of agricultural land has declined from 0.48 ha in 1951 to 0.14 ha in 2001. Besides the pressure of human population, there are about 500 million cattle and other livestock living off the biomass from the land.

Till the 1970s, agricultural productivity was very low. However, after that 1970s, there was a huge increase in India's agricultural production due to the Green Revolution. An increase in agricultural production has been brought about not merely by bringing additional area under cultivation, but by the extension of irrigation facilities, use of better seeds and better agricultural techniques, water management, and plant protection. The general perception is that the key causes for the success of the Green Revolution were better genetic material with higher production potential and better ability for nutrient uptake, higher demands on irrigation (which were met), improved cultivation practices, and, of course, higher profitability which led to area expansion. The percentage of land irrigated increased from 17% of the gross cropped area in the 1950s to 41% in 2000 (Figure 1b). Along with the area under irrigation, the composition of irrigation has changed over time, especially in the recent years. The proportion of area under canal and tank irrigation has declined while that under well irrigation has gone up substantially. The increase in the area under well irrigation coupled with the decline in tank irrigation invariably results in overexploitation of groundwater, resulting in environmental problems such as waterlogging and increased soil salinity on the one hand and desertification on the other hand. The foodgrain production in the country increased from 50 MT (million tonnes) in the 1950s to 209 MT in 2001. Along with this, India's fertilizer consumption increased from 0.3 million tonnes in the 1960s to 16 million tonnes in 2001 and the pesticide consumption increased from 2353 tonnes in the 1960s to 48 350 tonnes in 2001.

This increase in the use of fertilizers, pesticides, and irrigation has also caused serious environmental degradation. It is estimated that about 174 million ha of land (around 53%) suffers from different types and varying degrees of degradation (Table 5). Around 800 ha of arable land is lost annually due to the ingress of ravines. An estimate by NBSSLUP (National Bureau of Soil Survey and Land Use Planning) (1990) indicated that the average loss of topsoil due to erosion is 19.6 tonnes/ha. All this has a direct bearing on the food production and the livelihood of the people. This is because unlike other countries, which have considerable scope for bringing new area under cultivation, India has very limited scope for the extension of cultivation to new lands. Already, about 49.7% of the total reported area is cultivated, although cultivable land, which is not cultivated at present (cultivable wasteland and other fallow lands, permanent pastures and grazing lands, and miscellaneous tree crops), is estimated at about 42 million ha (around 13.6% of the total). However, most of this area comprises marginal and sub-marginal lands and the extension of agriculture into this area will be costly, as it requires extensive work for soil and water conservation, irrigation, and reclamation.

Framework for accounting

First, we suggest a consistent framework for physical and monetary accounts (land cover, land use, and production) for different states and union territories in India. We assess the period 1992/93 to 2000/01 to see how land use and land cover changed over the 10-year period. A 10-year time frame is considered because land degradation occurs slowly, and such a time period can sufficiently capture these changes. Finally, we annualize our results to the annual loss due to degradation by applying a ‘straight line’ method. By accounting for land resources, we also account for the soil resources on land because the value of land depends on whether or not the soil is fertile. It is not possible to separate land accounts from soil accounts. Hence, we consider both land as well as soil in our paper.

Physical accounts

Our framework is very similar to the SEEA framework. The physical accounts for agricultural and pastoral lands under the SEEA framework include items such as opening and closing stocks, other accumulation, and other volume changes (Table 2). Opening and closing stocks refer to the quantity of land (area in hectares) at the beginning and end of the accounting period. The land area under agricultural and pastoral lands can be increased (artificially) for economic reasons by means of land reclamation (from the sea or river beds). Increase or decrease in the quantity of land comes under the other accumulation category, which simply pertains to the changes in the quantity of land (additions or reductions in areas devoted to specific use) caused by economic decisions. Included in this category are changes in land use and/or transfer of non-economic land from the environment to the economy for production purposes and vice versa. Lands subjected to shifting cultivation involve areas that are opened up for agriculture from forestry and thus, represent additions to the inventory.² On the other hand, conversions from agricultural to non-agricultural uses would decrease agricultural areas and increase other types of land. Quantitative losses of land due to economic uses can be caused due to the partition of states or the transfer of districts to some states or, in some cases, due to natural disasters (for example river/sea coastal erosion—in the case of river erosion, in states such as Assam, the area lost is not inconsiderable; or, for example, the December 2004 tsunami that submerged large portions of arable land).

² It is argued that including shifting cultivation in inventories made sense in the olden days when the cycle used to be of 15–20 years as the land area brought under cultivation in a specific year might have been cultivated again only after 14–19 years. However, in recent years, the shifting cultivation cycle has come down to three to four years, in which case it may nearly be valid to include such areas as net accrual. Such lands, in this monograph, if cultivated for one year and not cultivated for three or four years in succession are treated as culturable wastelands, which have the potential to be converted into agriculture (and hence fall under the other accumulation category).

Table 2**A framework for accounting for agricultural land and pastureland**

Activity	Description
Opening stock	Land under cultivation and grazing
Changes in quantity	Asset increase due to land reclamation/improvement
Other accumulation	Changes in land use Transfer of land from the environment to economic use
Other volume changes	Changes in land use and land area due to natural, political, or other non-economic causes Transfer of land from economic use to environment
Closing stock	Land under cultivation or grazing
Changes in quality of land*	Soil erosion or nutrient loss (tonnes) Land/soil contamination including salinization and other changes in soil quality
Impact on other sectors of the economy**	Extent of sedimentation in waterways Amount of greenhouse gases released to the atmosphere Extent of contamination of waterways by pesticides and fertilizers

Note * Quality measures are not part of the asset accounts, but are used in assessing the cost of productivity losses

** These are not given in the SEEA (System of Integrated Environmental and Economic Accounting) framework. However, in order to mention the sector's impact on other sectors, we are incorporating them here itself.

As such, these changes are entered in the category other volume changes. An adjustment was included in the physical accounts to balance the resulting closing stock of the previous year to the opening stock of the following year.

Changes in land and soil quality affect land productivity and economic value, the most notable of which is topsoil erosion measured in tonnes of soil lost, which affects the productivity of agricultural land. The physical extent of land for general and specific uses was accounted for in the supplementary accounts and expressed in hectares. Specifically, the land use account represents the physical area by specific type of land use and land utilization.

Valuation of the stock of assets

The next step was to develop the monetary accounts using physical accounting framework. In order to monetize the physical accounts, valuation is essential. At first sight, valuation of land seems straightforward; in practice, a number of complications arise. The first problem is that although there is a market for land, relatively little land changes hands in any year and so a comprehensive set of prices to cover all land

types in all locations is seldom available. Even when prices are recorded, they may be subject to many distortions. Further, some land will never be exchanged on the market but will change hands as it is passed on from one generation to the next. This also includes some of the land for which no market transactions can take place (for example, wastelands). Sales involving agricultural land may also cover aspects other than the initial purpose of the land. For instance, agricultural land with fertile soil and plenty of ground water will fetch a higher price compared to equivalent land without these. Moreover, land sale data would include sales involving conversion of agricultural land to non-agricultural use. Transactions of this nature are likely to be plentiful, and they change the essential basis of the transaction, making it inappropriate for computing cropland sale values.

In such cases, where market prices cannot be used, SEEA suggests using the net present value of future benefits accruing from holding or using the asset as a proxy for market prices. The asset would not be a cost-effective purchase if the value of future benefits did not at least equal the market price. Thus, the net present value should be compatible with the market prices. If there are no market prices and it is not possible to calculate the net present value of an asset, then the cost of producing it may be used as a lower bound on its value. Again, the argument runs that it would not be worthwhile to construct the asset unless the benefits are expected to be at least as great as the costs.

In this paper we used the net present value approach to estimate the value of the asset and the changes in assets. The conceptual framework behind the net present value approach is as follows. A piece of agricultural land is characterized by several attributes: soil quality, soil texture, soil fertility measured in terms of nutrients, associated water resources, etc. With the help of these natural factors and other inputs such as seeds, rainfall, fertilizers, etc. some output is produced which can be marketed at some market value. When the value of man-made inputs are deducted from the output, we get the economic rent or land rent, which is considered as payment for the use of natural resources. The variations in these economic rents or land rents are due to differences in the quality of land and the inputs mentioned earlier. The economic rent is expected to change every year with changes in the levels of outputs/input use, their prices, and the discount rate. Since the resource unit is expected to contribute to the production of one or more resource commodities over a period of time, the asset value for any one land use, say agriculture, will be equal to the present value of the stream of land rent over the economic life of the resource over the relevant planning period. Similarly, the value of the pastureland will be equal to the present value of the stream of land rent over the economic life of the resource (Francisco and de Los Angeles 1998). The land rent is obtained by estimating the annual net returns

from the use of the resource over time, less a reasonable allowance³ for profit, which can be represented by

$$NPV = \sum_{n=1}^T \frac{LR_n}{(1+i)^n}$$

where 'NPV' is the net present value of the asset in year 'n'; 'T' is the length of the planning horizon/or economic life of the resource; 'i' is the discount rate; and 'LR_n' is the land rent in year 'n'.

Five sets of assumptions are critical in this estimation procedure.

- 1 The first assumption relates to prices, costs, and yield data as a function of time. If one assumes constant prices, then the observed changes in the value of the land rent can only be attributed to changes in the yield or productivity of the resources and in the time-value of money.
- 2 The second assumption relates to the expected value of the resource at the end of the planning horizon, that is, for how much can the land be sold for non-agricultural purposes. This is difficult to estimate and cannot be equated to zero. Some value needs to be assumed.
- 3 The third assumption refers to the choice of the discount rate to be used in weighting the present consumption value versus that of future consumption. In general, a lower discount rate favours future consumption, while a high discount rate gives more preference to present consumption.
- 4 The cost of production is assumed to include the value of all material and labour inputs along with normal return on capital (that is, profit).
- 5 Another important assumption to be made is regarding the variable 'n', the economic life of the resource. Basically, this variable measures the number of years the land can remain productive or can be used for production purposes. Once the asset reaches the end of its lifetime, it is not possible to produce anything on it, but such land can be used for some other purposes (say, construction purposes). If no such option exists, then the asset value at the end of the period may indeed be zero (in some cases this can be a temporary phenomenon as the fertility of the land can be improved by leaving it fallow for some period).

The change in the value of assets (depreciation or appreciation) is estimated as the change in asset value during the accounting period. On a year-to-year basis, land depreciation is simply measured as the difference between the asset value at the beginning of the year and at the end of the year.

³ In this monograph, we took the net value added from the data published by the Central Statistical Organization. They usually allow a margin of 10% as return on capital.

If used sustainably, land has an infinite life. No adjustment for degradation is required and the whole resource rent can be considered as income. However, as discussed earlier, the use of land for agriculture using unsustainable practices would mean degradation of the land due to soil erosion in the form of the loss of nutrients from the topsoil, movement of soil (changes in soil depth), salinization due to improper irrigation practices, deposition of chemical fertilizers on land, etc. In such cases, adjustment to income is necessary. Several techniques can be used to estimate the extent of degradation caused which are discussed as follows. In this study we considered only the costs of degradation due to soil erosion and sedimentation and did not estimate the damage caused to the soil and water from eutrophication.

Cost of soil erosion

Soil erosion is a natural process and only when it erodes beyond the tolerable rate, does it have an impact. Under natural conditions, the soil lost is largely replenished. However, when the natural rate of replenishment is exceeded by erosion, a physical depreciation of soil resources takes place. In the absence of other forces at play, any loss of soil erosion beyond a tolerable level can be considered as human induced. In this study, we were interested in human-induced soil erosion. We consider that soil erosion impacts the economy in two ways: (1) erosion of topsoil and (2) sedimentation of waterways. Mainly two approaches have been used in the literature to value the on-site effects of erosion. One approach measures the impact on the soil as a resource and the second approach is based on the effects of erosion on agricultural production. The effects of erosion on soil properties can be examined from the perspective of certain indicators of soil characteristics such as soil nutrient content, soil moisture capacity, etc. The effects of erosion on agricultural production can be valued in terms of the reductions in crop yields, which can be directly captured through the loss in market value. The most common approach for valuing the loss of soil and soil nutrients is the replacement cost method. This is based on the cost of replacing soil nutrients with artificial fertilizers or the cost of physically returning eroded sediment to the land (the labour costs or the cost of buying fertilizers).

We preferred to use the replacement cost approach over the loss in productivity approach, though under optimal conditions, both should give the same value. This is because crop yields are not dependent on soil productivity alone but are also determined by a number of factors such as rainfall, fertilizer application rates, climate, pests, and irrigation practices. Moreover, the impact of erosion on crop production is complicated by the dynamic nature of agriculture. Though the soil has degraded, farmers can respond by adjusting their level of inputs by adopting the cropping patterns, that are less sensitive to erosion. If we assume everything else to be same, then erosion can have an impact on declining crop yields.

Cost of sedimentation

Siltation or sedimentation in a reservoir is a very serious problem, for it considerably reduces its life. The life of a reservoir depends on the rate of silt inflow and its dead storage capacity. It has been estimated that many of the reservoirs in India are losing capacity at a rate of 1% – 2% every year (SOER 2001). In order to estimate the cost of sedimentation, two approaches can be used. The first approach is to estimate the value of lost storage capacity and the second approach is to use the maintenance cost method, that is, how much would it cost to remove sediment from water. In this study, we used the cost of removing sediments from reservoirs as an indicative value of the costs imposed by off-site effects of erosion. As rivers have a different hydrology compared to reservoirs, it may be possible that the cost of treating sediments may vary considerably between reservoirs and rivers. Accordingly, the estimates can be higher or lower than the estimates presented in this paper. We were conscious of the fact that sedimentation and soil erosion may have causes both natural as well as human induced, and that their effects stretch beyond the agricultural value. However, as their effects are a reduction in national asset values and the proximate asset class is agricultural land, these effects were modelled and accounted for accordingly.

Cost of degraded lands

Due to unsustainable practices, some of the lands become degraded and are categorized as wastelands. These lands comprise salt-affected land, land subjected to chemical deposition, land subjected to shifting cultivation, gullied and ravined land, waterlogged land, etc., which can have an effect on productivity. For example, salinity directly affects the productivity of the soil by rendering it unfit for healthy crop growth. Indirectly, it lowers productivity through adverse effects on the availability of nutrients and on the beneficial activities of soil micro flora. Apart from salinity, the deposition of heavy metals or industrial effluents and indiscriminate use of agro-chemicals such as fertilizers and pesticides are also responsible for land degradation. The value of such changes are only partly reflected in the current value added in agriculture and does not give a complete picture of the extent of degradation. Though the soil degrades, farmers can respond by adjusting their level of inputs by adopting the cropping patterns that are less sensitive to erosion. Moreover, such lands, if left untreated, cause more damage to the environment than the estimates given by a loss in the economic productivity approach. Hence, from time to time, the government incurs some expenditure in treating these lands. We used these expenditures as a proxy to estimate the value of degradation.

Before getting the data in the desired accounting framework, we would like to comment on the basic distinction between land cover and land use. Land cover reflects the (bio) physical dimension of the earth's surface and corresponds, in some sense, to the notion of ecosystems. For example, agricultural land and pastureland come under the category of land cover. Land use, on the other hand, is based on the functional dimension of land for different purposes or economic activities. For example, if we treat agricultural land as land cover, then in any particular year it can be used to grow various kinds of main crops or commercial crops, which can vary across different years, and this is referred to as land use (Table 3). From the land-cover-change matrix, it can be seen that the area put to non-agricultural uses, barren and uncultivable land, land under forests, fallow land other than current fallow, and current fallow has gone up in the last 10 years, while the area under permanent pastures and other grazing lands, land under miscellaneous crops and groves, cultivable waste land, and the net area sown has come down (Table 4). In reality, though, the area under forests is shown as 'increased', in many places the actual tree cover area has gone down. These statistics are based on the reported land utilization statistics.

Physical accounts

In the next step, we tried to bring the information into the accounting framework mentioned in Table 2. The opening stock of agricultural land and pastureland was taken as the opening area (net area sown) in the year 1992. The closing stock was the stock of agricultural land present at the end of 2001 (net area sown). The reason why we chose 1992 as the opening year was that degradation does not take place suddenly but occurs over a period of time and we believed that a 10-year period could sufficiently capture the land degradation. At the end all the estimates were annualized to obtain estimates on a year-to-year basis. The area under agricultural land and pastureland was taken from the *Agricultural Statistics* published by the Ministry of Agriculture. The land-use-change matrix was obtained from the land use classification in different years as published in the *Statistical Abstract of India*.

As seen in Table 2, the stock can change due to several reasons. It can change either due to economic reasons or due to changes in the quantity of land under particular land use or due to transfer from the environment to economic uses. Such detailed information is not available from the published data. Only land-use change data is available from Table 4. For example, in the state of Andhra Pradesh, the area put to agricultural use decreased by 82 000 ha. This decrease could be as a result of increase in the area put to non-agricultural uses (Annexure I) or due to improvement of land which was earlier unfit for cultivation. All the changes in land-use classification basically imply other accumulations. Reliable data on shifting cultivation (other volume changes) was not available for the two time periods. Similar was the case with the changes in quantity due to economic activity. Hence, we did not dichotomize the cause of the

Table 3

Area under different categories of crops in India for 2000/01 ('000 hectare)

State	Cereals	Pulses	Oilseeds	Sugar	Fibres	Drugs and narcotics	Condi- ments and spices	Fruits and vegetables	Other crops	Fodder crops	Pasture land
Andhra Pradesh	5489.3	1797.1	2675.6	217.4	1128.0	218.0	432.8	697.9	0.102	130.0	675.000
Arunachal Pradesh	177.4	6.2	24.8	0	0	0	0	72.1	0.280	0	4.000
Assam	2776.0	111.5	310.4	27.0	100.0	235.0	73.5	345.3	12.117	8.0	163.000
Bihar	6472.5	780.0	171.0	93.5	182.0	18.0	0	976.2	0	11.0	105.333
Chhattisgarh	4005.6	563.4	275.5	0	0	0	0	96.0	0	0	852.000
Goa	57.9	10.8	1.8	0	0	0	1.6	18.1	0.872	0	1.000
Gujarat	2513.2	634.7	2695.0	177.7	1545.0	165.0	154.0	376.5	275.200	1318.0	849.000
Haryana	4179.0	111.9	453.5	143.0	546.0	4.0	0	172.4	147.400	510.0	34.000
Himachal Pradesh	801.4	35.1	18.9	2.8	0	3.0	0	172.4	0	10.0	1529.000
Jammu and Kashmir	876.6	31.2	70.4	0.1	0	0	0	186.6	0	46.0	126.000
Jharkhand	1719.7	116.3	50.1	0	0	0	0	170.7	0	0	0
Karnataka	5729.0	2061.0	2197.8	417.1	541.0	268.0	341.0	670.6	19.735	55.0	959.000
Kerala	353.7	22.1	8.8	3.4	5.0	130.0	329.0	349.3	474.350	3.0	0.500
Madhya Pradesh	6521.8	3324.0	5612.5	74.9	498.0	21.0	322.1	301.7	0.189	700.0	2524.000
Maharashtra	9766.9	3552.8	2523.3	595.0	3282.0	6.0	124.0	938.3	1.588	1290.0	1341.000
Manipur	164.2	0	2.3	0.7	0	0	0	34.4	4.029	0	0
Meghalaya	126.6	4.6	8.7	0.1	16.0	1.0	10.0	61.8	0.585	0	0
Mizoram	58.5	2.4	7.2	1.0	0	0	1.0	25.9	1.791	0	23.000
Nagaland	193.1	17.4	36.3	0.8	1.0	0	0	51.6	0.493	0	0
Orissa	4640.3	604.3	277.3	16.8	94.0	7.0	157.3	917.9	0	0	443.000
Punjab	6221.0	59.0	87.4	121.0	726.0	3.0	0	165.2	15.800	653.0	7.000
Rajasthan	8984.1	2374.8	2645.7	13.5	594.0	85.0	458.8	115.1	3056.200	3491.0	1707.000
Sikkim	70.0	6.1	10.0	0	0	0	0	22.9	18.710	0	69.000
Tamil Nadu	3190.0	745.9	1056.0	315.3	182.0	115.0	125.0	443.0	26.495	179.0	123.000
Tripura	243.8	10.1	6.3	1.0	3.0	29.0	2.3	60.7	0	0	0
Uttar Pradesh	17422.2	2679.3	1395.4	1938.4	16.0	176.0	0	955.9	2.900	969.0	293.333
Uttaranchal	979.8	28.5	22.0	1938.4	0	0	0	296.6	0.388	0	0
West Bengal	5918.3	322.3	599.6	21.6	625.0	163.0	7.7	1208.7	0.931	2.0	4.000
Andaman and Nicobar Islands	10.9	1.3	0	0.2	0	0	4.0	6.8	0	0	4.000
Chandigarh	0	0	0	0	0	0	0	0.2	0	2.0	0
Daman and Diu	2.0	1.3	0	0	0	0	0	0.5	0	1.0	0.500
Dadra and Nagar Haveli	16.3	4.3	0.1	0	0	0	0	2.2	0	0	1.000
Delhi	49.5	0.6	4.8	0	0	0	0	3.0	0	1.0	0.500
Lakshadweep	0	0	0	0	0	0	0	0.5	0	0	0
Pondicherry	26.4	5.8	1.3	2.5	0	0	0	6.0	0	0	0
India	99757.0	20026.1	23249.8	6123.2	10086.0	1648.0	2544.1	9923.0	4060.170	9379.0	11838.000

Source Author's compilation based on the data taken from www.indiastat.com

changes between the opening and closing stocks. This did not affect our estimates because any change in agricultural land or pastureland is reflected in the total production and hence the value. If the agricultural land increases due to whatsoever reason, it is reflected in increased production and vice versa. If this increase in agricultural area came because of land improvements, the investments on this land improvement would have already been recorded by CSO (Central Statistical Organization) in GCF (gross capital formation). If the agricultural land is converted to non-agricultural use, it indicates decrease in the capital in the agricultural sector but increase in value in the other sector which should be accounted for there. From Table 4, it can be seen that in the states of Gujarat, Karnataka, Madhya Pradesh, Maharashtra, Orissa,

Table 4

Land-use-change matrix for the period 1992/93–2000/01 ('000 hectare)

State	Reporting area for land utilization statistics	Land under forests	Area put to non-agricultural uses	Barren and uncultivable land	Permanent pastures and other grazing land	Land under miscellaneous tree crops and groves	Cultivable wasteland	Fallow lands, other than current fallows	Current fallow	Net area sown
Andhra Pradesh	0	–82	198	42	–145	11	–47	–57	–570	649
Arunachal Pradesh	–1	0	–24	–27	4	–8	37	–2	5	14
Assam	–2	–52	156	–80	–21	–13	–24	–19	22	28
Bihar and Jharkhand	0	0	273	–4	–21	48	–43	–83	–446	275
Goa	0	0	15	–15	0	0	–4	0	0	3
Gujarat	–10	–21	18	–3	1	0	0	–20	155	–140
Haryana	26	–56	49	16	3	3	–14	0	–26	52
Himachal Pradesh	1152	56	113	661	326	14	4	–10	6	–18
Jammu and Kashmir	0	0	0	–2	1	0	–1	1	–18	18
Karnataka	0	–7	108	–7	38	–14	–16	–7	282	–378
Kerala	–1	0	79	–26	–2	–19	–32	7	36	–44
Madhya Pradesh and Chhattisgarh	200	553	144	–299	–273	–52	8	–47	282	–115
Maharashtra	0	151	114	105	161	–61	–45	77	–117	–384
Manipur	0	0	0	0	0	0	0	0	0	0
Meghalaya	–12	15	3	–6	0	–1	–52	–6	6	29
Mizoram	7	323	–10	–185	19	28	53	–103	–147	29
Nagaland	49	0	37	0	0	–4	–26	–27	–27	96
Orissa	31	335	218	311	–220	–375	–146	246	137	–475
Punjab	0	18	–85	–21	3	6	–1	–8	–35	125
Rajasthan	13	212	92	–162	–64	–4	–443	579	876	–1073
Sikkim	0	0	0	0	0	0	0	0	0	0
Tamil Nadu	–21	–17	117	–34	2	24	48	177	172	–510
Tripura	0	0	–2	3	0	0	0	0	–12	12
Uttar Pradesh and Uttaranchal	–30	1	89	–95	–8	15	–142	–169	–75	353
West Bengal	2	–4	82	–32	–3	–4	–52	–9	99	–77
Union territories	0	2	16	–2	–1	–10	10	–2	3	–15
India	1404	1426	1798	137	–199	–415	–929	519	611	–1544

Source Author's compilation based on the data taken from www.indiastat.com

Rajasthan, and Tamil Nadu, there has been decline in agricultural land mostly due to conversion to fallow land. In the states of Andhra Pradesh, Bihar, Punjab, and Uttar Pradesh the agricultural land has increased due to decrease in current fallow, and other fallow land. Where the land is converted from other uses into agriculture, it accounts for GCF in the agricultural sector.

Changes in quality of land

As mentioned earlier, intensive agriculture and wrong management practices can lead to degradation of land mainly caused by soil erosion, and salt and chemical deposition on the land, and also have a negative impact on other assets such as surface water, ground water, and health. Here, we would like to clarify the terms 'wasteland' and 'degraded land'. The terms wasteland and degraded lands are in essence, synonymous. Wasteland is defined as degraded land which can be brought under vegetative cover with reasonable efforts. These lands are currently underutilized, and are deteriorating for lack of appropriate water and soil management or on account of natural causes. Wastelands can also result

from inherent/imposed disabilities such as by location, environment, chemical, and physical properties of the soils or other financial or management constraints (Reddy 2003). As per NRSA (National Remote Sensing Agency), wasteland/degraded land can be classified into 13 categories: (1) sandy, (2) hilly, (3) rocky, (4) snow-covered regions, (5) mining and industrial wastelands (6) forest-based degradation, (7) degraded land under plantation crops (8) gullied/ravined land, (9) upland with or without scrub, (10) waterlogged and marshy land; (11) land affected by salinity and alkalinity, (12) shifting cultivation area, and (13) degraded pasture and grazing lands. Of all the categories of wastelands, only the gullied/ravined land, upland with or without scrubs, waterlogged and marshy land, land affected by salinity and alkalinity, shifting cultivation area, and degraded pasture and grazing lands are considered in this paper for further analysis.⁴

Estimates of land degradation were available from a number of sources—Ministry of Agriculture, UNEP (United Nations Environment Programme), NRSA, and various individual studies (Table 5). From Table 5, it can be seen that the extent of degradation is about 14.6% of the geographical area in 1988/89 (NRSA 1989). Interestingly, between 1984 (SPWD 1984) and 1988/89 (NRSA 1989), the extent of degradation went up from 12.958 million ha to 44.39 million ha. The composite estimate for 1986–99 (NRSA 1999) is 63.18 million ha. However, the estimates from NRSA and SPWD (Society for Promotion of Wastelands Development) cannot be compared due to the differences in the assessment methodology and the scale.

We felt that estimates by NRSA were more accurate as they were generated using remote sensing techniques covering the entire country. However, we needed at least two time points for comparison. NRSA published some estimates for the year 1988/89 using a 1:250 000 scale covering 442 districts under different agro-climatic zones. Another set of estimates was available for the year 1999 using a 1:50 000 scale covering 584 districts (the survey was done in different years from 1986) (NRSA 2000). These two data sets were not strictly comparable because of the scale differences and the differences in coverage. However, as the NRSA data was more accurate, we used the estimates published by NRSA (2000) for analysis. The NRSA estimates had to be adjusted for the land already degraded. The estimate by SPWD (1984) indicated that about 12.95 million ha, i.e. 20% of the land was already in a degraded state during the early 1980s, while the NRSA (2000) estimates indicated that about 63.81 million ha was degraded.⁵ This meant 20% of this land was in degraded state by 1982. We assumed that the remaining 80% of the

⁴ Upland, with or without scrub, is also considered because this category is either barren due to unsustainable grazing and cultivation or is occasionally cultivated.

⁵ We do recognize the differences in scale and approach between these two sources. As we felt NRSA (2000) data is more authentic and cannot be compared with any other source, we adjusted the latest estimates by a proportion to take into account the already degraded land.

Table 5

Area under various categories of wastelands as given by different sources

Category of wasteland	NRSA 1988/89 (square kilometre)	NRSA 1986-99 (square kilometre)	NAEB (1993) (square kilometre)	SPWD (1984) (million hectare)	Department of Agriculture (million hectare) (1985)
Water erosion	—	—	—	7.36	107.12
Wind erosion	—	—	—	1.292	17.79
Salt-affected area	19883.8	20477.38	—	—	—
	12427.96	0.716	7.61	—	—
Waterlogged area	12196.7	16568.45	4266.17	—	8.52
Marshy/swampy land	8238.8	—	—	—	—
Gullied/ravined area	20203.3	20553.35	19433.64	—	39.45
Land with or without scrubs	265145.6	<i>fallows 194014.29</i>	124397.7	9.369	—
Sandy area	55720.9	50021.65	15241.64	—	1.46
Steep sloping area	62514.1	7656.29	4121.07	—	—
Barren rocky area	—	64584.77	25722.6	—	—
Snow/glacial area	—	55788.49	2973.16	—	—
Degraded forest	162742.7	140652.31	96099.04	3.5889	19.49
Forest blanks area	18138.5	—	—	—	—
Degraded land under plantation crops	—	5828.09	4931.65	—	—
Degraded pasture/grazing land	—	25978.91	13148.69	—	—
Shifting cultivation area	—	35142.20	18542.76	—	4.91
Special problem area	—	—	—	—	2.73
Total wasteland	624784.4	638518.31	341580.8	12.958	173.64
Total geographical area	—	3166414.00	1888061.59	—	—

Note The estimates published by different sources may not be comparable due to the differences in scale and assessment methods.

NRSA - National Remote Sensing Agency; NAEB - National Afforestation and Eco-development Board; SPWD - Society for Promotion of Wastelands Development

Source Author's compilation from various sources.

land was degraded over 20 years. We multiplied the amount of land degraded as per NRSA (2000) with 0.80 and then divided it by 20 to reflect the average annual land degradation.

As our aim was to develop accounts for different states, we needed data for different states. For 2000, for the first time, the NWDB (National Wasteland Development Board) provided data at the state level, which revealed substantial variations (Table 6). From Table 6, it can be seen that the extent of wasteland ranges from 3.7% in Kerala to 64% in Jammu and Kashmir. Among all the states, Jammu and Kashmir has the highest extent of wasteland followed by Manipur at 58%, Himachal Pradesh at 56%, and both Nagaland and Sikkim at 50% as these states have very high proportion of natural wastelands (barren rocky, steep sloping area, land under snow cover, sandy desert or coastal region). However, such natural wastelands are not treated as degraded lands in this paper. If we consider only the land degraded as a result of human activities like agriculture, the states of Manipur, Mizoram, and Nagaland top the list with more than 15% of the geographical area placed under the degraded lands category, while the states of Jammu and Kashmir and Himachal Pradesh have wastelands of less than five per cent of their geographical area.

Table 6

State-wise wastelands of India in the year 2000 (square kilometre)

State	Gl and R	US	WL and ML	S/L	SH/C	UU/DF	DPG	DPC	S and DL	M and IWL	BR/SA	SSA	SC/GA	Total wastelands	% Total geographical area
Andhra Pradesh	692.70	20257.00	1035.02	603.26	13.80	22237.80	709.29	52.91	464.70	98.88	5196.27	388.96	0	51750.20	18.81
Arunachal Pradesh	0	3326.80	41.47	0	3088.10	1416.67	2134.99	6.07	309.43	0.30	1262.36	7.93	6732.2	18326.30	21.88
Assam	0	843.72	1633.56	0	8391.50	3112.71	2217.85	0	3764.50	0.43	54.88	0	0	20019.20	25.52
Bihar	559.20	4689.90	1198.87	0.51	45.45	13066.50	164.97	79.80	222.08	184.23	688.91	97.10	0	20997.60	12.08
Goa	0	292.83	41.02	0	0	71.99	2.47	32.19	0	110.73	58.55	3.49	0	613.27	16.57
Gujarat	1013.00	21787.00	2656.26	7637.30	0	5443.02	387.45	78.32	188.42	49.66	3293.39	487.31	0	43021.30	21.95
Haryana	49.50	988.42	238.30	285.63	0	732.52	721.65	134.12	465.01	13.72	105.12	0	0	3733.98	8.45
Himachal Pradesh	121.90	2056.50	15.69	1.36	0	4589.98	4278.17	2457.59	105.04	85.66	3858.04	1529.67	12559.0	31659.00	56.87
Jammu and Kashmir	21.25	4495.30	246.50	0	0	2491.66	267.51	640.56	869.26	0.31	32821.50	1685.42	21905.0	65444.20	64.55
Karnataka	301.50	9087.70	32.76	125.11	0	8299.41	97.46	104.74	43.96	77.78	2627.89	40.97	0	20839.30	10.87
Kerala	0	357.93	136.00	0	0	609.30	3.99	25.65	27.87	0.49	146.46	140.49	0	1448.18	3.73
Madhya Pradesh	7569.00	36978.00	51.72	162.81	0	20437.80	302.44	910.40	24.57	141.44	2950.97	184.65	0	69713.80	15.72
Maharashtra	1700.00	31387.00	527.57	251.66	0	13430.70	1349.40	687.43	77.63	100.45	2587.42	1389.57	0	53489.10	17.38
Manipur	0	1.32	324.60	0	12014.00	608.64	0	0	0	0	0	0	0	12948.60	58.00
Meghalaya	0	4190.60	14.87	0	2086.80	3612.11	0	0	0	0	0	0	0	9904.38	44.16
Mizoram	0	0	0	0	3761.20	310.45	0	0	0	0	0	0	0	4071.68	19.31
Nagaland	0	1596.50	0	0	5224.70	1582.99	0	0	0	0	0	0	0	8404.10	50.69
Orissa	185.80	8358.70	379.10	51.49	115.28	10014.10	13.43	193.93	212.49	35.45	1574.09	207.88	0	21341.70	13.71
Punjab	168.50	339.44	352.01	173.29	0	353.29	113.71	81.58	619.67	26.89	0	0	0	2228.40	4.42
Rajasthan	4953.00	27153.00	289.66	2723.00	0	12541.90	12208.40	21.14	40640.00	128.65	4799.02	182.28	0	105639.00	30.87
Sikkim	0	1073.10	0	0	0	1060.57	0	0	0	0	10.34	0	1425.6	3569.58	50.30
Tripura	0	286.87	0.11	0	400.88	588.18	0	0	0	0	0	0	0	1276.03	12.17
Tamil Nadu	226.10	7697.90	415.80	2479.70	0.53	9634.25	168.94	221.96	590.80	120.46	1155.92	301.50	0	23013.90	17.70
Uttar Pradesh	2807.00	5499.00	4981.43	5811.90	0	3338.32	446.36	50.44	470.21	29.26	1180.13	992.83	13166.0	38772.80	13.17
West Bengal	171.90	1245.20	1931.54	131.25	0	777.58	384.97	2.93	879.13	47.34	130.46	16.24	0	5718.48	6.44
Union Territories	12.83	25.74	24.60	39.01	0	289.97	5.43	46.34	47.33	0	83.05	0	0	574.30	5.23
India	20553.00	194014.00	16568.50	20477.00	35142.00	140652.00	25978.90	5828.09	50022.00	1252.10	64584.80	7656.29	55788.0	638518.00	20.17

BR/SA – Barren rocky/stony waste/sheet rocky Area; DPG – degraded pastures/grazing land; DPC – degraded land under plantation Crops; GL and R – guilleted and or ravinous land; M and IWL – mining industrial wastelands;

S/A – land affected by salinity/alkalinity-coastal/inland; SC – snow covered and or glacial area; S and DL – sands-desertic coastal; SH/C – shifting cultivation area; SSA – steep slopping area; UU/DF – under-utilized degraded notified forest land; WL and ML – waterlogged and marshy land; US – upland with or without scrub

Source Ministry of Rural Development (2000)

As land degradation takes place largely in the form of soil erosion, which is a serious threat to our future well being, we also included soil resources in the accounts for agriculture. The two main agents of soil erosion are wind and water. Water-related erosion takes place directly through floods and surface run off and indirectly through excess or inappropriate use of water resulting in salinity and alkalinity. Using water contaminated with industrial pollutants can result in severe damage to croplands, with significant decline in the yield rates. Erosion occurs in agricultural lands, construction sites, roadways, disturbed lands, surfaces mines, and in areas where natural or geological disturbances take place. Erosion can broadly be classified into five types: (1) sheet erosion (removal of a thin, relatively uniform layer of soil particles), (2) rill erosion (erosion in numerous small channels that are small enough to be obliterated by normal tillage), (3) gully erosion (larger upland channels), and (4) stream channel (erosion caused by stream flow), and (5) mass erosion (enmass movement of soil). Although soil erosion is caused mainly by natural factors (climate and hydrology), soil topography, soil surface conditions and their interactions, the management and use of land play a major role in aggravating the situation.

Soil erosion estimates are usually calculated through USLE (universal soil loss equation), where the soil loss in tonnes per hectare is regressed against variables such as the erosive capacity of rainfall, erosion of soil, length of slope, steepness of slope; land cover and management, and support practices (contouring, strip cropping, etc.) (Table 7). These estimates are usually available from different studies for a specific location but are usually generalized at the aggregate level. However, the data is not available for all the climatic zones. We used a study by Singh, Babu, Narain, *et al* (1992), which published the soil erosion rates for different regions of India. Based on the iso-erosion map generated by them, they divided the entire country into five soil erosion zones ranging from an area of no erosion to slight, medium, severe, and very severe erosion areas. We found this data to be useful in estimating the soil erosion rates for the entire country (Table 8). The erosion rate contributed by each state is then computed using the share of the agricultural area in each state to the total in India.

Soil erosion not only has on-site but also off-site impact by way of sedimentation of the waterways. The Central Water Commission has published some data on the sediment load of some of the major reservoirs. However, as the data is for reservoirs, it is difficult to get state-wise disaggregated estimates. A study by Sharma (2002) gives the sediment load per square kilometre per year for all major rivers and their tributaries in India and Nepal at various monitoring points. The study is based upon all published sources of information and also on controlled laboratory experiments (Table 9). However, as a particular river originates in one state and often flows in more than two to three states, we had to make some assumptions to estimate the sediment load in different rivers.

Table 7

Annual soil loss estimates in different regions of India as per the universal soil loss equation

Land resource region	Soil loss (tonnes per square kilometre)	Major land use	Area covered (‘000 square kilo- metre)
North Himalayan forest region	287	Forest	131.70
Punjab-Haryana alluvial plains	330	Agriculture	101.25
Upper Gangetic alluvial plains	1440–3320	Agriculture and wasteland	200.00
Lower Gangetic alluvial plains	287–940	Agriculture	145.50
North-eastern forest region	2780–4095	Agriculture/shifting cultivation	161.00
Gujarat alluvial plain region	240–3320	Agriculture	62.75
Red soil region	240–360	Agriculture	68.80
Black soil region	2370–11250	Agriculture	67.34
Lateritic soils	3930	Agriculture	61.00

Source Narayana and Babu (1983)

Table 8

Estimates of soil erosion in India

Soil erosion rate range (Mg/ha/yr)	Soil erosion class	Area (km ²)	Low estimate	Medium estimate	High estimate
0–5	Slight	801 350	0	200 337 500	400 675 000
5–10	Moderate	1 405 640	702 820 000	1 054 230 000	1 405 640 000
10–20	High	805 030	805 030 000	1 207 545 000	1 610 060 000
20–40	Very high	160 050	320 100 000	480 150 000	640 200 000
40–80	Severe	83 300	333 200 000	499 800 000	666 400 000
>80	Very severe	31 895	255 160 000	318 950 000	382 740 000
Total		3 287 265	2 416 310 000	3 761 012 500	5 106 000 000

Mg/ha/yr = t/ha/yr; km² – square kilometre

Source First three columns are based on Singh, Babu, Narain, *et al.* 1992, and the next three columns are authors’ computations.

Though we tried to estimate the state-wise sediment load using the length of the rivers in major states, published data existed only for some major rivers and not for the smaller rivers. Hence, first we estimated the sediment loads in various major rivers (all the tributaries of a river are added up as they ultimately flow into the main river). A paper by Amarsinghe (2004) published the percentage of the geographical area covered by major rivers in all states in India. Using this data, we first found the sediment load of the different rivers in different states. As sediments are contributed by various natural factors and also other land-use changes and not necessarily by agriculture alone, we first identified the proportion of land degraded as a result of agricultural activities in the total geographical area of each states. Using these values as weights, we

Table 9

Sediment load in Indian rivers

River	Location	Sediment (tonnes)	River	Location	Sediment (tonnes)	River	Location	Sediment (tonnes)	River	Location	Sediment (tonnes)
Sutlej	Bhakra	45128160	Godavari	Nanded	25000000	Bagmati	Chovar	760000	Sina	Wadakbal	6480000
Sutlej	Gobindsagar	44061000	Godavari	Basar	16000000	Betwa	Matatila	17404800	Tunga	Shimoga	370000
Banas	Dantowada	3009107	Godavari	Sriramsagar	79272864	Betwa	Sahijna	10537340	Tungabhadra	Tungabhadra	1450000
Bhadar	Bhadar	3956875	Godavari	Mancheril	133000000	Betwa	Gandhisagar	29400000	Tungabhadra	Tungabhadra	2559260
Mahi	Kadana	16291968	Godavari	Perur	133000000	Chambal	Gandhisagar	11000000	Varoda	Marol	661635
Mahi	Mouth	22100000	Godavari	Rajhamundry	170000000	Chambal	Udi	18032265	Krishna	Vijayawada	4110000
Tawa	Tawa	6800000	Godavari	Mouth	170000000	Gandak	Confluence	24000000	Godavari	Ramtek	286412
Narmada	Garudeshwar	69700000	Indravati	Nowrangpur	3000000	Ghagra	Confluence	125000000	Godavari	Dhulle	10000000
Narmada	Mouth	125000000	Indravati	Jadaiapur	4000000	Gomti	Confluence	6000000	Godavari	Gagra	12000000
Narmada	Mouth	61400000	Indravati	P.Gudem	21000000	Kaligandaki	Setibeni	32000000	Godavari	Domail	14639000
Girna and Panza	Girna	4955992	Kaddam	Kaddam	3404992	Kankai	Mainachuli	5800000	Jhelum	Mangla	63595515
Tapi	Savkhoea	24700000	Lakhamvara	Lakhamvaram	399588	Karnali	Asaraghat	17000000	Mand	Kurubhata	2540004
Tapti	Ukai	70936500	Manair	Ramappa L.	66608	Karnali	Chisapani	105000000	Ong	Salebhata	1889993
Tapti	Mouth	102000000	Manjeera	Saigaon	3000000	Ken	Chila	63121056	Pairi	Baronda	3029984
Kuttiyadi	Peruvannam'hi	280784	Manjeera	Raipalli	6000000	Kosi	Chatara	133000000	Seonath	Singa	1854278
Malampuzha	Malampuzha	526288	Manjira	Manjira	2381340	Bhilganga	Tehri	13962949	Seonath	Jondhra	4329949
Malani	Peechi	14338	Kinnarsani	Kinnarsani	113730	Kosi	Baltara	80000000	Tel	Kantamal	6790028
Bharathpuzh	Mangalam	75852	Kanigiri	Kanigiri	88998	Kulekhani	Kulekhani	2000	Brahmani	Samal	20400000
Aliyar	Aliyar	231465	Musi	Musi	483395	Lotharkhola	Lothar	1400000	Mayurakshi	Mayurakshi	4464000
Kailmani'har	Manimutharu	275724	Tandava	Tandava	366212	Narayani	Narayanghat	176000000	Damodar	Panchet Hill	8919960
Vaigai	Vaigai	1254921	Hindri	Gajuladinne	1699516	Phewa	Phewa	769912	Damodar	Mouth	28000000
Kundah	Upperhawani	2584	Tamileru	Tamileru	688597	Gandak	Gandak	195974400	Barakae	Maithon	9000420
Bhawani	Lowerhawani	1764000	Ananir	Ananir	580160	Ramganga	Ramganga	10060140	Ganga/Brahmaputra		1100864000
Cauvery	Mettur	14896600	Kadam	Swarna	251720	Ramganga	Confluence	10000000	Irawadi	Dela	259780000
Cauvery	Musiri	1500000	Mehadrigad	Mehadrigadda	774400	Rapti	Bagasoti	17000000	Burhi Gan'k	Rosera	28000000
Cauvery	Mouth	32310000	Konam	Konam	267957	Seti	Phoolbari	33000000	Shakkar	Gadarwara	1781950
Pannalarui	Krishnagiri	1308630	Pampa	Pampa	220100	Seti	Banga	190000000	Indus	Kachural	87000000
Ponnair	Sathnur	1537292	Munyeru	Lower Saileru	60243	Son	Confluence	50000000	Indus	Pratab B	160000000
Gundukamm	Cumbumtak	1375305	Manjira	Nizamsagar	14860390	Sunkosi	Kampughat	75900000	Indus	Darband	147511133
Palar	Palar	33740	Penganga	P.G. Bridge	14000000	Tamor	Mulghat	41400000	Indus	Tarbela	188000000
Pennar	Somasila	6900000	Pranahita	Tekra	65000000	Tons	Ichari	913818	Indus	Kalabagh	750300000
Aliaru	Pocharam	94220	Purna	Purna	10000000	Tons	Ichari	7924000	Indus	Kotri	480916000
Bhima	Ghod	2286000	Sabari	Konta	6000000	Trishuli	Betrawati	3400000	Arun	Tribeni	48440000
Bhima	Takali	14075104	Sidhapana	Magleaoon	2000000	Yamuna	Tajewala	18081508	Wyra and Pangi	Wyra	285420
Bhima	Yedgir	46039717	Sileru	Machkud	600000	Yamuna	Delhi	26089200	Nira	Sarati	1029600
Dindi	Dindi	94080	Wainganga	Pauni	21000000	Yamuna	Okhla	28752454	Mahanadi	Tikarapara	30700000
Issa	Himayatsagar	817500	Wardha	Bamini	51000000	Yamuna	Etawah	8445691	Mahanadi	Naraj	67865476
Koyna	Shivejisagar	961389	Wainganga	Asthi	22000000	Yamuna	Aliahabad	64327728	Ganga	Brahma Conce	520000000
Krishna	Karad	1690000	Hamp	A'Kore	497515	Yamuna	Confluence	125000000	Brahmaputra	Ganga Confluence	540000000
Krishna	Bagalkot	2810000	Hasdeo	Bamnidih	4850016	Ganga	Haridwar	1400000	Muneru	Shanigram L	51039
Krishna	Huvanpur	9170000	lb	Sundargarh	2760015	Ganga	Kannauj	15000000	Mahanadi	Hirakud	77307165
Krishna	Bawapuram	6380000	Jonk	Rampur	680010	Ganga	Aliahabad	228000000	Ganga	Delta, B. D	1450000000
Krishna	Srisaillam	116825247	Mahanadi	Rajim	3499620	Ganga	Ghazipur	340000000	Ken	Chilla	63121056
Krishna	Morvakonda	67720000	Mahanadi	Tikarapara	29889820	Ganga	Farakka	729000000	Barakae	Maithon	9000420
Krishna	Mouth	64000000	Mahanadi	Basantpur	18799879	Ganga	Calcutta	328000000	lb	Sundargarh	2760015

Source: Sharma (2002)

found the contribution of agricultural practices to the sediment load of each state⁶ (Table 10).

Construction of monetary accounts

To construct the monetary accounts, we used various approaches as mentioned earlier. For estimating the value of change in asset accounts, we used the net present value, method. To compute the net present value we had to estimate the present value of the future net returns from the land, which depend on the cropping patterns, quality of soil, rainfall, etc. (Figure 3 shows how the cropping patterns have changed over the decade. Annexure II gives the details of various commodities considered under various commodity groups.) We felt that this could be captured by taking the time-series data on the value of output in agriculture. Hence, to estimate the present value of future net returns from agriculture, we used the data on the value of output in agriculture from 1950/51 to 2000/01. We fitted a linear regression model using time as an independent variable and the value of output as the dependent variable. Using this trend variable (time), we predicted the average future net returns.

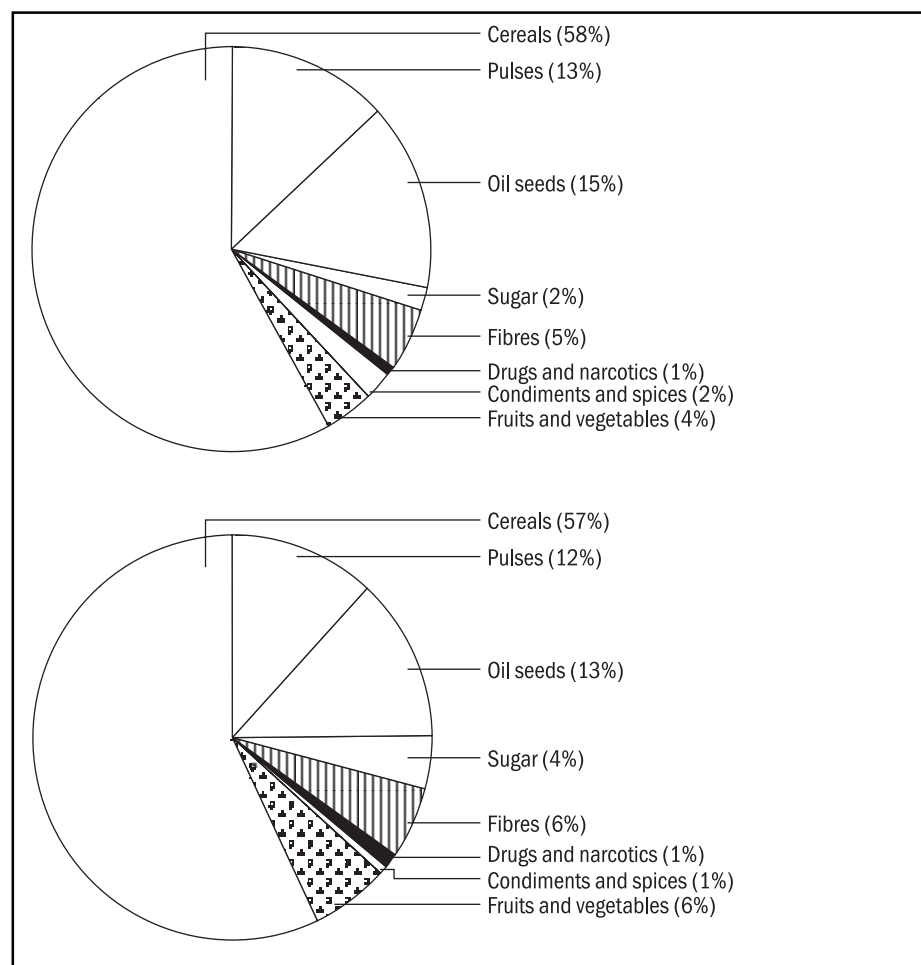


Figure 3

Change in cropping pattern in 1992 and 2001

⁶ As river sediment load is due to many reasons, by using the land degraded as a result of agricultural practices as weight, we attribute only a small portion of the sediment load to agricultural practices, netting out other effects.

Table 10

Physical accounts for agricultural land and pastureland

State	Agricultural land ('000 hectare)				Pastureland ('000 hectare)				Land degradation ('000 hectare)				Soil erosion (million tonnes per year)						
	(Change in 10 year period)				(As per the latest estimate)				On-site impact							Off-site impacts			
	Opening stocks (2)	Changes in quantity (3)	Closing stock (4)	Opening stocks (5)	Changes in quantity (6)	Closing stock (7)	GI and R (8)	US (9)	WL/ML (10)	S/A (11)	DP and DG (12)	SC (13)	Total (14)	Soil erosion		K Loss (18)	Water sedimentation (MT/year) (19)		
														(MT/year) (15)	N Loss (16)			P Loss (17)	
Andhra Pradesh	10466	649	11115	1078	-134	944	69.27	2025.70	103.50	60.33	70.93	1.38	2331.11	275.9	0.106	0.239	3.684	7.989	
Arunachal Pradesh	150	14	164	44	-4	40	0	332.68	4.15	0	213.50	308.81	859.14	4.0	0.002	0.003	0.053	13.068	
Assam	2706	28	2734	431	-34	397	0	84.37	163.36	0	221.79	839.15	1308.66	71.3	0.027	0.062	0.953	12.463	
Bihar	7162	275	7437	422	27	449	55.92	468.99	119.89	0.05	16.50	4.55	665.89	188.8	0.073	0.164	2.521	30.904	
Goa	138	3	141	2	0	2	0	29.28	4.10	0	0.25	0	33.63	3.6	0.001	0.003	0.049	0.009	
Gujarat	9583	-140	9443	852	1	853	101.30	2178.70	265.63	763.73	38.75	0	3348.10	252.7	0.097	0.219	3.373	4.064	
Haryana	3474	52	3526	35	6	41	4.95	98.84	23.83	28.56	72.17	0	228.35	91.6	0.035	0.079	1.223	5.825	
Himachal Pradesh	573	-18	555	1246	340	1586	12.19	205.65	1.57	0.14	427.82	0	647.36	15.1	0.006	0.013	0.202	3.445	
Jammu and Kashmir	730	18	748	197	1	198	2.13	449.53	24.65	0	26.75	0	503.06	19.2	0.007	0.017	0.257	6.438	
Karnataka	10788	-378	10410	1238	877	2115	30.15	908.77	3.28	12.51	9.75	0	964.45	284.4	0.110	0.247	3.798	15.611	
Kerala	2250	-44	2206	36	-21	15	0	35.79	13.60	0	0.40	0	49.79	59.3	0.023	0.051	0.792	0.612	
Madhya Pradesh	19542	-115	19427	2783	-345	2438	756.90	3697.80	5.17	16.28	30.24	0	4506.40	515.2	0.198	0.447	6.879	252.455	
Maharashtra	18020	-384	17636	1467	100	1567	170.00	3138.70	52.76	25.17	134.94	0	3521.56	475.1	0.183	0.412	6.343	75.786	
Manipur	140	0	140	24	0	24	0	0.13	32.46	0	0	1201.40	1233.99	3.7	0.001	0.003	0.049	0.011	
Meghalaya	201	29	230	156	-1	155	0	419.06	1.49	0	0	208.68	629.23	5.3	0.002	0.005	0.071	0.562	
Mizoram	65	29	94	7	47	54	0	0	0	0	0	376.12	376.12	1.7	0.001	0.001	0.023	0.008	
Nagaland	204	96	300	129	-4	125	0	159.65	0	0	0	522.47	682.12	5.4	0.002	0.005	0.072	0.702	
Orissa	6304	-475	5829	1520	-595	925	18.58	835.87	37.91	5.15	1.34	11.53	910.38	166.2	0.064	0.144	2.219	8.556	
Punjab	4139	125	4264	8	9	17	16.85	33.94	35.20	17.33	11.37	0	114.70	109.1	0.042	0.095	1.457	5.277	
Rajasthan	16938	-1073	15865	1789	-68	1721	495.30	2715.30	28.97	272.30	1220.84	0	4732.71	446.6	0.172	0.387	5.962	163.952	
Sikkim	95	0	95	74	0	74	0	28.69	0.01	0	0	40.09	68.79	2.5	0.001	0.002	0.033	0.126	
Tamil Nadu	5813	-510	5303	352	26	378	0	107.31	0	0	0	0	107.31	153.3	0.059	0.133	2.046	0.501	
Tripura	268	12	280	27	0	27	22.61	769.79	41.58	247.97	16.89	0.05	1098.90	7.1	0.003	0.006	0.094	0.002	
Uttar Pradesh	17259	353	17612	857	7	864	280.70	549.90	498.14	581.19	44.64	0	1954.57	455.1	0.175	0.395	6.075	120.951	
West Bengal	5494	-77	5417	68	-7	61	17.19	124.52	193.15	13.13	38.50	0	386.49	144.9	0.056	0.126	1.934	12.397	
Union Territories	143	-15	128	35	-11	24	1.28	2.57	2.46	3.90	0.05	0	10.27	3.8	0.001	0.003	0.050	0	
India	142645	-1544	141101	14877	-614	14263	2055.30	19401.40	1656.85	2047.70	2597.89	25703.84	27759.14	3761.0	1.448	3.261	50.213	741.713	

Notes

GI and R – gullied and ravined land; US – upland with or without scrub; WL and ML – waterlogged and marshy land; S/A – land affected by salinity/alkalinity – coastal/inland; DP and DG – degraded pastures and degraded grazing; SC – snow covered, N – nitrogen;

P – phosphorus; K – potassium; MT – metric tonnes

The net present value of future net returns was obtained using two different discount rates of 4% and 10%.⁷

Table 11 gives the values of output and input for the year 2001/02. As the agricultural sector has subsidies going into it, in reality we should adjust the values for the subsidies as well (Table 12). As we could not get information on state-wise subsidies, we assumed the percentage of agricultural subsidies in the GDP and distributed this subsidy in proportion to the value added by the agricultural sector. This would not be far off the mark, as it is likely that the bulk of the subsidies are provided by central funding, the major state-specific subsidy being free or near-free irrigation or electricity for irrigation, and in a minor way for other agricultural operations. We deducted these subsidies from the respective GSDPs, and these adjustments are given in Table 13.

To find the net present value we made some assumptions about the discount rate, life of the agricultural plot, and value at the end of the lifetime etc. We assumed the lifespan to be 30 years and the discount rate to be five per cent. However, we explored the sensitivity of the estimates for different time frame (50 years) and discount rate (10%) as well (Table 14). All the entries in columns 2–7 in Table 10 were multiplied with the net present value of land to obtain the monetary estimates given in Table 15 (columns 2–7). For the purpose of estimating the value of depletion, we used a lower bound of 30 years. The estimates would have been quite different if a different life span was assumed. Moreover, we did not make any assumption about the value of agricultural land at the end of the lifespan of 30 years: it might remain in agriculture or may be converted to other uses, which should be included as well. The opening stocks were multiplied with the net present value of agricultural land from 1992 till 2030. The values of closing stocks were multiplied with the net present value of agricultural land from 2001 till 2030. As the difference in values could be because of the change in prices used, we introduced the revaluation term, which took into account the difference in values between the opening and closing stocks.

Similarly, the opening stock of pasture and grazing lands was multiplied with its net present value. Unfortunately, we do not have good published data on the price of fodder in different states. Along with agricultural output, we get by-products like straws and stalks and this value is recorded by CSO, so we used this figure as a proxy. We assumed that these by-products came from cereals, pulses and millets, oil seeds, sugar cane and fibres (as assumed by various demand projections on availability of the fodder). We extrapolated the value of these by-products per hectare from 1950/51 to 2001/02 into the future. Using the mean contribution of different states in the value of by-products, we estimated the net present value in different states. However, as these prices reflected the price of

⁷ We wanted to analyse the impact of using different discount rates.

Table 11

Value of inputs and output from agriculture in 2002/03 (rupees lakh)

State	Seed	Organic manure	Chemical fertilizers	Repair maintenance	Feed of livestock	Irrigation charges	Agriculture	Livestock	Electricity	Pesticides	Diesel oil	Total value of input	Total value of output
Andhra Pradesh	65967	26007	148503	16996	240810	2585	36535	43	15792	11273	19186	583697	2832180
Arunachal Pradesh	1900	152	18	227	1172	32	651	11	0	24	29	4216	50452
Assam	29735	5244	7518	3081	30883	46	15526	16	98	436	1659	94242	1203583
Bihar	55707	32916	64348	8470	192687	1811	27983	195	1830	1775	44240	431962	2169233
Goa	1386	173	623	43	1990	6	656	2	21	0	78	4978	50850
Gujarat	57562	8191	92886	15656	253838	5720	21032	7	19136	7174	54428	535630	1630403
Haryana	30042	21555	64941	6428	153249	2619	20099	3	23472	7795	31026	361229	1558075
Himachal Pradesh	10435	4229	2699	2169	27426	20	4180	1	191	307	256	51913	324063
Jammu and Kashmir	6237	30647	5482	516	41833	148	5482	14	994	121	842	92316	424936
Karnataka	53678	19667	98424	27117	164361	2600	31160	38	16001	4576	17517	435139	2415514
Kerala	6765	67749	20150	18468	48543	700	15485	55	1861	928	2508	183212	1200354
Madhya Pradesh	130991	33816	113812	30740	301129	3591	27613	16	26492	2534	37448	708182	2140561
Maharashtra	76420	31772	142232	44208	412053	5798	54498	76	33011	5641	42346	848055	4224688
Manipur	1512	418	931	55	4544	46	707	3	15	32	213	8476	54774
Meghalaya	3836	707	111	318	4620	4	1061	7	7	16	111	10798	82249
Mizoram	1395	45	30	30	1747	4	525	1	0	24	9	3810	40706
Nagaland	2874	398	52	178	4595	3	1518	3	0	16	11	9648	117711
Orissa	34388	4297	26213	10713	142555	839	16193	26	1894	1428	2451	240997	1255268
Punjab	38578	14299	105210	18358	150736	2143	29455	3	0	11039	51432	421253	2283305
Rajasthan	46473	101813	71263	17794	296413	4999	17458	21	17846	4963	47728	626771	1353332
Sikkim	1629	92	44	10	1327	1	599	0	0	24	0	3726	46463
Tamil Nadu	31419	60872	79449	11243	111094	474	19622	21	669	2792	13043	330698	1521059
Tripura	3010	699	1031	86	5614	2	1950	2	233	32	76	12735	151126
Uttar Pradesh	220522	18214	256597	37918	602264	20471	80622	121	48372	11499	152248	1448848	6249755
West Bengal	50549	23952	95532	11680	242123	611	49944	242	3425	5996	23847	507901	3871656
Andaman and Nicobar Islands	157	224	0	15	620	0	220	0	0	8	17	1261	17091
Dadra and Nagar Haveli	141	296	0	55	563	0	67	0	1	8	57	1188	5155
Daman and Diu	141	29	0	53	108	0	15	0	3	0	25	374	1188
Delhi	206	164	1235	1170	13091	63	761	9	160	97	206	17162	59010
Lakshadweep	2	9	0	1	40	0	29	0	0	0	2	83	2212
Pondicherry	250	310	1686	36	1074	10	219	2	160	129	55	3931	16973
Chandigarh	4	49	31	12	249	0	15	0	11	8	0	379	1135
Jharkand	13889	49	31	12	249	0	6470	0	11	8	0	20719	501558
Chhattisgarh	23385	49	31	12	249	0	7472	0	11	8	0	31217	579262
Uttaranchal	6933	49	31	12	249	0	6166	0	11	8	0	13459	477957
Total	963912	509005	1401050	283844	3453353	55346	481880	938	211695	80695	543094	7984812	38913838

Source Central Statistical Organization

Table 12

Extent of subsidies

<i>Agriculture subsidies (rupees crore)</i>							
Year	Fertilizer	Electricity	Irrigation	Others	Total	GDP	Percentage
1993/94	4562	2400	5872	1235	14 069	781 345	1.800613
1994/95	5769	2338	6772	1246	16 125	838 031	1.924153
1995/96	6735	1977	7931	1034	17 677	899 563	1.965065
1996/97	7578	8356	9221	895	26 050	970 083	2.685337
1997/98	9918	4937	10 318	983	26 156	1 016 399	2.573399
1998/99	11 596	3819	11 827	1182	28 424	1 082 472	2.625842
1999/2000	13 244	4276	11 487	1937	30 944	1 148 500	2.694297
2000/01	13 800	6449	13 681	854	34 784	1 902 998	1.827853

Note GDP – gross domestic product

Source Ministry of Agriculture (2004)

dry fodder and not green fodder, we used the assumption that 12 tonnes of green fodder is equivalent to 4 tonnes of dry fodder.⁸ Using this assumption we converted the dry fodder values into green fodder values. Here, instead of multiplying the opening stocks with the net present value in 1992 and the closing stocks with the net present value in 2001, we multiply the opening and closing stocks of pasture and grazing lands with the average net present value of these two years (Table 14).

As discussed earlier, changes in the quality of soil and land can be captured through the tonnes of soil lost or through the lost output approach. We attempt to value both in this paper to get an idea about how these estimates would differ. For the loss in production method, we used the net present value of agricultural land as discussed above. In the case of salinity, the NBSSLUP (1990) has estimated the loss of production at 25% across soil qualities and crops. However, some individual estimates put the losses at about 50% on an average for different crops and intensities of degradation (Reddy 2003). We took the former value as it gives an aggregate estimate for the whole of India. In the case of water-logging no aggregate was available, as waterlogging is mostly confined to command areas. At the micro level, the losses due to waterlogging are estimated at 40% in the case of paddy and 80% in the case of potato (Reddy 2003). Since most of the waterlogged regions dominantly grow paddy or wheat, we took the average of 40% loss in paddy production because of waterlogging. However, for the purpose of this analysis, we assumed that this lost productivity is already reflected in the present output and hence not considered. For the rest of the degraded land categories like gullies and marshy land, degraded pasture and uplands with or without scrubs, we assumed that entire value is lost.

⁸ (<http://dhad.nic.in/chapter6/chap6.htm>)

Table 13

Adjustments in the national accounts for 2001/02 (rupees million)

State	L = G/K													Depletion and degradation as per cent of ESDP (adjusted for subsidies)
	A	B	C	D	E	F	G=C+D+E+F	F=BC	G=F/B	H	I	J = H-I	K= F-I	
GSDP 2002/03	NSDP current prices 2002/03	Changes in quantity of land	Cost of land reclamation	Replacement cost of soil nutrients	Cost of sedimentation	Total adjustment for depletion and degradation	ESDP	ESDP/NSDP	Value added by agriculture	Agricultural subsidies	Value added by agriculture adjusted for subsidies	ESDP after adjusting for agricultural subsidies		
Andhra Pradesh	1607684.0	1439754.0	696.143	372.51	17671.75	974.61	-17720.62	1422033.38	0.988	283218.0	22753.75	260464.25	1399279.6	1.27
Arunachal Pradesh	19450.5	17395.1	0.288	137.29	253.27	1594.25	-527.57	18867.53	0.970	5045.2	405.33	4639.87	16462.2	3.20
Assam	354314.2	317208.0	6.828	209.12	4569.06	1520.53	-4980.48	312227.52	0.984	120358.3	9669.59	110688.71	302557.9	1.65
Bihar	897150.2	787033.0	251.675	106.41	12092.97	3770.32	-12054.12	774978.88	0.985	267079.1	21457.15	245621.95	753521.7	1.60
Goa	77711.0	67356.0	0.049	5.37	233.01	1.05	-243.71	67112.29	0.996	5085.0	408.53	4676.47	66703.8	0.37
Gujarat	1382850.0	1144047.0	-109.068	535.03	16180.81	495.86	-17359.93	1126687.07	0.985	163040.3	13098.67	149941.63	1113588.4	1.56
Haryana	658372.0	579374.0	4.653	36.49	5865.82	710.67	-5934.15	573439.85	0.990	155807.5	12517.58	143289.92	560922.3	1.06
Himachal Pradesh	159460.0	142024.0	39.018	103.45	967.51	420.26	-1135.38	140888.62	0.992	32406.3	2603.52	29802.78	138285.1	0.82
Jammu and Kashmir	147495.0	128052.0	2.528	80.39	1232.60	785.47	-1390.85	126661.15	0.989	42493.6	3413.94	39079.66	123247.2	1.13
Karnataka	1139292.0	1004063.0	-156.128	154.12	18215.44	1904.52	-18679.81	985383.19	0.981	241551.4	19406.25	222145.15	965976.9	1.93
Kerala	761819.0	696021.0	-24.522	7.96	3799.10	74.61	-3839.54	692181.46	0.994	120035.4	9643.65	110391.75	682537.8	0.56
Madhya Pradesh	1132756.0	974607.0	-244.546	720.12	32996.49	30799.46	-34681.28	939925.72	0.964	271982.3	21851.07	250131.23	918074.6	3.78
Maharashtra	2951911.0	2632253.0	-508.739	562.75	30426.61	9245.83	-32060.84	2600192.16	0.988	422468.8	33941.17	388527.63	2566251.0	1.25
Manipur	35312.0	32047.8	0	197.19	236.39	1.29	-630.77	31417.03	0.980	5477.4	440.05	5037.35	30977.0	2.04
Meghalaya	43429.0	38422.7	0.608	100.55	339.39	68.58	-539.88	37882.82	0.986	8224.9	660.79	7564.11	37222.0	1.45
Mizoram	17687.2	16346.1	0.470	60.10	109.75	1.01	-229.49	16116.61	0.986	4070.6	327.03	3743.57	15789.6	1.45
Nagaland	36793.6	34272.0	2.134	109.00	344.45	85.64	-560.32	33711.68	0.984	11771.1	945.69	10825.41	32766.0	1.71
Orissa	446844.5	387373.0	-315.571	145.48	10644.25	1043.81	-11250.77	376122.23	0.971	125526.8	10084.83	115441.97	366037.4	3.07
Punjab	707508.7	629677.5	110.792	18.33	6988.66	643.79	-6914.53	622762.97	0.989	228330.5	18344.08	209986.42	604418.9	1.14
Rajasthan	873717.5	768878.0	-920.135	756.29	28599.66	20002.11	-31032.37	737845.63	0.960	135333.2	10872.68	124460.52	726973.0	4.27
Sikkim	11527.3	10386.5	0	10.99	160.41	15.43	-182.39	10204.11	0.982	4646.3	373.28	4273.02	9830.8	1.86
Tamil Nadu	1537287.0	1367809.0	-429.325	171.15	9815.20	61.16	-10278.82	1357530.18	0.992	152105.9	12220.20	139885.70	1345310.0	0.76
Tripura	60616.9	56603.4	0.507	175.60	452.52	0.23	-803.22	55800.18	0.986	15112.6	1214.15	13898.45	54586.0	1.47
Uttar Pradesh	1796015.0	1568625.0	796.094	312.34	29141.66	14756.03	-28970.25	1539654.75	0.982	672771.2	54050.47	618720.73	1485604.3	1.95
West Bengal	1671371.0	1537807.0	-90.256	61.76	9276.57	1512.49	-9490.35	1528316.65	0.994	387165.6	31104.90	356060.70	1497211.7	0.63
Union territories	767080.0	706390.0	-1.324	1.64	241.45	0	-246.06	706143.94	1.000	10276.4	825.61	9450.79	705318.3	0.03
Total	19295454.0	17083824.0	-8878.250	4435.91	240854.79	90489.00	-258604.87	16825219.13	0.985	3891383.8	312633.98	3578749.82	16512585.2	1.57

ESDP - Environment adjusted state domestic product; GSDP - gross state domestic product; NSDP-net state domestic product

Source Computed

Table 14

Net present values of agricultural output and fodder used in the study

State	Agricultural output										Fodder									
	Mean share		4% discount rate		10% discount rate		5% discount rate		10% discount rate		Mean share		4% discount rate		10% discount rate		5% discount rate		10% discount rate	
	In total		NPV1992		NPV2001		NPV1992		NPV2001		In total		NPV1992		NPV2001		NPV1992		NPV2001	
	value	till 2032	till 2032	till 2032	till 2032	till 2032	till 2050	till 2050	till 2050	till 2050	value	till 2032	till 2032	till 2032	till 2032	till 2032	till 2050	till 2050	till 2050	till 2050
Andhra Pradesh	0.08	22645.65	22731.06	10549.02	11830.51	28326.42	30505.58	10990.61	12691.04	0.08	1900.39	1951.17	863.81	1016.18	2462.92	2751.82	899.77	1100.97		
Arunachal Pradesh	0	443.45	445.13	206.57	231.67	554.69	597.37	215.22	248.52	0	37.21	38.21	16.92	19.90	48.23	53.89	17.62	21.56		
Assam	0.02	7065.68	7092.33	3291.40	3691.24	8838.14	9518.06	3429.18	3959.74	0.02	592.94	608.79	269.52	317.06	768.46	858.60	280.74	343.51		
Bihar	0.06	17856.36	17923.71	8318.02	9328.50	22335.71	24054.01	8666.22	10007.04	0.06	1498.48	1538.52	681.13	801.27	1942.04	2169.84	709.48	868.13		
Goa	0	325.20	326.43	151.49	169.89	406.78	438.07	157.83	182.25	0	27.29	28.02	12.40	14.59	35.37	39.52	12.92	15.81		
Gujarat	0.05	15609.54	15668.41	7271.38	8154.71	19525.26	21027.34	7575.77	8747.87	0.05	1309.93	1344.93	595.42	700.45	1697.68	1896.82	620.21	758.89		
Haryana	0.01	1738.33	1744.89	809.77	908.14	2174.40	2341.68	843.67	974.20	0.01	145.88	149.78	66.31	78.00	189.06	211.24	69.07	84.51		
Himachal Pradesh	0.04	11352.39	11395.21	5288.28	5930.70	14200.19	15292.61	5509.65	6362.09	0.04	952.68	978.13	433.03	509.42	1234.67	1379.50	451.06	551.92		
Jammu and Kashmir	0.01	2770.10	2780.55	1290.40	1447.15	3464.99	3731.56	1344.41	1552.42	0.01	232.46	238.67	105.66	124.30	301.27	336.61	110.06	134.67		
Karnataka	0.07	20242.14	20318.48	9429.39	10574.87	25319.97	27267.84	9824.11	11344.07	0.07	1698.69	1744.08	772.13	908.32	2201.52	2459.75	804.28	984.12		
Kerala	0.03	9936.30	9973.77	4628.62	5190.91	12428.86	13385.02	4822.38	5568.49	0.03	833.84	856.12	379.02	445.87	1080.66	1207.42	394.80	483.08		
Madhya Pradesh	0.08	24091.31	24182.17	11222.45	12585.75	30134.72	32453.00	11692.23	13501.22	0.08	2021.71	2075.73	918.96	1081.05	2620.15	2927.49	957.21	1171.26		
Maharashtra	0.10	28382.45	28489.50	13221.39	14827.52	35502.32	38233.52	13774.85	15906.05	0.10	2381.82	2445.46	1082.64	1273.60	3086.85	3448.94	1127.71	1379.88		
Manipur	0	431.63	433.26	201.06	225.49	539.90	581.44	209.48	241.89	0	36.22	37.19	16.46	19.37	46.94	52.45	17.15	20.98		
Meghalaya	0	422.76	424.35	196.93	220.86	528.81	569.49	205.18	236.92	0	35.48	36.43	16.13	18.97	45.98	51.37	16.80	20.55		
Mizoram	0	229.41	230.28	106.87	119.85	286.96	309.04	111.34	128.57	0	19.25	19.77	8.75	10.29	24.95	27.88	9.12	11.15		
Nagaland	0	449.37	451.06	209.33	234.76	562.09	605.33	218.09	251.83	0	37.71	38.72	17.14	20.16	48.87	54.61	17.85	21.85		
Orissa	0.03	10069.33	10107.31	4690.59	5260.41	12595.27	13564.23	4886.95	5643.04	0.03	845.00	867.58	384.09	451.84	1095.13	1223.59	400.08	489.54		
Punjab	0.06	17407.00	17472.65	8108.70	9093.74	21773.62	23448.67	8448.13	9755.20	0.06	1460.77	1499.80	663.99	781.10	1893.17	2115.24	691.63	846.28		
Rajasthan	0.06	16877.81	16941.47	7862.18	8817.28	21111.69	22735.82	8191.30	9458.64	0.06	1416.36	1454.21	643.80	757.36	1835.61	2050.93	670.60	820.55		
Sikkim	0	162.60	163.21	75.74	84.94	203.39	219.03	78.91	91.12	0	13.65	14.01	6.20	7.30	17.88	19.76	6.46	7.91		
Tamil Nadu	0.06	17058.15	17122.48	7946.19	8911.49	21337.26	22978.74	8278.83	9559.70	0.06	1431.50	1469.74	650.68	765.45	1855.23	2072.85	677.77	829.32		
Tripura	0	845.52	848.71	393.87	441.71	1057.62	1138.98	410.35	473.84	0	70.95	72.85	32.25	37.94	91.96	102.74	33.59	41.11		
Uttar Pradesh	0.15	44877.42	45046.67	20905.23	23444.79	56135.12	60453.61	21780.34	25150.14	0.15	3766.05	3866.68	1711.84	2013.78	4880.82	5453.35	1783.10	2181.82		
West Bengal	0.08	22911.73	22998.14	10672.96	11969.51	28659.23	30864.00	11119.74	12840.16	0.08	1922.72	1974.09	873.96	1028.12	2491.86	2784.15	910.34	1113.91		
Union territories	0.01	1487.04	1492.65	692.71	776.86	1860.08	2003.17	721.71	833.37	0.01	124.79	128.13	56.72	66.73	161.73	180.70	59.08	72.30		
Total	1.00	295688.68	296803.87	137740.55	154473.24	369863.49	398317.22	143506.49	165709.42	1.00	24813.78	25476.79	11278.96	13268.42	32158.81	35931.05	11748.51	14375.59		

Note NPV - net present value

Source Computed

Table 15

Monetary accounts for agricultural land and pastureland

State	Changes in quantity				Changes in quantity				Changes in quality of land										Replacement cost per annum of				For 20 years Cost of reclamation	Per annum Cost of sediment removal
	Agricultural Land (rupees million)				Pastureland (rupees million)				Productivity losses due to land degradation (20- year period)															
	Opening Stocks	Changes in quantity	Revaluation	Closing stock	Opening Stock	Changes in quantity	Closing stock											N	P	K	Total			
								G and R	U/S	WL and ML	S/A	DP and DG	SC	Total										
Andhra Pradesh	212875.84	13200.50	7163.59	233239.92	5392.88	-670.36	4722.52	1431.26	41855.01	855.42	934.84	1465.53	28.51	46570.58	513.18	734.54	16424.03	17671.75	6070.426	974.61				
Arunachal Pradesh	59.74	5.58	2.07	67.39	4.31	-0.39	3.92	0	73.62	0.67	0	86.38	124.95	285.62	7.35	10.53	235.39	253.27	4359.495	1594.23				
Assam	17172.86	177.69	549.78	17900.33	672.74	-53.07	619.67	0	297.50	421.25	0	1429.79	5409.80	7558.34	132.68	189.92	4246.46	4569.06	4881.998	1520.53				
Bihar	114865.11	4410.49	3779.44	123055.03	1664.65	106.51	1771.15	911.06	4179.17	781.29	0.62	268.77	74.05	6214.97	351.17	502.65	11239.15	12092.97	4134.878	3770.32				
Goa	40.31	0.88	1.30	42.49	0.14	0	0.14	0	4.75	0.49	0	0.07	0	5.31	6.77	9.69	216.56	233.01	3399.979	1.05				
Gujarat	134354.52	-1962.81	4195.04	136586.75	2937.96	3.45	2941.41	1442.74	16971.54	1513.24	8157.90	551.81	0	28637.24	469.88	672.56	15038.36	16180.81	7252.519	495.86				
Haryana	5424.05	81.19	174.44	5679.69	13.44	2.30	15.74	7.85	85.74	15.12	33.98	114.46	0	257.15	170.34	243.82	5451.66	5865.82	3626.307	710.67				
Himachal Pradesh	5842.55	-183.54	179.31	5838.33	3124.80	852.67	3977.47	126.26	1165.06	6.50	1.06	4431.32	0	5730.20	28.10	40.21	899.19	967.51	4113.342	420.26				
Jammu and Kashmir	1816.27	44.78	58.97	1920.02	120.55	0.61	121.17	5.37	621.42	24.92	0	67.61	0	719.33	35.79	51.23	1145.57	1232.60	3945.609	785.47				
Karnataka	196136.37	-6872.41	5997.13	195261.09	5535.97	3921.69	9457.66	556.84	9180.03	24.20	173.30	180.00	0	10114.37	528.97	757.13	16929.34	18215.44	4481.909	1904.52				
Kerala	20080.19	-392.68	623.83	20311.34	79.02	-46.10	32.93	0	177.48	49.32	0	3.62	0	230.42	110.32	157.91	3530.87	3799.10	3418.762	74.61				
Madhya Pradesh	422853.76	-2488.39	13319.90	433685.30	14811.21	-1836.10	12975.11	16637.44	44456.74	45.47	268.40	664.79	0	62072.85	958.20	1371.52	30666.77	32996.49	8598.852	30799.46				
Maharashtra	459373.04	-9789.08	14245.80	463829.74	9198.08	627.00	9825.07	4402.37	44456.33	546.48	488.78	3494.44	0	53388.40	883.57	1264.70	28278.33	30426.61	7454.141	9245.83				
Manipur	54.27	0	1.72	55.99	2.29	0	2.29	0	0.03	5.11	0	0	0	473.13	6.86	9.83	219.70	236.39	4795.205	1.29				
Meghalaya	76.32	11.01	2.77	90.10	14.57	-0.09	14.48	0	88.41	0.23	0	0	0	80.49	169.13	9.86	14.11	315.42	339.39	4092.263	68.58			
Mizoram	13.39	5.98	0.61	19.98	0.35	2.38	2.74	0	0	0	0	0	0	78.73	78.73	3.19	4.56	102.00	109.75	3798.066	1.01			
Nagaland	82.34	38.75	3.84	124.92	12.81	-0.40	12.41	0	35.80	0	0	0	0	214.21	250.02	10.00	14.32	320.13	344.45	4153.742	85.64			
Orissa	57013.50	-4295.91	1670.44	54388.03	3381.13	-1323.53	2057.59	170.70	4200.23	139.32	35.48	12.34	105.91	4663.98	309.10	442.43	9892.71	10644.25	4419.058	1043.81				
Punjab	64711.30	1954.32	2112.40	68778.02	30.76	34.61	65.37	267.62	294.86	223.63	206.42	180.60	0	1173.12	202.95	290.49	6495.23	6988.66	3494.202	643.79				
Rajasthan	256766.90	-16265.85	7620.66	248121.71	6670.27	-253.54	6416.73	7627.32	22870.08	178.42	3144.94	18800.20	0	52620.97	830.52	1188.76	26580.38	28599.66	8861.900	20002.11				
Sikkim	13.87	0	0.44	14.31	2.66	0	2.66	0	2.33	0	0	0	0	5.95	8.28	4.66	149.08	160.41	3440.840	15.43				
Tamil Nadu	89062.11	-7813.81	2574.48	83822.79	1326.45	97.98	1424.43	0	913.49	0	0	0	0	913.49	285.03	407.97	9122.19	9815.20	3485.618	61.16				
Tripura	203.52	9.11	6.74	219.38	5.04	0	5.04	17.44	324.81	12.83	143.47	13.03	0.04	511.63	13.14	18.81	420.57	452.52	4638.179	0.23				
Uttar Pradesh	695671.59	14228.64	22494.31	732394.53	8496.22	69.40	8565.61	11493.64	12315.31	8158.86	17848.21	1827.68	0	51643.71	846.26	1211.29	27084.11	29141.66	5632.761	14756.03				
West Bengal	113059.54	-1584.56	3532.26	115007.24	344.18	-35.43	308.75	359.35	1423.74	1615.14	205.78	804.77	0	4408.78	269.39	385.59	8621.60	9276.57	3810.115	1512.49				
Union Territories	190.99	-20.03	5.42	176.38	11.50	-3.61	7.88	1.74	1.91	1.34	3.97	0.07	0	9.03	7.01	10.04	224.41	241.45	3372.827	0				
India	2867814.37	-17500.20	14894.50	2940630.80	63853.98	1495.98	931670.80	45459.00	205995.40	14619.25	31647.20	34397.31	6595.78	338713.90	6994.31	10011.26	223849.21	240854.79	123733.000	90489.00				

Gi and R - gullied and ravined land; US - upland with or without scrub; WL and ML - waterlogged and marshy land; S/A-land affected by salinity/alkalinity -coastal/inland; DP and DG - degraded pastures and degraded grazing; SC - snow covered; N-nitrogen; P - phosphorus; K - potassium

Source Computed

Another way to estimate the value of degraded land is the maintenance cost approach. Given the scale of land degradation and soil erosion, from time to time the government incurs some expenditure in repairing and rehabilitating the degraded land (for example) various watershed development programmes). We took the expenditures incurred from the Ninth Plan onwards during 1998–2002 to estimate the average cost incurred to rehabilitate the lands and deducted these from the estimates accordingly (Table 16).

To estimate the cost of the loss of nutrients through soil erosion, we used the replacement cost approach. As soil erosion represents a major cause of on-site nutrient loss, the volume of soil loss can be used to estimate the nutrient loss of the study area. This will help in estimating the value of loss in non-marketed environmental attribute (soil) occurring as a result of farming activities (marketed good). In order to estimate the value of loss in environmental attribute, we required data on macronutrient loss. This loss is specific to the site similar to the soil erosion data. We have very few estimates on the extent of nutrient loss due to soil erosion. Some site-specific studies on the extent of nutrient loss are available. A study by Verma, Bhola, Prakash, *et al.* (1983) for medium black soils indicated that on cultivated fallow land, of the 3.4 tonnes of soil loss per hectare the nutrient losses of nitrogen, phosphorus and potassium are 10 kg/ha (kilogram per hectare), 3 kg/ha, and 0.06 kg/ha respectively. Similarly, on other kinds of crops, depending on the management practice, out of the 1 tonne/ha loss of soil, the average loss in nitrogen, phosphorus and

Table 16

Total investments made in treating the degraded lands under various schemes

Department of Agriculture and Cooperation Scheme	Year of Start of scheme	Up to Eighth Plan		Ninth Plan (1997–2001)	
		Area treated (Lakh hectare)	Total investment (rupees Crore)	Area treated (Lakh hectare)	Total investment (rupees Crore)
1 NWDPR (National Watershed Development Project)	1990/91	42.33	967.93	21.19	792.15
2 RVP and FPR (River valley projects and Flood prone rivers)	1962/1981	38.89	819.95	8.17	470.14
3 WDPSCA (Watershed development Programme in shifting cultivation areas)	1974/75	0.74	93.73	1.30	63.40
4 Alkali soil	1985/86	4.84	62.29	1.00	13.75
5 EAPs (Externally aided projects)		10.00	646.00	5.00	1425.00
Department of Land Resources					
1 DPAP (Drought Prone Area Programme)	1973/74	68.60	1109.95	44.94	657.31
2 DDP (Desert Development Programme)	1977/78	8.48	722.79	24.77	518.67
3 IWDP (Integrated Wasteland Development Programme)	1989/90	2.84	216.16	35.65	496.32
Ministry of Environment and Forests					
IAEPS (Integrated Afforestation and Ecodevelopment Project Scheme)	1989/90	2.98	203.12	1.23	141.54

Source Tenth Five-year Plan report (2002–07)

potassium is 6 kg/ha, 1.31 kg/ha, and 0.54 kg/ha, respectively. Such estimates on site-specific studies are available. However, this cannot be extrapolated for the entire country. At the aggregate level, some efforts have been made to estimate the loss of available nutrients in the topsoil of each of the 24 soil types in India, the land area under each type, and the annual erosion rate in these soils by the Central Soil and Water Conservation Research and Training Institute. Based on this, they found that India lost nearly 74 MT of major nutrients annually due to erosion. However, 61% of the soil is moved and the effective loss is 39%. Of the remaining, the country loses 0.8 MT of nitrogen, 1.8 MT of phosphorus, and 26.3 million tonnes of potassium every year. According to another estimate by Government of India, the quantity of nutrients lost due to erosion each year ranges from 5.8 MT to 8.4 MT. As per the estimates of NBSSLUP (1990), the average topsoil loss due to erosion is 19.6 tonnes/ha. Of this, 1.39% is actual nutrient loss in terms of nitrogen, phosphorus, and potassium. We used the same proportion of nitrogen, phosphorus, and potassium (as given by NBSSLUP) lost through erosion in our study as well.

However, while computing the replacement cost, we did not compute the cost of the organic matter lost. This can be quite significant as can be seen by taking Punjab as an example. Due to intensive farming, the soil organic content went down to 0.2% in 1990 from 0.5% in 1960. Loss in soil organic carbon means wasteful application of fertilizers, loss in soil biological activity, and poor moisture retention. The soil yield loss function can be derived from empirical studies relating the productivity level of soils for a given land use/crop to the varying rates of erosion. Using this technique, the yield response functions measure the difference in yields between each soil type as compared to normal fertile soils. However, given the large number of crops that are grown in various parts of the country, it is difficult to come up with damage functions for all the crops in different states taking into account their specific conditions (for example, land use, crop management factor, altitude, slope, etc.). Though some studies have been done to estimate the organic carbon stock in Indian soils, the amount of organic carbon lost due to agricultural practices is not available for the entire country, thus limiting the use of this method. Moreover, the loss in organic matter is partly reflected through reduced profits due to increasing use of fertilizers for the same level of output.

We estimated the on-site cost of soil erosion by analysing soil nutrient expressed per tonne of soil basis. Due to the important role played by macronutrients in the soil and because most data are only available for these soil nutrients, the analysis has focused on nitrogen, phosphorus, and potassium. The values of available nitrogen, phosphorus, and potassium are estimated in terms of the equivalent levels of urea (46 0 0), single superphosphate or P_2O_5 (0 16 0), and murate of potash or K_2O (0 0 60). Valuation was done using the price of fertilizer per kilogram of

nutrient published by the Fertilizer Association of India (2000). The nutrients lost were multiplied with the price of fertilizer per kilogram of the nutrient to get the replacement costs.

To get the monetary estimates for the cost of sedimentation, we used the maintenance cost approach. There are mainly three methods – sediment sluicing, flushing, and dredging – to reduce the amount of sediments flowing into the reservoir, thereby prolonging the life of the reservoir. Sediment sluicing is the name given to a type of reservoir operation that pulls down the sediment level at the start of the flood season and then allows as much sediment-heavy floodwater as possible to pass through the dam before it has a chance to settle. This method can drastically slow down the rate of reservoir sedimentation but has been used successfully only in a few projects (Jauhari 1999). Sediment flushing is a method of washing out the accumulated deposits from a reservoir. Flushing out a long reservoir will require several months and in general will have little impact on a seriously sedimented reservoir. An obvious way of restoring reservoir capacity is dredging. However, this is extremely expensive and is normally viable only for small, urban water supply reservoirs where water consumers can afford the cost, and landfill sites are available to take the dredged sediment. A study by Mahmood (1987) cited in Bruijzneel and Bremmer (1989) cites the cost of dredging at 2–3 dollars per cubic metre in 1987; around 20 times more than the cost of providing additional storage in a new dam. Restoring the original capacity of a major reservoir would require the removal (and transport and dumping) of billions of cubic metres of sediment. We used this value (after adjusting for inflation) as an approximate cost incurred in removing sediments.

Table 15 gives the monetary estimates. In the monetary accounts the value of the change in quantity of land was observed over a 10-year period. Hence, we divided this value by 10. Similarly, for the extent of land degradation, as some land already existed in a degraded state before the study period, we made adjustment for this. The earliest estimate available was of the one by SPWD (1984) (Table 5). We could have taken the NRSA estimate as it is more reliable, but between the NRSA (1989) and NRSA (1999) reports, there was a difference in the coverage of area and scale as well. Hence, we decided to use the earlier estimate of SPWD (1984). We deducted the value of the land degraded from the already existing wasteland from our final estimates. Soil erosion estimates and sedimentation rates were already expressed on an annual basis, hence they were used without further adjustment. A summary of the assumptions we made is given in Annexure III.

Our ultimate objective was to adjust the national accounts for the degradation of the environment due to land use for agriculture and grazing (Table 13). The estimates in columns 6–9 of Table 13 were derived from the monetary asset accounts (Table 15). The total adjustments for depletion and degradation were computed by summing up the depletion and externality costs imposed by agriculture on the environment. The cost of externalities considered included the replacement cost of soil nutrients, cost of treatment of sediments from the waterways, and the cost of rehabilitating the degraded land. The reason we deducted the cost of rehabilitating the lands was because from time to time the government incurs some expenditure in rehabilitating these lands, which should be deducted. Moreover, any land if left untreated causes more harm than good to the environment. Assuming that these lands are treated in the course of time, the rent captured in the current year must be adjusted for the costs the sector imposes on the environment. We computed the ESDP (environment adjusted state domestic product) for all the states after adjusting for subsidies. From Table 13 it can be seen that in most of the states agriculture does impose significant external costs on the environment in the form of soil erosion and sedimentation of waterways. We did not consider the other impacts on human health due to the contamination of the waterways with pesticides and fertilizers, which can be quite significant. Despite this, the extent of impact on the environment is quite high. It can be seen that the costs range from 0.3% – 4.5% of the NSDP (net state domestic product) (adjusted for subsidies) in different states. It is surprising that in Arunachal Pradesh a high value of three per cent is recorded despite the region being more forested than agricultural. This may be because of factors like frequent flooding of the Brahmaputra followed by the nature of cropping pattern and uneven terrain. All these factors contribute to higher environmental costs elsewhere downstream, which should be deducted from the state product. Similarly in the states Madhya Pradesh, Orissa, and Rajasthan the gap between ESDP and NSDP is around three per cent to four per cent and in the other states it is about one per cent to two per cent. Our estimates indicate that if environmental externalities are taken into account, the contribution of agriculture to GDP is lower than what the estimates indicate. The results also indicate the proportion of NSDP that has to be set aside to maintain the environmental capital in tact.

Our study has certain limitations. We could not get data on the extent of contamination of waterways by fertilizers and pesticides, which in turn lead to many health hazards. We did not consider the net emissions of greenhouse gases from agricultural activities. In our replacement cost estimates for soil erosion, we did not address the loss of organic carbon due to agriculture and instead modelled only nitrogen, phosphorus, and potassium replacement. Our study did not consider other aspects of erosion, such as its effects on the soil's physical structure, moisture capacity, organic matter content, soil fauna, and the levels of many other nutrients. Moreover, the replenishment of soil nutrients by itself is

insufficient to restore original soil productivity. Erosion removes nutrients from the soil not only in the form available to plants but also from soil reserves of nutrients in 'fixed' form that are unavailable to plants. However, artificial fertilizers supply nutrients only in an available form. The replacement of soil nutrients with fertilizers therefore oversupplies nutrients in available form and fails to replenish soil reserves of fixed nutrients. Furthermore, artificial fertilizers are subject to volatilization and leaching, which makes them highly inefficient in replacing soil nutrients. These losses should be taken into account in the calculation of the replacement cost, though in practice they are ignored (Clark 1996). Regarding the cost of sedimentation, we used an estimate of the cost of sedimentation in reservoirs. Given that rivers have a different hydrology from reservoirs and the sediment load is different, this estimate may be much lower than the actual. Our estimate thus represents only a lower bound.

Agriculture has some positive externalities as well. In contrast to the studies done for developed nations our study did not consider the environmental benefits of agriculture largely because these are not material in an Indian context. Unlike Europe/the UK where the value of a 'farm and field' lifestyle and agritourism is significant due to its charm vis-à-vis the urban life, in India farms and fields neither have the same facilities nor is there similar demand for experiencing such a lifestyle.

Our results should thus be viewed with an active consciousness of the limitations of the available data. Data required for agricultural accounting is site-specific. It depends on the local conditions, topography, crop management factors, etc. However, in line with our stated objectives, we used aggregate estimates available from various secondary sources. Site-specific estimates can be used at a more disaggregated level of accounts (such as the state and its districts) at a later stage.

Annexure I

Standard definitions of various categories of land use adopted in the land utilization statistics.

<i>Forests</i>	Forests include all lands classed as forests under any legal enactment dealing with forests or administered as forests, whether state owned or private, and whether wooded or maintained as potential forestland. The area of crops raised in the forests and grazing lands or the area open for grazing within the forests should be included in the forest area category.
<i>Land under non-agricultural use</i>	This category includes all lands occupied by buildings, roads, and railways or underwater, for example, rivers and canals, and other lands put to uses other than agriculture.
<i>Barren and uncultivable land</i>	This includes all barren and uncultivable lands, such as mountains, deserts, etc. which cannot be brought under cultivation, except at a high cost, such land is classified as uncultivable, whether it is in isolated blocks or within cultivated holdings.
<i>Permanent pastures and other grazing land</i>	This category covers all grazing lands whether or not they are permanent pastures and meadows. Village commons and grazing lands are included under this category.
<i>Miscellaneous tree crops and groves</i>	All cultivable land which is not included under the net area sown, but is put to some agricultural use is included under this category. This means lands under Casuarina trees, thatching grass, bamboo bushes, and other groves for fuel, etc. which are not included under 'orchards' are classified under this category.
<i>Cultivable wasteland</i>	This category includes all lands available for cultivation, whether taken up for cultivation or not, or taken up for cultivation once but not cultivated during the current years and for the last five years or more in succession. Such lands may be either fallow or covered with shrubs and jungles, which are not put to any use. They may be assessed or unassessed and may lie in isolated blocks or within cultivated holdings. Land once cultivated, but not cultivated for five years in succession, shall also be included in this category after the period of five years.
<i>Current fallows</i>	This class comprises cropped areas, which are kept fallow during the current years only. For example, if any seedling area is not cropped again in the same year, it may be treated as current fallow.
<i>Other fallow land</i>	This category includes all lands, which were taken up for cultivation but are temporarily out of cultivation for a period of not less than one year and not more than five years. The reason for keeping such lands fallow may be any one of the following. 1 Poverty of the cultivators, 2 Inadequate supply of water, 3 Silting of canals and rivers, 4 Un-remunerative nature of farming, and 5 Unfavourable climate.
<i>Net area sown</i>	This term denotes the net area sown under crops and orchards, wherein the areas sown more than once in the same year only once.

Source Ministry of Rural Development (2000)

Annexure II

Commodities included in various groups

Cereals	Paddy, wheat, jowar, bajra, barley, maize, ragi, small millets, and other cereals
Pulses	Gram, arhar, urad, moong, masoor, horse gram, and other pulses
Oilseeds	Linseed, sesame, groundnut, rapeseed and mustard, castor, coconut, nigerseed, safflower, sunflower, soyabean, and other oilseeds
Sugar	Sugarcane and gur, other sugar, and total sugar
Fibre	Kapas, jute, sunhemp, mesta, and other fibres
Drugs and narcotics	Tea, coffee, tobacco, and other drugs and narcotics
Condiments and spices	Cardamom, dry chillies, black pepper, dry ginger, turmeric, arecanut, garlic, coriander, and other condiments and spices
Fruits and vegetables	Banana, cashewnut, potato, sweet potato, tapioca, onion, other horticulture crops, floriculture
Other crops	Rubber, guarseed, miscellaneous crops, and total other crops

Source CSO (2002)

Summary of working assumptions

We have used the following assumptions and methods in our study.

- Opening stocks were multiplied with the net present value of agriculture in 1992 and closing stocks with the net present value of agriculture in 2001. The difference between opening stock and closing stock gave the loss due to changes in quantity. However, the difference in value could also be due to the price changes between the opening and closing years. This had to be netted out.
- To compute the net present value, we used the value added by agriculture, published by Central Statistical organization.
- To estimate the present value of future net returns from agriculture, we used the data on the value of output in agriculture from 1950/51 to 2000/01. We fitted a linear model using time as the independent variable and the value of output as the dependent variable. Using this trend (time) variable, we extrapolated into future. We used a discount rate of 4% and 10%.
- For computing productivity losses due to land degradation we used the following assumptions.
 - For gullied and ravenous lands, upland with or without scrub – entire productivity loss.
 - For waterlogged / marshy land – 40% loss in productivity
 - For saline or alkaline lands – 25% loss in productivity
 - For degraded pastures and grazing land – entire productivity loss
- For estimating the value of soil erosion, we used the replacement cost method, i.e. the cost of replacing the nutrients in the soil by fertilizers.
 - Replacement cost of nitrogen = nitrogen lost in tonnes * price per kilogram of nitrate in urea * content of nitrogen in the fertilizer (urea)
 - Replacement cost of phosphorus = phosphorus lost in tonnes * price per kilogram of phosphorus in super phosphate * content of phosphorus in the fertilizer (super phosphate)
 - Replacement cost of potassium = potassium lost in tonnes * price per kilogram of potassium in potash * content of potassium in the fertilizer (potash)
- To estimate the cost of removing sedimentation, we used an estimate of 3 dollars. Converting this into rupees we got the cost of sedimentation as 122 rupees per tonne of sediment.
- We also estimated the value of land degradation using the maintenance cost method. For this using the expenditures incurred on various land development schemes, we estimated the average costs.

The accounts were adjusted as follows.

- Depletion = change in value of agricultural land + change in pastureland value
- Degradation (loss in productivity) = Total loss in productivity due to land degradation * adjustment for previously degraded land
- Total adjustment = Depletion – replacement cost of soil nutrients – cost of sedimentation – cost of rehabilitating the lands.
- ESDP = adjusted SDP after agricultural subsidies + total adjustment for depletion and degradation
- For agricultural subsidies, we computed the extent of subsidies going into fertilizers, pesticides, electricity, seeds, and water. The data is available only at the all India level. We estimated the extent of subsidies as a percentage of the GDP and distributed this among the states based on farm output value. We adjusted the NSDP in different states using the estimated subsidy.

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Green Accounting for India's States and Union Territories Project

In common with most developing nations, India faces many trade-offs in its attempt to improve the living standards of its people. The trade-offs emerge in various arenas, and several mechanisms for decision-making (including political institutions) have been developed to help choose between competing alternatives. Unfortunately, most of these decision mechanisms do not take into account intergenerational choices, i.e. trade-offs between the needs of the present and the future generations. In our view, it is urgently necessary to develop a mechanism to do this because many of the choices we make today could severely affect the welfare of our children tomorrow.

Therefore, we propose to build a framework of national accounts that presents genuine net additions to national wealth. This system of environmentally-adjusted national income accounts will not only account for the depletion of natural resources and the costs of pollution but also reward additions to the stock of human capital.

The Green Accounting for Indian States and Union Territories Project (GAISP) aims to set up economic models for preparing annual estimates of 'genuine savings', i.e. true 'value addition', at both state and national levels. The publication of the results will enable policy-makers and the public to engage in a debate on the sustainability of growth as well as make cross-state comparisons. It is hoped that a policy consequence of the project is gradual increases in budgetary allocations for improvements in education, public health, and environmental conservation, all of which are key elements needed to secure India's long-term future.

Monograph 2

This monograph is part of a larger effort to build an empirically-based framework that would allow policy judgements regarding the accumulation and depletion of natural and human capital. In this monograph, we have attempted to adjust national accounts for land degradation associated with agriculture. Specifically, we have considered the cost of soil nutrients replacement, sedimentation of waterways and rehabilitation of degraded land. For now, we have ignored other externalities such as the environmental contamination caused by the use of pesticides and fertilizers. Our study suggests that the 'true' economic contribution of agriculture in many states may be significantly smaller than generally assumed. Of course, we recognize that the results need to be treated with caution due to data limitations. Nonetheless, we believe that we have established a workable and consistent methodology as well as have identified gaps in the available data.

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