State of Environment Punjab- 2007

Punjab State Council for Science & Technology

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Foreword

Human well being is intricately linked with the well being of the environment. However, over the years, increased pressure on environment and natural resources has led to environmental damage, thus reducing the benefits of development. We need to understand that 'development', 'progress' and 'quality of life' are compatible only when nature's life support systems are protected and conserved and the actions of the present do not jeopardize progress in future. Hence, the words 'ecology', 'environment', 'economy' and 'sensitization' of citizen on sustainability have assumed critical importance.

Recent years have seen an increasing awareness of these issues. Various movements by citizen groups for conservation of ecosystems and restoration of natural balance are not just idealistic. Rather, they plead for adoption of saner and more practical measures to promote development which is sustainable in the long run. This includes thoughtful & thrifty use of resources, greater care in planning, adoption of less wasteful technologies, careful siting of projects and eco-friendly life styles and working methods. However, policy makers, administrators and implementers of projects need scientifically validated and collated data to be able to take such decisions. I hope the present report will act as an enabling tool in this direction and will empower our citizen with information about the health of their immediate environment to motivate them to take positive actions.

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Preface

The Ministry of Environment & Forests, Government of India's effort to bring out Status of Environment Reports (SoEs) of all states & U.Ts of the Country on a regular basis, is aimed at helping people understand problems of their immediate environment & promoting their participation in its protection. It recognizes the potential of people as a limitless resource to improve their environment for their own betterment by understanding the delicate linkages between ecology and economy.

The Punjab State Council for Science & Technology has been identified as the State Host Institute (SHI) for SoE Punjab with The Energy & Resources Institute (TERI), New Delhi, as the National Host Institute (NHI).

The SoE-2005 attempted to present an indepth analysis of three issues of environment *viz*. air, water & biodiversity, and their inter linkages. The second report in the series, SoE-2007, focuses on four major issues *viz*. Agriculture & Environment, Municipal Solid Waste, Hazardous Waste & Bio-Medical Waste Management. It tries to highlight the driving forces which affect the environment, the pressures exerted, the current status and impact and remedial action taken by government, institutions & people at large.

It is hoped that the present report, as the previous one, will be received with equal enthusiasm by all sections of society and will help to spur action at both, government and people's level by providing an information base for improved decision making.

Authors

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Abbreviations

AAQM	Ambient Air Quality Monitoring Program
ADI	Area Diversity Index/Acceptable Daily Intake
ADIRF	Agricultural Diversification, Infrastructure, Reserch and Development Fund
AIDS	Aquired Immuno Deficiency Syndrome
AP	Andhra Pradesh
As	Arsenic
Asr.	Amritsar
BC	Before Christ
B.Ed	Bachelor of Education
BBMB	Bhakhra Beas Management Board
BFRs	Brominated Flame Retardents
BHC	Benzene Hexa Chloride
BIS	Bureau a of Indian Standards
BMW	Bio-Medical Waste
BNL	Budha Nallah Lower
BNU	Budha Nallah Upper
BOD	Biochemical Oxygen Demand
Bt	*Bacillus thuringiensis*
C	Carbon
Ca	Calcium
CBP	Community Biogas Plant
CBWTF	Common Bio-Medical Waste Treatment Facility
CC	Carbon Credits
Cd	Cadmium
CDC	California Design & Construction
CDM	Cleaner Development Mechanism
CDRSRM	M/s Chowdhary Dhampat Rai Steel Rolling Mills, Mandi Gobindhgarh
CGWB	Central Ground Water Board
CH_4	Methane
CHC	Community Health Care
Cm	Centi meter
CO	Carbon Monoxide
Co	Cobalt
CO_2	Carbon Dioxide
COD	Chemical Oxygen Demand
CPCB	Central Pollution Control Board
Cr	Chromium
CRT	Cathode Ray Tube
CSE	Center for Science & Environment
CTI	Cleaner Technology Initiatives
Cu	Copper
D/S	Down-stream
DBO	Design Build & Operate
DBT	Department of Biotechnology
DDT	Dichloro Diphenyl Trichloroethane
Deptt.	Department
DO	Dissolved Oxygen
DPR	Detailed Project Report
DST	Department of Science & Technology
DTPA	Diethylene Triamine Penta-acetic Acid
ELTOP	Electronic Township
ENVIS	Environment Information System
EPA	Environment Protection Agency
eq.	Equivalent
ESI	Employee's State Insurance Corporation
ET	Evapo Transpiration
EU	European Union
FASS	Farmers Advisory Service Scheme
FCO	Fertilizer Control Order
Fe	Iron
Fig.	Figure
FYM	Farm Yard Manure
GDP	Gross Domestic Product
GEAC	Genetical Engineering Approval Committee
GEC	Ground Water Estimation Committee

GEF	Global Environment Fund
Gg	Gigagram
GHGs	Green House Gases
gm	Gram
GNDU	Guru Nanak Dev University
GoI	Governmet of India
GoP	Government of Punjab
GSDP	Gross State Domestic Product
GW	Ground Water
ha	Hactare
HBV	Hepatitis B Virus
HCE	Health Care Establishments
HCH	Hexa Chlorocyclohexane
HDR	Human Deveopment Report
Hg	Mercury
HIV	Human Immuno Deficiency Virus
Hons.	Honors
HP	Horse Power
HRD	Human Resource Department
HSD	High Speed Diesel
HW	Hazardous Waste
H/W	Head Works
HYVs	High Yielding Varieties
IARI	Indian Agriculture Research Institute
IDC	Institute of Development Communication
IFPRI	International Food Policies Research Institute
IISc	Indian Institute of Sciences
IMA	Indian Medical Association
INM	Integrated Nutrient Management
IPM	Integrated Pest Management
J&K	Jammu & Kashmir
Jal.	Jalandhar
JPPL	Jalkheri Power Plant Limited
K	Potassium
Kcal.	Kilo Calorie
KCC	Kisan Credit Card
Kg	Kilo Gram
KVKs	Krishi Vigyan Kendras
KW	Kilo Watt
KWH	Kilo Watt Hour
L&M	Large & Medium
LCC	Leaf Color Chart
LD	Lethal Dose
LDLo	Lethal Dose Low
LIS	Land Information System
LPG	Liquified Petroluem Gas
MAF	Million Acre Feet
Max.	Maximum
MC	Municipal Corporation
MCTW	Municipal Corporation Tube Well
M.Garh.	Mandi Gobindgarh
M.Sc.	Master of Science
MSIC	Modi Steels and Industrial Corporation, Mandi Gobindgarh
M.Tech.	Master of Technology
Mg	Magnesium
mg/l	Milligram per Liter
mham	Million Hectare Meter
min.	Minimum
mm	Milli Meter
MMT	Million Metric Tons
Mn	Mangnese
MoEF	Ministry of Environment & Forests
MPN	Most Probable Number
MRL	Maximum Residual Limit
MSP	Minimum Support Price
MSW	Municipal Solid Waste
MT	Metric Ton
N	Nitrogen
NA	Not Available/Not Applicable
Na	Sodium
NAAQM	National Ambient Air Quality Monitoring
NACO	National AIDS Control Organization

NBA	National Biodiversity Authority
NCERT	National Council of Education Research & Training
NEAC	National Environment Awareness Campaign
NEERI	National Environmental Engineering Research Institute, Nagpur
NFL	National Fertilizers Ltd., Naya Nangal
NGC	National Greens Corps
NGO	Non Government Organization
NGPL	Nimbuan Greenfields Punjab Limited
NHM	National Horticulture Mission
Ni	Nickel
NO_2^-	Nitrite
NO_3^-	Nitrate
NO_x	Nitrogen Dioxide
NPV	*Nuclear Polyhydrosis Virus*
NRSA	National Remote Sensing Agency
NSSO	National Sample Survey Organization
NWMP	National Water Monitoring Programme
OBCs	Other Backward Classes
P	Phosphorus
(P)	Provisional
PACL	Punjab Alkalies & Chemical Ltd.
PAFC	Punjab Agro Foodgrains Corporations
PAN	Protected Area Network
PAU	Punjab Agricultural University
Pb	Lead
PBB	Punjab Biodiversity Board
PCB	Poly Chlorinated Biphynyl
PCPL	Punjab Chemicals & Pharmaceuticals Ltd.
PEC	Punjab Engineering College
PGIMER	Post Graduate Institute of Medical Education & Research
PHC	Primary Health Centre
PHSC	Punjab Health Systems Corporation
ppb	Parts per Billion
PPCB	Punjab Pollution Control Board
Ppm	Parts per Million
PRSC	Punjab Remote Sensing Centre
P/S	Point Source
PSCST	Punjab State Council for Science & Technology
PSEB	Punjab School Education Board
PSEB	Punjab State Electricity Board
PSFC	Punjab State Farmers Corporation
PVC	Poly Vinyl Chloride
Q	Quick estimates
Qt	Quintal
R&D	Research & Development
RIL	M/s Rallis India Ltd.
R.O	Regional Offices
Rs.	Rupees
RSPM	Respirable Suspended Particulate Matter
SC	Schedule Caste
Se	Selenium
SGTB	Sri Guru Teg Bahadur
SLI	Starting lighting ignition
SMPB	State Medicinal Plants Board
SO_2	Sulphur Dioxide
SO_4	Sulphate
SOC	Soil Organic Carbon
SoE	State of Environment
SPCB	State Pollution Control Board
SPM	Suspended Particulate Matter
Sq km	Square kiolometer
SSI	Small Scale Industries
ST	Schedule Tribe
SW	Sewerage Water
T/ha	Tons per hactare
TDS	Total Dissolved Solids
TERI	The Energy & Resources Institute
TFDS	Total Floating & Dissolved Solids
TGA	Total Geographic Area
Th ha	Thousand hactare

TMT	Thousand Metric Tons
TN	Tamil Nadu
TPA	Tons Per Annum
TPD	Tons Per Day
TSDF	Treatment Storage & Disposal Facility
U/S	Up-stream
µg/gm	Micro gram per gram
UK	United Kingdom
UNDP	United Nations Development Progamme
UNESCO	United Nations Education Scientific & Cultural Organization
UP	Uttar Pradesh
USA	United States of America
w.e.f.	With Effect From
WHO	World Health Organization
w.r.t.	With Respect To
WTO	World Trade Organization
Zn	Zinc

Executive Summary

Punjab is a small state. It occupies only 1.57% of the country's total geographical spread and is a part of the Indo-Gangetic plains formed due to alluvial deposits by rivers and tributaries. Two major rivers, the Sutlej and Beas, traverse the state and Ravi and Ghaggar touch its northern and southern borders, respectively. This river pattern divides the state into three geographical areas popularly known as 'Majha' (North of Beas), 'Malwa' (South of Sutlej) and 'Doaba' (between Sutlej & Beas). On the basis of geomorphology the state can be divided into hills, table lands, intermontane valleys, piedmont plains, alluvial plains, sand dunes, palaeochannels, flood plains, wetlands and salt affected areas. Some of these areas like paleochannels, sand dunes, salt affected, wet/water logged areas and alluvial plains have experienced drastic changes in the past couple of decades due to human interventions. The state supports 2.4% of the country's population with a population density of 484 persons per sq km. The climate is typically subtropical. Land use in the state is shared by agriculture, forests, water bodies, built up areas, barren & uncultured land, etc.

The state, which has done remarkably well in the field of agriculture, is also on its way to rapid industrialization. About 0.2 million small scale industries and 562 large and medium industries are functioning in the state, out of which about 13000 units are under red category. With good road infrastructure vehicular population is also high. These are a major causes of air pollution in the state which is being monitored by Punjab Pollution Control Board at 7 locations in residential/commercial areas and at 12 locations in industrial areas. Data indicate that Suspended Particulate Matter is a major cause of concern with respect to air quality.

The water quality in the three major rivers (Ravi, Beas & Sutlej), as well as, in river Ghaggar is also being monitored by the Board. The state has six major canals (Upper Bari Doab Canal, Bist Doab Canal, Sirhind Canal, Bhakra Main Canal, Bikaner Canal & Ferozepur Canal Circle) with a total canal network of 14.5 thousand km and a complementary drainage network of eight thousand km. Besides surface water, groundwater is also a major source of water for irrigation and domestic use. The total surface and groundwater availability is estimated to be 3.13 mham. The deficit is being met

through over exploitation of groundwater resulting in water stress, especially is central districts of the state. Biological diversity in the state indicates that agricultural biodiversity conservation is as important as wild biodiversity to support its agricultural base. Amongst plants, about 1900 species of angiosperms have been recorded. Amongst animals, birds and fishes are important taxa, with more than 500 species of birds and 130 species of fishes being recorded from the state.

Infrastructure and educational facilities in the state are also well developed with a literacy rate of about 70%. The state has about 20,000 primary, middle, high & senior secondary schools, about 250 colleges and 125 technical & vocational institutions, over 30 professional colleges and 7 universities. However, environment education is, in general, inadequate, both, in the formal and non-formal sectors.

Agriculture and Environment

Punjab is the most stunning example of green revolution in India. In 1950-60s, the country was importing food grains putting a heavy drain on its foreign reserves. Hence, the policy to adopt agricultural practices which promoted grain production for National Food Security was followed. The Government of India invested more than Rs. 70 million to promote agriculture in Punjab, Andhra Pradesh, Tamil Nadu, Gujrat, etc. with Punjab emerging as the forerunner. The innovative and hard working farmers of the state adopted green revolution and made it a great success. As a result, by 1984, 1.8 m ha and 2.8 m ha areas were brought under paddy and wheat respectively. A committee for 'Diversification of Punjab Agriculture', set up in 1985, suggested diversification of crops, but as minimum support price for grains, subsidies for chemical fertilizers and irrigation facilities improved (in the interest of National Food Security), farmers in the state continued to bring more and more areas under wheat and paddy. The state is now at cross roads.

The state's agriculture has reached a platue under the available technologies and natural resource base and has become unsustainable and non profitable. Over intensification of agriculture over the years has led to overall degradation of the fragile agro ecosystem of the state and high cost of production and diminishing economic returns from agricultural practices are affecting the socio-economic condition of farmers. The major driving forces, which have affected the natural ecosystem and prevalent agricultural practices, are increase in demand of food grain due to increase in population, emphasis on agrarian economy, intensive and extensive agriculture as a result of green revolution, change in distribution of land holdings over the years, good irrigation facilities, procurement facilities for grain, easy availability of credit and subsidies for input intensive agriculture.

Seventy percent population of the state is engaged in agriculture and allied activities. However, with increase in population per capita availability of land and water is decreasing, thus affecting productivity per unit area. In the last five years, the production of food grains in Punjab has increased by only 2% as against 8.6 % rise in its population. As a result contribution of agriculture sector to the state's GDP has declined from 46.13% in 1993-94 to 37.07% in 2004-05. The services (tertiary) sector has taken over as the leading contributor to GDP with the largest share of 39%. Agricultural growth rate in Punjab has also slowed down from 5.0% in 1980s to 2.4% in 1990s and to 1.9% in 2000s.

More than 83% of the total land in the state is under agriculture (as compared to national average of 40.38%). Though the total land under agriculture increased by about 5% from the sixties to the

seventies but it remained more or less constant thereafter. However, barren, unculturable, fallow and other uncultivated lands have recorded a sharp decline between 1960-61 to 2004-05. Data also indicates that with increase in developmental activities, more and more good agricultural land is being used for industrial zones, housing complexes, transport systems, recreational purposes, etc. thus indicating that now marginal lands are being brought under the plough, thus adversely affecting the ecology. Further, out of about one million operational holdings, about 63% are smaller than 4 ha, indicating fragmentation of land. These farmers have been forced to over use their land by increasing croping intensity (croping intensity has increased from 126% in 1960-61 to 189% in 2005) and adopting the wheat-paddy mono-cropping practices. The various central and state level policies like Minimum Support Price (MSP) & effective procurement of selected crops, subsides on agricultural inputs & energy and available credit facilities over the years have played a key role in influencing the farmers to adopt this cropping pattern. Further, the policy of free electricity to farmers has resulted in excessive mining of groundwater resources due to cultivation of water-guzzler crops like paddy. The subsidy on fertilizers has encouraged the farmers towards excessive use of nitrogenous fertilizers with relative under-utilization of other fertilizers and micronutrients leading to unbalanced fertilizer use which, in turn, has adversely affected soil quality over time, apart from causing environmental pollution.

The above driving forces have induced several pressures on the agricultural pattern and environment. The area under paddy has increased twelve fold from 227 th ha in 1960-61 to 2642 th ha in the year 2006. This has led to decline in area under other major kharif crops like maize, bajra, jowar, sugarcane, groundnut, pulses, etc. The area under wheat has increased by two and a half times between 1960 to 2006, from 1400 th ha to 3468 th ha, respectively. This has been at the expense of area under other rabi season crops especially gram, barley, rapeseed, mustard and sunflower. Area under total pulses has also reduced sharply. Area under American cotton has been fluctuating around 5 % of total gross copped area of Punjab. Area Diversity Index studies also testify the same.

Further, in place of a broad range of traditional varieties which were naturally suited to the climatic and edaphic conditions of the state, farmers have adopted a narrow range of High Yield Varieties. The area under input intensive HYVs of wheat has increased from 69% in 1970-71 to 100% in 2000-01. Similarly, area under HYVs of rice comprised 33% of total area under rice in 1970-71. It increased to 100% in 2005. This has resulted in the loss of domesticated floral biodiversity of the state. Prior to the green revolution, 41 varieties of wheat, 37 varieties of rice, four varieties of maize, three varieties of bajra, 16 varieties of sugarcane, 19 varieties of pulses, nine varieties of oil seeds and 10 varieties of cotton were reported to be in use in Punjab. Data indicates that out of 47 post green revolution varieties of wheat released by PAU, only 5 are widely used. Similarly, out of 19 varieties of rice released, only eight are currently in use. Desi maize is however, still favored by farmers.

Data also indicates that there has been a decline (12.7%) in total livestock population in the state (from 9,858 million to 8.607 million) during the inter-censal period of 1997 to 2003 indicating an erosion in traditional integrated farming practices. The domesticated agricultural faunal diversity includes three breeds each of cows, buffaloes and sheep and two breeds each of goats and poultry. Out of these Murrah & Nili Ravi breeds of buffaloes, Hariana & Sahiwal breeds of cattle, Lohi, Nali, & Desi breeds of sheep and Beetal breed of goat are indigenous. Out of these, Sahiwal breed of cattle, Nilli Ravi of buffaloes, Lohi of sheep and Beetal breed of goat are threatened.

A high cropping intensity has also led to heavy requirement of water for irrigation purposes. The total demand of water for agriculture (based on cropping pattern & practices) presently stands at 4.38 mham against the total availability of 3.13 mham. Hence, the deficit of 1.25 mham is met through over-exploitation of under ground water reserves through tube wells, resulting in rapid decline of water table in the entire state (except south western parts due to limited extraction because of its brackish and saline quality). The present ground water development in the state is 145% with 75% of total area of the state being over exploited as per data provided by Central Ground Water Board (CGWB) & Department of Irrigation, Punjab (2004). Out of 137 blocks, 103 blocks are *overexploited*, 5 blocks are *critical*, 4 blocks are *semi critical* and only 25 blocks are in *safe* category. All the blocks of various districts like Amritsar(16 blocks), Jalandhar (10 blocks) , Moga (5 blocks), Kapurthala (5 blocks), Sangrur (12 blocks), Fatehgarh Sahib (5 blocks), Patiala (8 out of 9 blocks) and Ludhiana (9 out of 10 blocks) are reported to be over-exploited. The water table is thus depleting at an annual average rate of 75 cm in these districts and by 55 cm across whole of the state. In contrast, low lying pockets in south western districts of the state are facing a severe problem of water logging and resultant soil salinity. Till the eighties and nineties large areas of the state were water logged. However, the situation has improved considerably over the years due to expansion and improvement in drainage system in the affected areas. The water logged areas have come down sharply to 0.3% of total area of state in 2004 as compared to 4.7% in the year 1998.

The nutrient status of soil is also a key element in agriculture. The soils of Punjab are low in nitrogen (N) content, low to medium in Phosphorus (P) and medium to high in Potassium (K), except in Kandi belt which has low to medium K content. The exploitive agricultural practices in past two to three decades have put a tremendous pressure on the state's soils and resulted in steady decline in its fertility, both with respect to macro (NPK) and micronutrients (zinc, iron & manganese). As a result, consumption of chemical fertilizers has increased more than eight times in the past 35 years. Similarly, pesticide consumption has also increased (from 3200 MT in 1980-81 to 7300 MT in 1994-95, however, it came down to 5970 MT in the year 2005-06). The state has highest per hectare usage of fertilizers (192.5 kg) and pesticides (923 gm) in the country. Results of various scientific studies and surveys conducted by researchers, as well as, Government & Non Government Organizations, on pesticide residues in the environment and food products during 1970 to 2006, indicate the presence of residues of chemical pesticides like organochlorines, organophosphates, synthetic pyrethroids and carbamates in human beings, milk, water, vegetables and other food products at levels, which are dangerous for human and cattle health. Large scale use of pesticides to control pests has also resulted in the development of pesticide resistance in various insects and pests.

The rapid adoption of the green revolution technology in Punjab has also led to a sharp increase in farm mechanization. Presently, the state has double the number of tractors it requires (14% of total population of tractors of India). This is leading to over capitalisation in farm mechanization and its under-utilization due to decrease in farm size. Further, open field burning of straw after combine harvesting is a common practice in the state in order to ensure early preparation of fields for the next crop. Punjab produces around 23 million tons of rice straw and 17 million tons of wheat straw annually. More than 80% of paddy straw (18.4 million tons) and almost 50% wheat straw (8.5 million tons) produced in the state is being burnt in fields every year. Apart form affecting the soil

fertility, this also causes air pollution due to emission of large amounts of suspended particulate matter besides gases like CH_4, CO, NO_x, SO_2, etc. leading to various health hazards like respiratory, skin & eye diseases. Intensive agriculture is also a contributor to greenhouse gasses (GHG) like, carbon dioxide, methane and nitrous oxide causing climate change. At an all India level, emissions from the agriculture sector are reported to be 28% of the aggregate national emissions. These include emissions from enteric fermentation in livestock, manure management, rice cultivation and burning of agricultural crop residues.

Declining farm yield and income due to economic (high cost of inputs like, seeds, fertilizers, pesticides and farm labour, as well as, low MSP) and ecological (low productivity of soil, receding water table, etc.) factors is pushing marginal and small farmers into the vicious cycle of debt. The total indebtedness is around Rs. 240 million (50% each from Institutional and Non Institutional sources) for the loans taken for tractors, tubewells, farm chemicals, seeds, as well as, for other social needs. As per results of a recent survey, the indebtedness of Punjab farmers on an average is Rs. 41,576/- (against the national average of Rs. 12,585/-). 65.4% of farmer households are under debt in the state, next only to Andhra Pradesh (82%) and Tamil Nadu (74.5%).

In response to the above, the state government has been focusing on agriculture and allied sectors (like, irrigation, flood control, energy, etc.) in all its Plans. The total funds allocated for these sectors have increased over the years although the percentage plan expenditure has slightly decreased. The state is following the National Agriculture Policy, 2000, for agricultural development. The department of Agriculture, with the help of other departments, is implementing various programmes at district and block level. The Punjab Agricultural University (PAU), Ludhiana is making significant contributions in extension education, awareness and training with respect to latest technologies at district level through Krishi Vigyan Kendras (KVKs). The Kisan Melas organized by the PAU each year also offer good platform for information dissemination and sharing and are highly valued by the farmers.

The state government has initiated new programs to promote sustainable agriculture and has set up various institutions like, Punjab State Farmers Commission, four Agriculture Councils and State Medicinal Plants Board. The main objective of these institutions is to bring down the area under rice and wheat cultivation by implementing crop diversification. Punjab Biodiversity Board has also been notified in the state to conserve agricultural biodiversity and ensure sustainable use of its components.

Various resource conservation technologies like Agricultural Diversification, timely transplantation of Paddy, Zero Tillage, Ridge planting method of paddy, artificial recharge of ground water and micro irrigation techniques (drip & sprinkler) for conservation of water in agriculture are being promoted in the state. To promote diversification of agriculture, contract farming was launched in the state in 2002 covering 8.9 thousand ha area and 9100 farmers. By kharif 2005, an area of more than 19 thousand ha had been brought under crops like moong, hyola, sunflower, barely, maize, etc, involving more than 0.1 million farmers. The cultivation of floriculture, aromatic & medicinal plants and agroforestry are also being promoted in the state.

To promote water conservation and recharge of ground water several watershed development projects are being implemented in the state especially in kandi area. The Department of Irrigation has also

been making efforts to control water logging in south western Punjab and provide adequate canal irrigation in other areas. Wetland conservation and restoration of village ponds to promote ground water recharge is also being promoted.

Further, to protect the soil from chemical pollution twenty eight chemical pesticides and insecticides have been banned in the state for use in agriculture. Various other programmes like promotion of organic farming, vermicomposting, biofertilizers, Integrated pest management and biopesticides are being implemented to reduce the dependence of farmers on chemicals. With the introduction of Bt cotton in Punjab, the area under cotton has increased from 449 th hectares in 2002-03 to 560 th hectares in 2005-06 and production of cotton has almost doubled (from 1083 th bales of 170 Kg each to 2200 th bales during the corresponding years). Though experts indicate a cost saving of 50% on insecticides and labour, however, the technology needs to be adopted with care.

Several initiatives for proper management of agricultural waste have also been taken up for promoting alternative uses of straw instead of its burning in the fields. The Department of Science, Technology & Environment, Government of Punjab constituted a task force in September, 2006 for formulation of policy to mitigate the problem due to severity of burning of agricultural waste in the open fields after harvesting, and its consequent effects on soil, ambient air and health affects on living organism. The task force has recommended several alternate uses which are under consideration. Further, the National Horticulture Mission (NHM) programmes are being implemented in the state with the twin objective of crop diversification and income generation to farmers. The state Animal Husbandry Department has also taken up several initiatives to promote animal husbandry. The establishment of Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana is one such step. Punjab has become the first state in the India to introduce the Herd Registration Act, 2006, for an animal recording system.

In an effort to increase income of farmers the state government is also promoting value addition to agricultural produce by promotion of food processing industry. Several such units have come up with help of Punjab Agro Industrial Corporation (PAIC). The Glaxo Smithkline Plant at Nabha, Nestle Plant at Moga, Nijjer Agro Foods at Jandiala and Dumex Plant at Jagraon are other high-tech agro/ food industries adding value to primary agricultural products.

In order to provide free information to farmers across the state with respect to agriculture & allied areas including meteorology a Kisan Call Centre has been set up by the Department of Agriculture and Cooperation, Government of India with a toll free telephone facility. Several popular programs have been initiated with the help of media also.

The present report recommends that the state Agriculture Policy should attempt to identify suitable cropping systems as per different agro climatic zones and block wise crop adjustment programs need to be prepared taking into account crop diversification through sustainable low input agriculture. For this, there is a need to develop accurate land information system to serve as a monitoring tool using remote sensing technology. Also, since the state is in the process of industrialization and urbanization, state land use policy needs to be dovetailed with state agriculture policy and no diversion of prime agriculture land be allowed.

Further, water use efficiency needs to be increased. A 10% increase in irrigation efficiency can help to bring additional 14 million ha area under irrigation. The gap between irrigation potential created and actual irrigation achieved also needs to be bridged. This is possible by arresting siltation in canals and reservoirs and by remodeling, reconditioning, repair, maintenance and upgradation of existing canal system to provide assured water supply upto the tail end. Revival and renovation of village ponds and water bodies also needs to be taken up in a big way and the policy of providing free electricity for agriculture needs to be reviewed as it leads to excessive irrigation and withdrawal of groundwater.

The state's agricultural and domesticated animal biodiversity needs to be protected and traditional varieties reintroduced in the farming system. Further, a gene/seed bank needs to be set up to preserve such varieties. Facilities like appropriate support price, procurement systems, assured markets, crop insurance schemes and institutional loans on easy terms, etc. also need to be extended to farmers adopting crop diversification programs. In order to ensure better remuneration to farmers post harvesting and value addition facilities need to be promoted.

The facility of carbon credits provided by UNFCC needs to be availed by reducing area under rice cultivation, promoting organic farming, biogasification of agricultural waste, etc. The ownership of expensive agriculture machinery by individual farmers also needs to be discouraged as far as possible. These facilities should be provided by village cooperatives or private entrepreneurs on custom hiring basis. Further, intensive research and development activities need to be taken up to achieve major breakthroughs for increasing crop and livestock production to meet global challenges.

Municipal Solid Waste

The State has registered 45% increase in its population during the last two decades. It is the 7th most urbanized state in the country with urban population increasing to 33.95% against a national average of 27.8%. The state has two cities with more than 1 million population. The urban areas are managed by 5 Municipal Corporations (population 0.3 m and above), 25 Class-I Cities/Municipal Councils (population 50,000-0.3 m), 45 Class-II Municipal Councils (population 30,000-50,000), 29 Class-III Municipal Councils (population 15,000-25,000) and 29 Nagar Panchayats (population below 15,000). The state also supports a large number of floating population from other states like Bihar, Uttar Pradesh, Rajasthan and Andhra Pradesh due to better employment opportunities and better labour wage rate. Most of these labourers settle down in the suburbs or slum areas thus adding to urban pressure. All the 137 Municipal Bodies (including towns and cantonments) are collectively generating 2944.4 tons/day of municipal solid waste per day out of which 73% is being generated in 5 Municipal Corporations (i.e. Ludhiana, Jalandhar, Amritsar, Bathinda and Patiala) alone. Further, change in life style towards 'consume and discard' culture is also responsible for adding to municipal solid waste and changing waste composition. It also adds pressure on the existing municipal solid waste handling infrastructure, as well as, disposal sites.

The physical composition of municipal solid waste generated in the state indicates that on an average, it contains 13% recyclables, 36.44% compostable matter and 40-50% inert material. The municipal authorities have identified landfill sites for all 137 local bodies but only 37 local bodies have land

adequate to handle solid waste for 20 years. Further, many towns do not have proper collection and transportation facilities. Information on existing infrastructure is also not available for all areas and data needs to be generated in this respect. Specific studies on health impacts of improper handling and disposal of municipal solid waste are also not available.

Some efforts are however, being made by the government to promote better management of municipal solid waste (MSW) in the state. The Punjab Pollution Control Board, being the regulatory agency for ensuring proper implementation of Municipal Solid Waste (Management & Handling) Rules, 2000, is monitoring waste collection and treatment by local bodies. It has been observed that over the years the content of plastic waste, especially carry bags, in MSW has increased considerably which adversely affects the environment. They choke the sewerage channels and drains and cause serious health effects on animals when ingested along with food waste. Hence a persuasive, as well as, punitive approach has been adopted to control the manufacture of plastic carry bags from recycled plastics and to prohibit disposal of non-biodegradable plastic waste in public places, drains and sewers. The Government of Punjab has enacted "The Punjab Plastic Carry Bags (Manufacture, Usage and Disposal) Control Act, 2005" and Rules are under preparation. The State has also published public notices and distributed information, education & communication materials about the ecological and public health hazards of plastic carry bags.

Besides actions by PPCB, the Department of Local Government, Punjab has constituted District Level Committees under the chairmanship of Deputy Commissioners/Additional Deputy Commissioners to identify landfill sites for all the Urban Local Bodies. The process for preparation of detailed project reports and setting up of need based solid waste management facilities has been initiated in some towns. M/s National Building Construction Corporation Ltd. has developed a combined facility for three Municipal Councils of Hoshiarpur (Adampur, Alwalpur and Sham Churasi) under centrally sponsored scheme of the Ministry of Urban Development and Poverty Alleviation, Government of India. Site for setting up of treatment and disposal facility near village Pandori, District Hoshiarpur has been approved by the District Administration. Punjab State Council for Science & Technology has also prepared Detailed Project Reports (DPRs) for Mandi Gobindgarh (major industrial town of the state) and Kartarpur for adopting integrated approach for proper management after gainful utilization of reusable/recyclable components of waste. The study shows that the available infrastructure required for collection of municipal waste is grossly inadequate. There is an urgent need to look into and adopt environmentally sound management practices including low cost technologies particularly vermicomposting for making nutrient rich manure from the waste.

To promote the '3R' principle of 'reduce, recycle and reuse' and to ensure segregation at source, awareness programmes are being organized by PPCB, PSCST, municipal authorities and MoEF-GoI at different levels in the State.

The present report recommends that adequate infrastructure be strengthened by the government at the local bodies level, landfill sites be scientifically developed and awareness & trainings be provided at all levels to promote waste segregation at source.

Hazardous Waste

With increase in industries in the state, the amount of industrial waste, including that from hazardous industries, has also increased. The increasing quantities and diversity of hazardous waste is a cause of concern. The PPCB is implementing the Hazardous Wastes (Manufacturing & Handling) Rules, 1989, as amended in 2000 & 2003.

Major driving forces leading to generation of hazardous wastes includes increase in production of industrial goods, use of lead acid batteries and electronic equipments. Further, inefficient technologies also lead to generation of high quantities of such waste. Out of more than 0.2 million small and large industries in the state, 2628 industries are generating hazardous waste. The total quantum of waste generation is about 124,674 tons per annum. This includes 96,992 tons of recyclable and 15,108 tons of incinerable hazardous waste. Further, a number of lead acid battery manufacturing and assembling units, whether in the organized or unorganized sector, contribute to hazardous waste generation. Furthermore, the electronic wastes from discarded electronic devices like computers and their peripherals, communication equipments, electronic typewriters, nickel cadmium batteries, picture tubes, electronic medical equipments, etc. are hazardous in nature. However, specific data on generation of all types of hazardous wastes and their quantities is not available. This is, therefore, a cause of concern and warrants immediate action. Data on health impacts of hazardous wastes is also not available.

The PPCB is responsible for collecting data and inspecting and ensuring proper storage/disposal of hazardous waste in the state. All major hazardous waste units in the state have installed captive incinerators in their premises. Now a Common Treatment, Storage and Disposal Facility (TSDF) is being set up at village Nimbuan, District Mohali with an expected life of 15 years. The entire industrial hazardous waste from Punjab is proposed to be stored/disposed at this facility. The PPCB is currently laying emphasis on promotion of clean and no-waste industrial technologies/processes in the state and organizing awareness programs. The study recommends that adequate precautions be taken by personnel dealing with hazardous waste handling in the state and cleaner technologies be promoted.

Bio-Medical Waste

Bio-Medical Waste originating from hospitals & clinics including veterinary health facilities, research laboratories, etc. during diagnosis, treatment or immunization of humans or animals or research related activities, has direct environmental consequences. In general, this waste can be categorized as infectious or non-infectious. The Bio-Medical Waste (Management & Handling) Rules, 1998 (amended in 2000), notified under Environment (Protection) Act, 1986, have categorized this waste into ten different types for which specific disposal options have been prescribed under the Act.

The major driving forces with respect to bio-medical waste generation in the state include, better human and animal health care facilities to cater to increasing population, increase in use of disposables, and limited awareness amongst the paramedics regarding environmentally sound and scientific disposal. As the number of health care establishments, both in public and private sector, and doctors as well as paramedical staff has increased by almost twice since 1980, the doctor to patient ratio has improved

in the state. Animal health care facilities have also increased by 83% from 1970 to 2001. To further promote research and strengthen medical facilities/programmes, the state government has established Baba Farid University of Health Sciences at Faridkot and Shri Guru Angad Dev University of Animal & Veterinary Sciences at Ludhiana. Thus, as health care facilities have improved the generation of bio-medical waste has also swelled.

The Punjab Pollution Control Board is responsible for implementation of Bio-Medical Waste (Management & Handling) Rules, 1998 in the state. PPCB and Punjab Health Systems Corporation (PHSC) are monitoring its collection, management and treatment. As per PPCB about 4478 kgs bio-medical waste is being generated per day from about 35000 beds in hospitals/clinics, etc. in the state. This, however, does not include bio-medical waste generated by small clinics and dispensaries which do not require authorization from PPCB. Data regarding bio-medical waste generated from veterinary centres is also not available.

Bio-medical waste is required to be properly segregated at source. As per Rules four recommended colour coded (Yellow, Red, Blue/White translucent and Black) containers are required to be used for segregation and collection of such wastes in the hospitals. However, some hospitals/nursing homes/ clinics do not follow these rules causing, management and disposal/treatment problems. This can lead to adverse health effects and spread dreaded diseases like Acquired Immuno Deficiency Syndrome (AIDS). Data further indicates that only 5% doctors and 2% paramedical staff has been trained in bio-medical waste handling till date.

Furthermore, institutions producing bio-medical wastes are required to get it safely transported and properly treated before disposal as per Bio-Medical Waste (Management & Handling) Rules 1998, either on their own, or through tie-up with any of the Common Bio-medical Waste Treatment Facilities set up in the state. So far four common Bio-medical Waste Treatment Facilities have been established which collect, transport and suitably treat waste as per Rules and are monitored regularly by PPCB and a committee constituted by the government (comprising representatives from the Board and Department of Health and Family Welfare to ensure proper implementation of Rules in the state). All the hospitals managed by the PHSC and ESI dispensaries in the state have made an agreement with the Common Bio-medical Waste Treatment Facilities for collection, transportation, treatment and disposal of their wastes and have also obtained authorization from the PPCB as required under Rules. However, a few private HCEs (Health Care Establishments) are yet to obtain the authorization of PPCB. Awareness-cum-training programmes and distribution of resource material by PPCB and PHSC for proper management and handling of bio-medical wastes would be helpful in improving the bio-medical waste management system in the State.

It is recommended that more common waste handling facilities be set up and besides capacity building of medical staff, awareness amongst general public, especially rag pickers be also created on harmful effects of bio-medical waste to dissuade them for reusing medical disposables.

It is hoped that the present report will help to raise the level of awareness of general public with regard to various environmental issues, equip policy planners and implementing departments with scientific data and prompt them to take ecologically sound decisions to promote sustainable development in the state.

1

Introduction

1

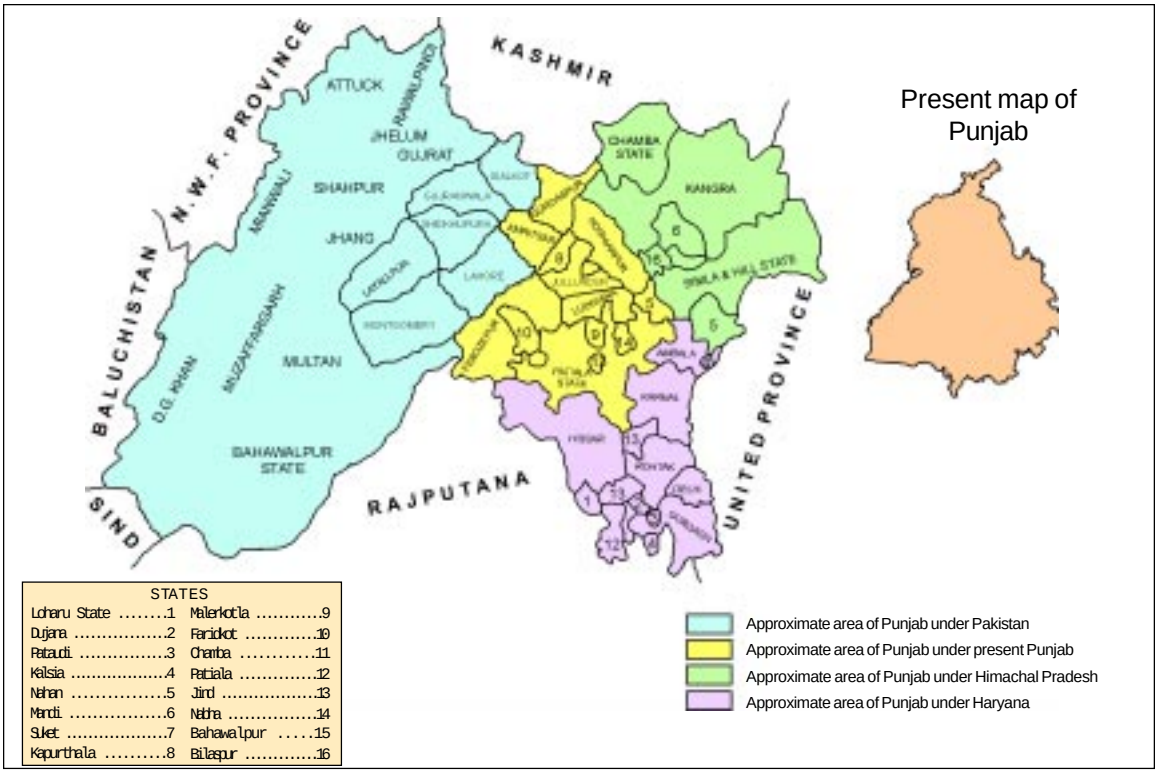
Introduction

'Punjab' – the name presents a picture of water aplenty, rich alluvial soil, green fields, ripe yellow grain, plenty of food & milk, hard working but fun loving people, phulkari, charkha, gatka, gidha, tappe, dhol and toomba. The state, which occupies only 50362 sq km of the country's total geographical area, has made a mark for itself throughout the world due to the ability of its people to take risks to adopt new technologies and to adapt to all types of environment and cultures, while closely guarding their own identity. It is believed that the present name 'Punjab' was assigned to the area in about 500 B.C., though the name 'Panchnada' is mentioned in the 'Mahabharata' and the 'Agrni Purana' (Gupta, 2004). Geographically located in the north west of the country, the state was on direct route of land invaders from Europe and the Middle East. The region was invaded and ruled by many different empires and races, including the Aryans, Persians, Greeks, Egyptians, Afghans, Mongols & Mughals. Around the time of the 15th Century, Guru Nanak Dev founded the Sikh religion, which quickly came to prominence in the region. The reign of Maharaja Ranjit Singh is one of the most important periods of medieval Punjab. The 19th Century saw the beginning of British rule, which led to the emergence of several heroic Punjabi freedom fighters.

In 1947, the state was split between east and west Punjab. The partition resulted in riots, terror and massive migration of masses creating problems of uncontrollable dimensions. However, the Punjabi spirit of tenacity and toughness sustained the uprooted people and they set to work to plough fresh fields. Today, the Punjab state comprising 1.57% of the country's total geographical area, contributes nearly 40% wheat and 60% rice to the central pool.

The State had a fairly large geographical spread prior to partition of the country surrounded by United Province (now Uttar Pradesh) in the east, Kashmir in the north, Baluchistan, North West Frontier Province and Sindh in the west and Rajputana in the south (Map 1.1). It extended from Simla and Kangra in north east to Rawalpindi and Attak in North West and from Gurgaon in South East to Bahawalpur and Dera Gani Khan in South West. Lahore was the capital city. The region also included 16 independent states. During the country's partition in 1947 a large muslim dominated area of the state went to Pakistan (Lahore and beyond). Chandigarh was identified as the new capital of

Map 1.1 Prepartition map of Punjab (1944)



Source: Carter, 2006

Indian Punjab. However, in November 1966, the state was again reorganized on linguistic basis into Punjab, Haryana and Himachal Pradesh with Chandigarh as the common capital of Punjab & Haryana, it itself being a union territory.

Administratively, the present Punjab was divided into 12 districts (Amritsar, Gurdaspur, Faridkot, Ferozepur, Kapurthala, Jalandhar, Ludhiana, Hoshiarpur, Ropar, Bathinda, Patiala & Sangrur) which were increased to 14 in 1992 (including Mansa & Fatehgarh Sahib), to 17 in 1996 (including Moga, Nawanshehar & Mukatsar) and to 20 in 2006 (Barnala, Mohali & Tarantaran) (Map 1.2).

Ecologically, the area under the present state of Punjab comprised grassland and cropland ecosystem interspersed with natural forest areas and orchards with abundant lotic and lentic water bodies. 'Shah Nahar', the first canal, was built in the 17th century to provide irrigation to Bist Doab and Majha regions, which were the most productive areas of the state. Subsequently, the Upper Bist Doab Canal was constructed in 1860-61, followed by Sirhind Canal in 1887 and the Bhakhra Canal System from 1948 to 1963. These irrigation facilities provided a big boost to agriculture (which was earlier rainfed) but adversely affected the natural forest ecosystem. Further, consolidation of land holdings and adoption of high yielding varieties resulted in the grand success of green revolution bringing Punjab to the international map and the forefront of economic progress. However, this

Map 1.2 Punjab districts

Prepared by: Punjab Remote Sensing Centre, Ludhiana

progress has not been sustainable and signs of fatigue in the ecosystem are now visible. The state, therefore, needs to take cognizance of the impacts on environment and adopt corrective measures.

DEMOGRAPHY

The total population of the state is 2.4% of the national population and is increasing by over 20 percent since the past two decades. The population density is 484 persons per sq km against the national average of 324. The sex ratio is, however, lopsided with 876 females per thousand males with increasing cases of female foeticide inspite of good literacy rate (69.95%). One major feature

of the state's demography is the high rate of increase in urban population (33.95%) in the previous decade indicating rural-urban migration. The urban population is further expected to increase to 45% by 2020 A.D. The state has 2 metro-cities (> 1 m population), 12 class I cities (>0.1 m population), 54 medium sized towns (>20,000 population), 89 small towns (< 20,000 population) and 12413 villages. About 28 towns habour slums comprising one fifth of their population. The growth of urban population has not been commensurate with growth of resources and services. The coverage of population with water supply and sewerage is given in Table 1.1 indicating a wide gap. The details are discussed in the 'State of Environment: Punjab, 2005' report (Tiwana *et al.*, 2005).

Table 1.1 Coverage of population with water supply and sewerage

Type of towns	Number of towns	Coverage of population in percentage	
		Water supply	Sewerage
Municipal Corporations	5	75	59
Municipal Councils Class I*	25	76	64
Municipal Councils Class II*	39	77	40
Municipal Councils Class III*	31	81	14
Nagar Panchayats	36	50	3
Total	**136**	**71.8**	**36**

*Classification as per Department of Local Government. *Source*: Punjab Water Supply & Sewerage Board (2002)

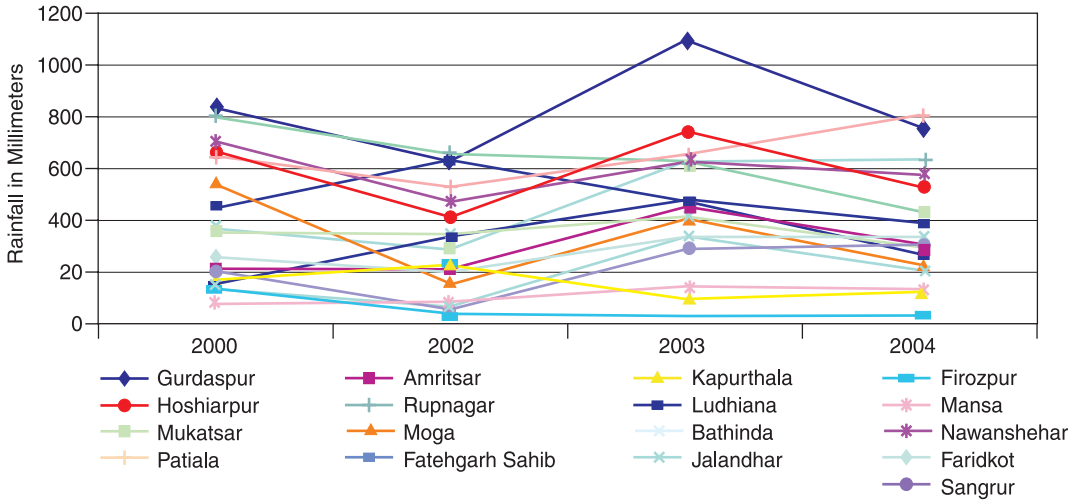
CLIMATE

As discussed in the previous report the climate of Punjab is typically subtropical with hot summers (temperatures reaching upto 47°C) and cold winders (temperatures reaching sub zero in certain areas). The average annual rainfall ranges from 58 cms in plains to 96 cms in sub montane regions and decreases from North to South. The climatic details have been discussed in the previous report. The district wise rainfall pattern in the past five years is presented in Fig. 1.1.

LANDFORMS

The state of Punjab is a part of the Indo-Gangetic plains formed by the fluvial deposits by rivers *viz*. Beas, Sutlej, Ravi, Ghaggar and their tributaries. Geomorphologically the area has been divided into eight geomorphic units *viz*. hills, table land, intermontane valley, piedmount plains, alluvial plains, sand dunes, palaeochannels and flood plains. A comparison of geomorphological maps of 1987 and 2004 prepared by PRSC (Maps1.3 & 1.4) shows that the anthropogenic interferences have modified the landforms to a great extent. There has been a sea change in the spread of palaeochannels, sand dunes, salt- affected and wet/waterlogged areas in the last seventeen years (Table 1.2). Sand dunes with a spread of 1498 sq km (2.97% of Total Geographic Area) during 1987 have reduced to 413 sq km (0.80% of TGA) due to levelling and being brought under irrigated agriculture. The geomorphogical

Fig. 1.1 Annual average rainfall (in mm) in various districts of Punjab



Source: Statistical Abstract of Punjab, 2005

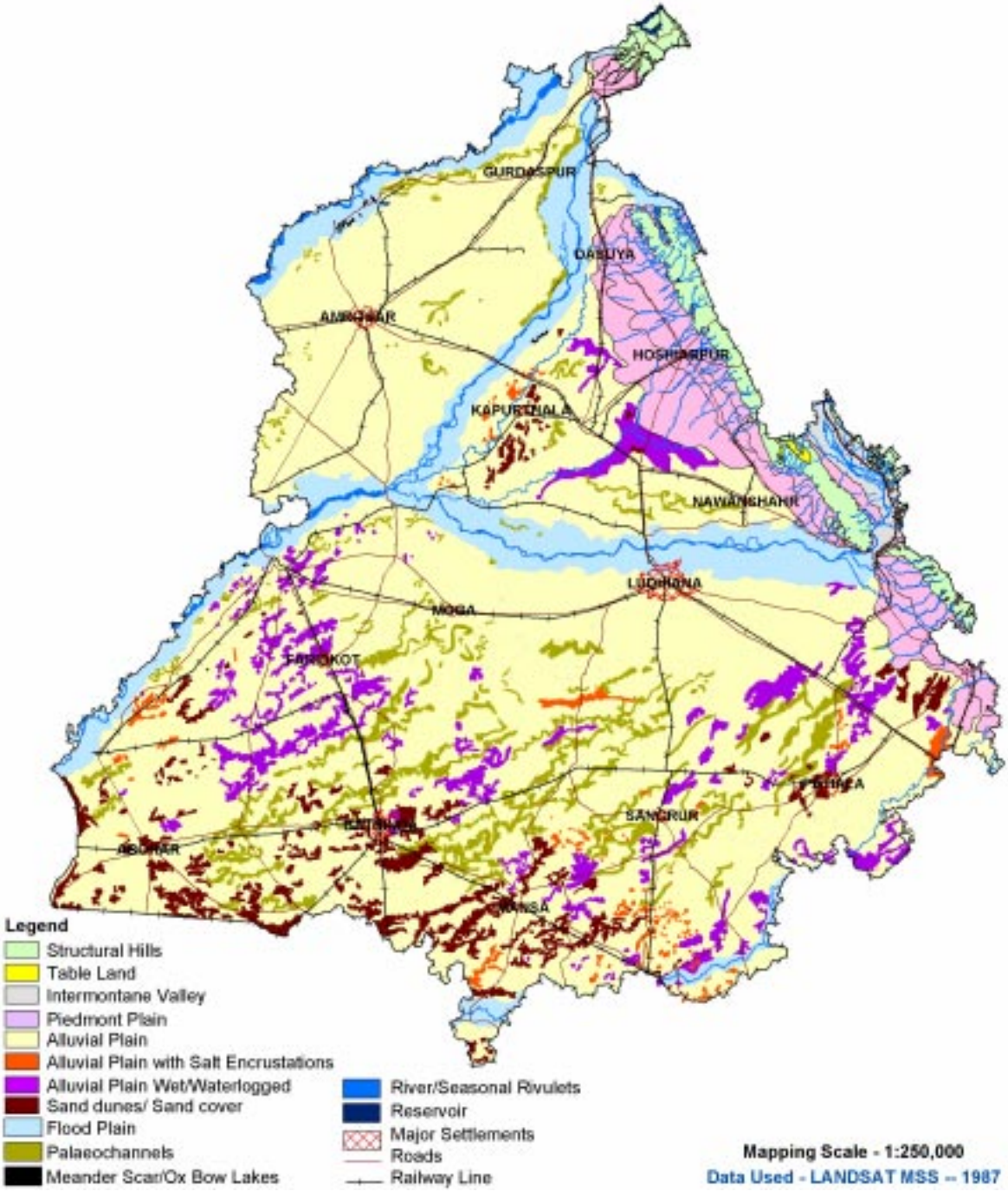
Table 1.2 Comparison of various landforms in Punjab (1987 & 2004)

Geomorphic unit	1987		2004	
	%	Area (sq km)	%	Area (sq km)
Hills	1380	2.74	1380	2.74
Intermontane Valley	331	0.66	331	0.66
Piedmont Plain	3323	6.60	3323	6.60
Table land	30	0.06	30	0.06
Alluvial Plain (AP)	33790	67.09	38728	76.90
AP Wet/Waterlogged	2183	4.33	853	1.69
AP salt affected	371	0.74	40	0.08
Flood Plain	5138	10.20	5138	10.20
Sand dunes	1498	2.97	413	0.82
Meander Scar/Ox Bow	176	0.35	4	0.01
Palaeochannels	2142	4.25	122	0.24
Total	**50362**	**100**	**50362**	**100**

Source: PRSC, 2004

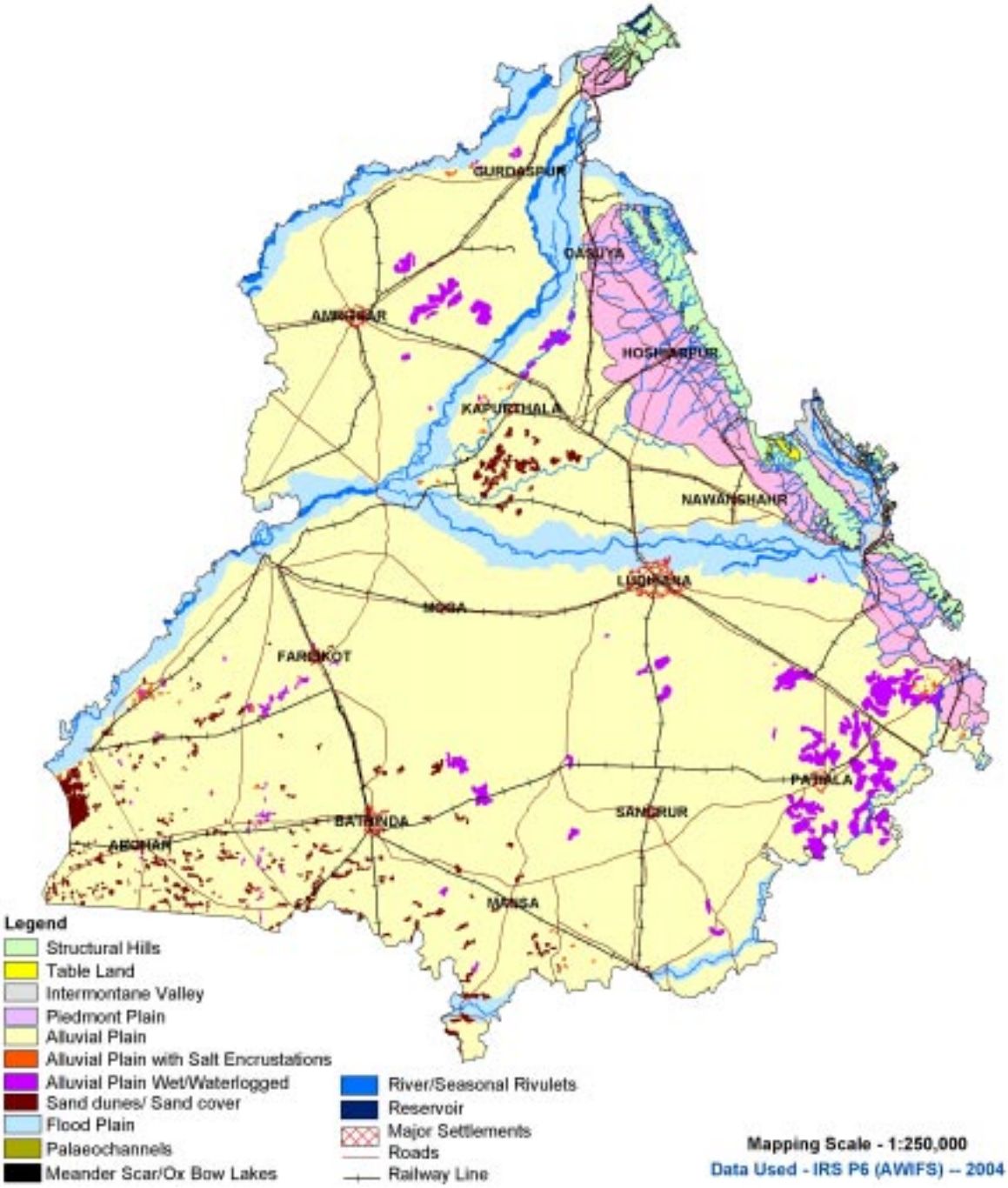
map (1987) shows a number of palaeochannels with a spread of 2142 sq km (4.25% to TGA) which was reduced to 122 sq km (0.24% of TGA) during 2004 (Maps 1.3 &1.4). Their spectral signatures are completely obliterated in 2004 satellite data as these have been brought under cultivation. Wet

Map 1.3 Punjab Geomorphology 1987



Prepared by: Punjab Remote Sensing Centre, Ludhiana

Map 1.4 Punjab Geomorphology 2004



Prepared by: Punjab Remote Sensing Centre, Ludhiana

land/waterlogged areas occupied 2183 sq km (4.33% of TGA) during 1987 which has been reduced to 853 sq km (1.69% of TGA). Alluvial plain with salt accumulation has been reduced from 371 sq km (0.74% of TGA) during 1987 to 40 sq km (0.08% of TGA) in 2004 as a result of reclamation and management of these lands for bringing them under productive use.

SOIL TYPES

Seven dominant soil types exist in the state (i.e. Fine Loamy Udic/Typic Haplustalfs, Coarse Loamy/ Typic Ustrochrepts, Fine Loamy/Typic Ustrochrepts, Coarse Loamy/Ustic Haplocambids, Fine Loamy/ Ustic Haplocabids, Ustic Torripsamments & Typic Ustipsamments). The Punjab Remote Sensing Centre (PRSC) is generating district wise data on soil types, physiography, geomorphology etc. The information on districts Ludhiana, Muktsar, Mansa and Faridkot has been discussed in the 'State of Environment: Punjab, 2005' (Tiwana *et al.*, 2005). Studies on other districts are in progress.

Studies on nutrient status of soils indicate that, in general, 50% of state's soils are low in nitrogen and 25% have low phosphorus content but potassium content is generally sufficient. Organic carbon is generally low. The details have been discussed in Chapter 2.

LAND USE

Land in the state is mainly shared by activities like, agriculture (84%) and forests (6.07%), besides built up areas, water bodies, wastelands, etc. (Table 1.3).

Table 1.3 Changes in land utilization pattern in Punjab (1960-61 to 2004-05) (Thousand Hectare)

	1961	1971	1981	1991	2001	2005 (p)**
Geographical Area	5036	5036	5036	5036	5036	5036
Net Sown Area	3757	4053	4191	4218	4250	4200
Total Cropped Area	4732	5678	6763	7502	7941	7932
Area under Forests	35	123	216	222	280	300
Land put to non agri. use	NA	416	436	343	410	458
Barren & Uncultivable land	NA	208	96	83	28	25
Total Fallow land	313	139	45	110	43	33
*Uncultivated land excluding fallow land	255	92	49	57	22	17

*Cultivable waste + Permanent pastures & grazing land + land under misc. tree crops/plantation
**Provisional

Source: Statistical Abstracts of Punjab (1991 & 2005)

AIR QUALITY

Punjab, which has done remarkably well in the field of agriculture, is also on its way to rapid industrialization through development of Small, Medium and Large scale industries. Around 0.2 million

small scale industries and 562 large and medium scale industries are functioning in the state. The growth in industry in the state is presented in Table 1.4 and Figs. 1.2 & 1.3. The slight decrease in number of Large & Medium industries is probably due to closure of some of these.

All industries are categorized into Red (highly polluting) and Green (Moderately, mildly or non-polluting) categories. The Red category industries require clearance from the environmental angle from Competent State Authority of the Department of Environment. As per latest data provided by the Punjab Pollution Control Board, a total of 13230 red category industries exist in Punjab out of which 10836 are in operation (Fig. 1.4). Out of these 2628 industries are producing hazardous wastes. Many of these industries use coal or rice husk as fuel. Together these contribute to suspended particulates, oxides of nitrogen and sulfur, organic compounds and other pollutants in the air.

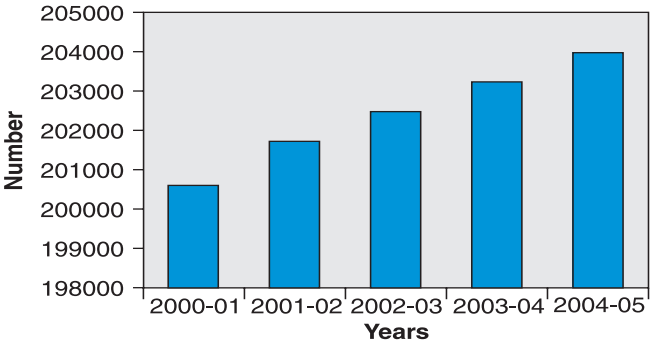
Table 1.4 Growth of industries in Punjab

Year	Small scale industries	Large scale industries
2000-01	200306	629
2001-02	201736	620
2002-03	202537	553
2003-04	203224	551
2004-05	203984	562*

*Provisional

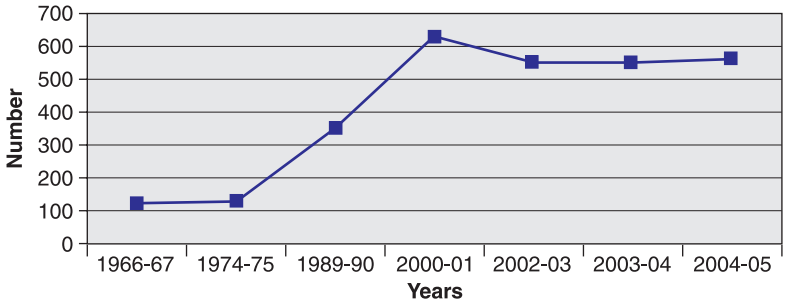
Source: Deptt. of Industries, 2006

Fig. 1.2 Growth of small scale industries in Punjab



Source: Deptt. of Industries, 2006

Fig. 1.3 Increase in number of Large & Medium scale industries in Punjab



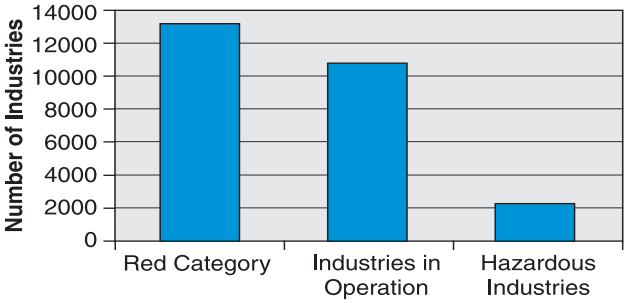
Source: Planning Commission, 2002 & Deptt. of Industries, 2006

Another factor which affects air quality is the increase in number of vehicles (Fig. 1.5) in the state (number of motorized vehicles in the state has increased by approximately 10.2 times from 3.6 lacs in 1980-81 to more than 37.0 lacs in 2004-05). A comparison of vehicular population of Punjab with

other states indicates that the state is amongst the top ten in India (Fig. 1.6) with a vehicular population density of one vehicle per 8 persons in the state *viz-a-viz* one vehicle per 200 persons in the country.

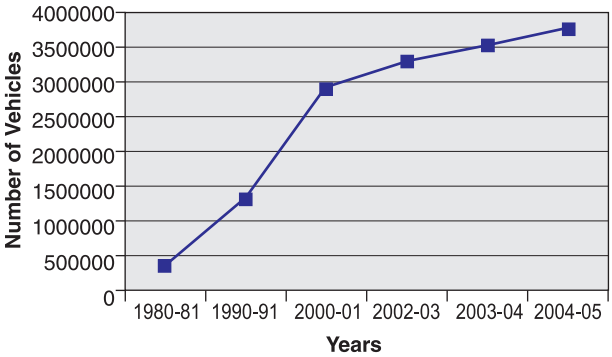
Pollution from agricultural activities also adversely affects the state's environment. The state produces about 23 million tons of rice straw, and 17 million tons of wheat straw every year, a part of which (about 81% of rice straw and 48% of wheat straw) is burnt in the fields to make way for the next crop. This causes severe air pollution especially during the months of March-April and October-November. The smoke also impairs visibility which can cause road accidents. The problem is especially severe during winter months when inversion phenomenon takes place. Though LPG is the main source of domestic fuel in urban areas, however, cow dung cakes and wood are still used in rural areas and slums. Further, due to high per capita income and adoption of modern life style, use of air conditioners and refrigerators in the state is increasing rapidly. This

Fig. 1.4 Status of red category industries in Punjab



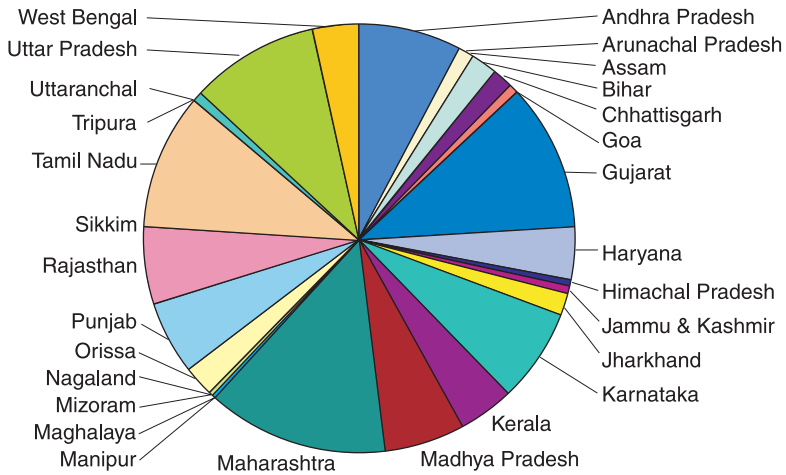
Source: PPCB, 2007

Fig. 1.5 Growth of vehicles in Punjab



Source: Statistical Abstract of Punjab, 2005

Fig. 1.6 Vehicular population of Punjab *vis a vis* other states of the Country



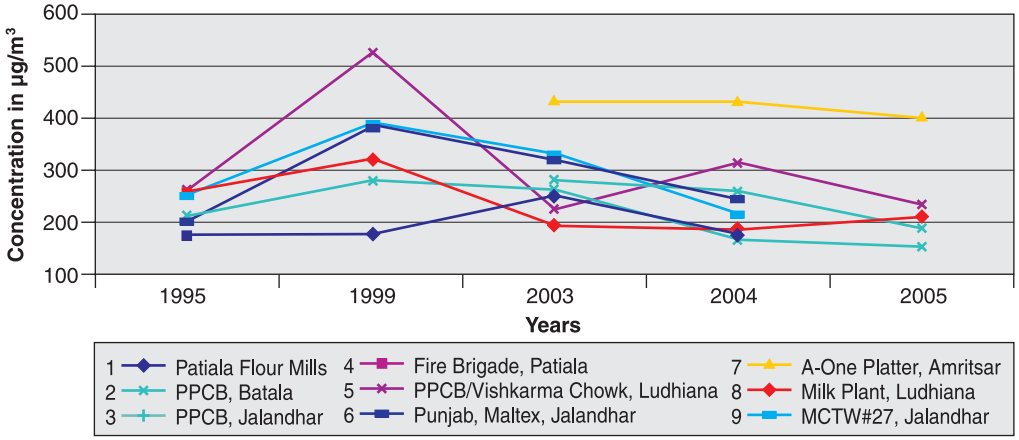
Source: Statistical Abstract of Punjab, 2005

contributes to air pollution by ozone depleting substances. Further, since the state faces acute power shortage problem, use of diesel/kerosene gensets in domestic and commercial sector is rampat.

The Punjab Pollution Control Board is monitoring the air quality of the state (SPM/RSPM, NO_x & SO_2) at 20 locations. Out of these nine are in residential-cum-commercial areas and 11 locations are in industrial areas.

As per data for the period 1995 to 2005, both, the 24 hourly and annual averages of SPM/RSPM at residential-cum-commercial monitoring locations (Fig.1.7) generally exceed the permissible limits for residential areas (24 hourly permissible limits for SPM and RSPM are 200 µg/m³ & 100 µg/m³ respectively and for Annual average permissible limits are 140 µg/m³ & 60 µg/m³) throughout the year. Maximum values have been observed in parts of Ludhiana followed by Mandi Gobingarh, Jalandhar and Amritsar w.r.t their permissible limits.

Fig. 1.7 Annual average SPM/RSPM concentrations in ambient air at residential-cum-commercial monitoring locations in Punjab



Permissible limit for SPM and RSPM: 140 µg/m³ & 60 µg/m³ respectively

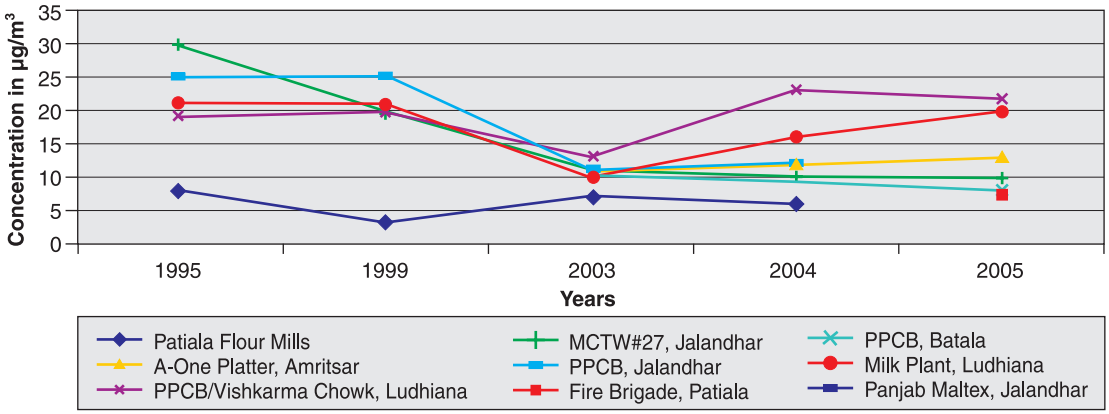
*Sr. No.	Pollutant Monitored	Year
1, 2, 4 and 7	SPM	1995 to 2005
5 and 8	RSPM	2003 and onwards
3, 6, and 9	RSPM	2004 and onwards

Source: PPCB, 2007

However, the SO_2 and NO_x levels (Figs. 1.8 & 1.9) at all locations remain within permissible limits.

In the Industrial areas, SPM/RSPM levels have been reported to be above permissible limits in Mandi Gobindgarh and in parts of Ludhiana with respect to annual averages. In other cities, however, these are below permissible limits (Figs. 1.10 & 1.11). From the year 2001 onwards, the monitoring of SPM at various stations in Ludhiana have been replaced by monitoring of RSPM. Similarly, in Mandi Gobindgarh and Jalandhar the monitoring of SPM was replaced by monitoring of RSPM in 2003 and

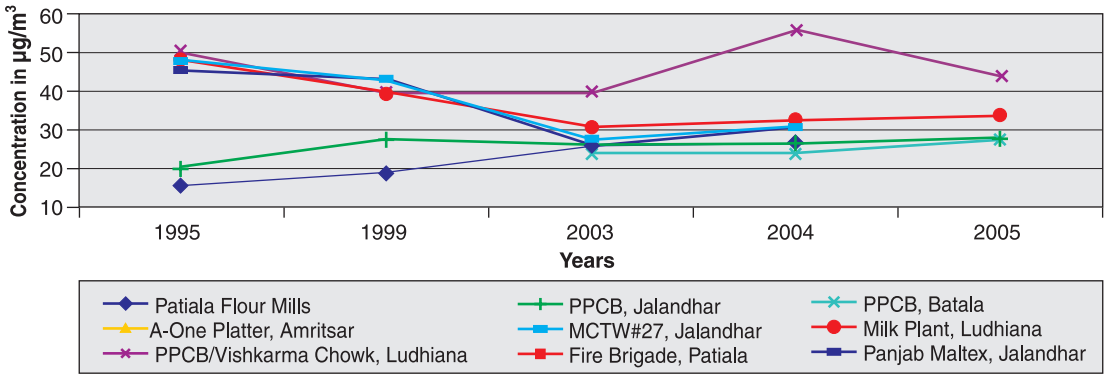
Fig. 1.8 Annual average SO_2 concentrations in ambient air at residential-cum-commercial monitoring locations in Punjab



Permissible limit: 60 µg/m³

Source: PPCB, 2007

Fig.1.9 Annual average NO_x concentrations in ambient air at residential-cum-commercial monitoring locations in Punjab



Permissible limit: 60 µg/m³

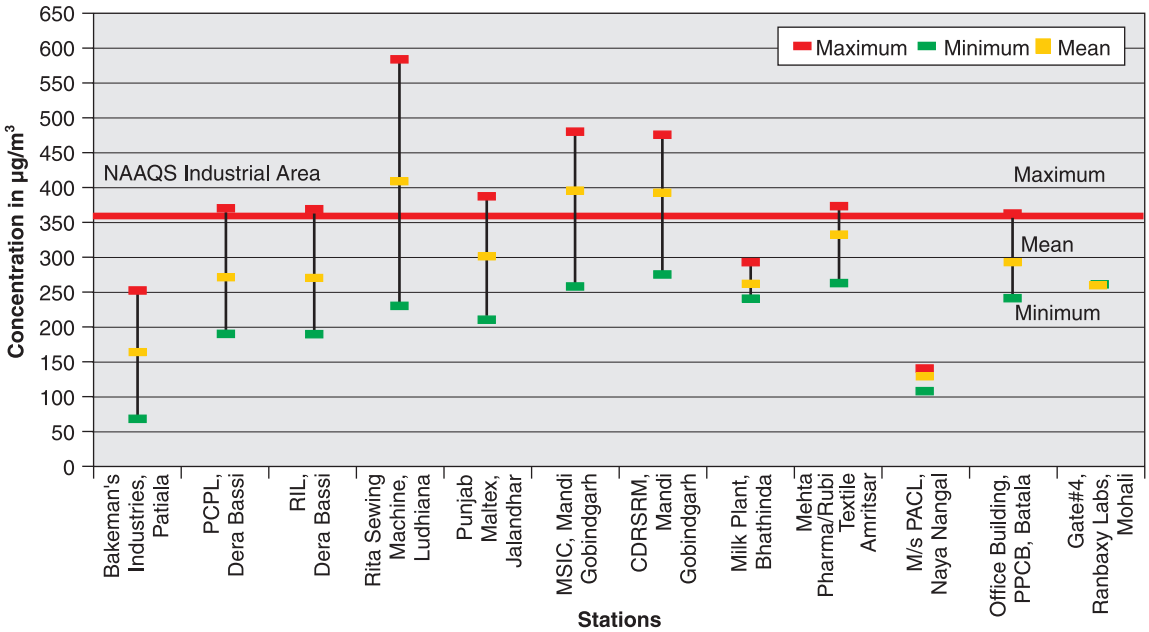
Source: PPCB, 2007

2004, respectively, as per guidelines of CPCB. A comparison of SPM/RSPM data with their respective permissible limits indicates that the concentration of SPM/RSPM are beyond the permissible limits at all the monitoring stations.

Figures 1.12 and 1.13 show the concentration of SO_2 and NO_x at various industrial locations of the state. Data indicates that the values are well within the permissible limits. The Central Pollution Control Board has categorized polluted areas on the basis of Exceedence Factor. It has categorized Mandi Gobindgarh in Punjab as 'Critically Polluted' area.

The state of air quality in the state has been discussed in detail, in 'State of Environment: Punjab, 2005'.

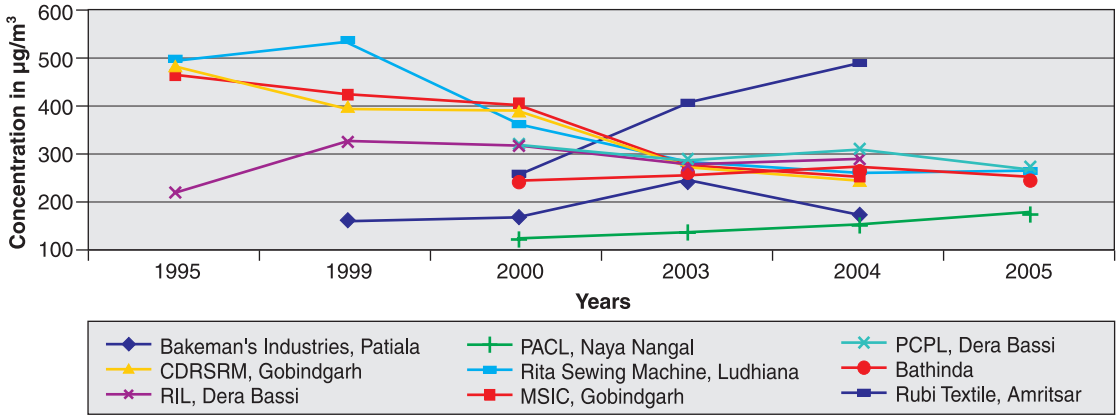
Fig. 1.10 Range and mean of annual averages of SPM (1994-2003) in ambient air at various industrial monitoring locations in the State



Permissible Limit: 360 µg/m³

Source: PPCB, 2007

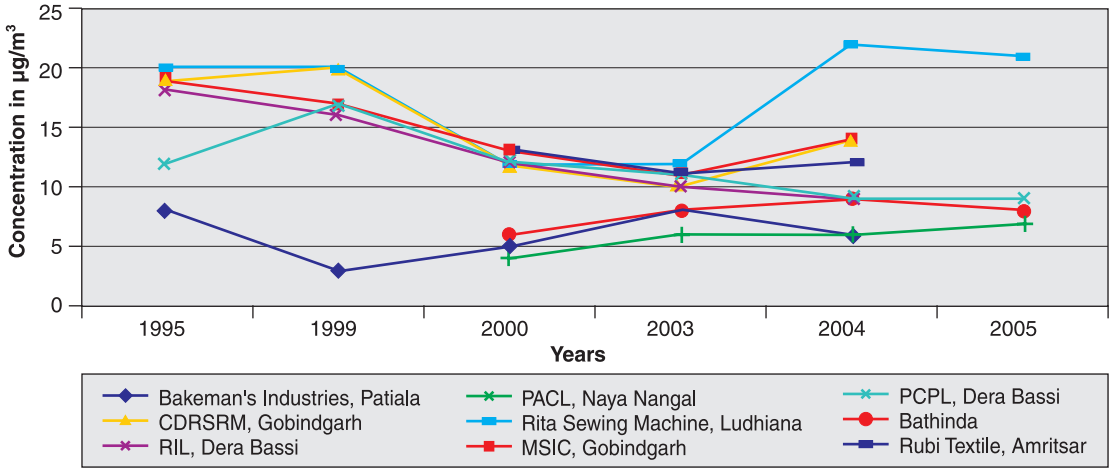
Fig. 1.11 Annual average SPM concentrations in ambient air at industrial monitoring locations in Punjab



Permissible limit: 360 µg/m³

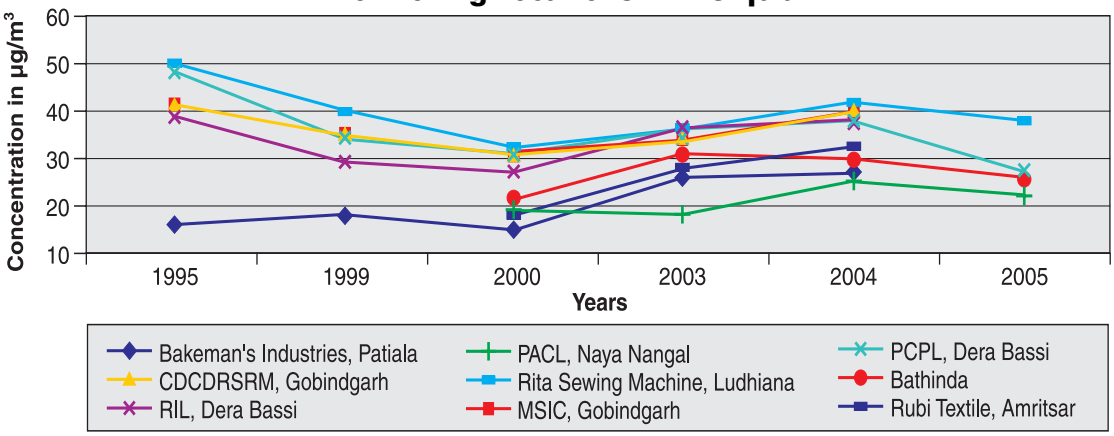
Source: PPCB, 2007

Fig. 1.12 Annual average SO_2 concentrations in ambient air at industrial monitoring locations in Punjab



Permissible limit: 80 µg/m³ *Source*: PPCB, 2007

Fig. 1.13 Annual average NO_x concentrations in ambient air at industrial monitoring locations in Punjab



Permissible Limit: 80 µg/m³ *Source*: PPCB, 2007

WATER AVAILABILITY & QUALITY

Three perennial rivers, namely the Sutlej, Beas and Ravi, flow through the state. In addition Ghaggar which is almost a seasonal river, flows through the south western part of Punjab. These have a water potential of about 14.54 Million Acre Feet (MAF) or 1.79 million hactare metre (mham). The state also has a network of canals (14500 km) and drains (800 km). Out of these six major canals are the Upper Bari Doab Canal; Bist Doab Canal; Sirhind Canal; Bikaner Canals; Bhakra Main Canal; and Ferozepur Canal.

The total surface and ground water resources in the state are estimated to be about 3.13 mham. With the ushering of green revolution and increase in paddy cultivation (which is not a staple crop of the area), ground water resources in the state are being used for irrigation to a large extent. The ground water is also a major source of drinking water. The total replenshable ground water resource in the state is 1.87 mham/yr out of which 0.18 mham is used for domestic & industrial uses. The net draft for irrigation is 1.61 mham/yr. The use of ground water in excess of recharge is leading to a fall in water table. The situation has reached alarming proportions in central Punjab. The issue has been discussed in detail in Chapter 2.

With respect to the quality of surface & ground water, it is affected when large amounts of wastes are released into the water by one or more of the following ways:

Direct point sources: Transfer of pollutants from industrial and municipal waste water disposal sites and refuse

Diffuse agricultural sources: Run off and soil erosion from agricultural lands carrying chemical fertilisers, herbicides and pesticides.

During the past two decades, rapid increase in population, urbanization, industrialization and agricultural practices have heavily polluted the fresh water resources of Punjab, both in physico-chemical and biological terms.

Surface water quality

Water quality has been classified as per Scheme for Zoning and Classification of lakes and rivers (surface/fresh water) as per Central Pollution Control Board. The prescribed tolerance limits with respect to certain selected parameters are given in Box 1.1.

Further, the Irrigation Department also classifies water for irrigation (Box 1.2).

Water quality in the aquatic ecosystems of Punjab is being monitored by the Punjab Pollution Control Board at 37 locations. The monitoring is being carried out under the National Water Quality Monitoring Program (NWMP) funded by CPCB. At each monitoring location, samples are collected every quarter (in the months of January, April, July and October) and analysed for physico-chemical parameters. The river wise data is as under.

River Sutlej

Many important towns like Nangal, Ropar, Ludhiana and Ferozepur are situated along this river. PPCB is monitoring the quality of the river for physico-chemical parameters (DO, BOD, COD, free ammonia, TDS and TFDS, pH, conductivity, alkalinity, hardness, Ca^{+}, Mg^{++}, Na^{+}, Cl^{-}, SO_4^{-}, NO_3^{-} and NO_2^{-}, etc.) at 15 locations under the scheme. In addition the Board has also initiated monitoring of certain heavy metals like Nickel (Ni), Chromium (Cr), Cadmium (Cd), Copper (Cu), Zinc (Zn), Lead (Pb), Iron (Fe), Arsenic (As) and Mercury (Hg)) and pesiticides (DDT, Endosulfan, Aldrin and BHC) since 2002 at five locations (Sutlej U/S Nangal, Sutlej D/S Rishabh Paper Mills, Sutlej D/S Budha Nallah, Sutlej D/S East Bein and Sutlej D/S Harike Lake) in water and sediments.

Box 1.1 Primary water quality criteria for various uses of fresh water

Constituent	Designated Best Use Class				
	A	B	C	D	E
1. Dissolved oxygen, mg/l, Min.	6	5	4	–	–
2. Biochemical Oxygen Demand, mg/l, Max.	2	3	3	–	–
3. Total coliform Organisms MPN/100 ml, Max.	50	500	5000	–	100
4. pH Value	6.5-8.5	6.5-8.5	6-9	6.5-8.5	6-8.5
5. Free ammonia (As N) mg/l, Max.	–	–	–	1.2	–
6. Electrical conductivity us/cm max.	–	–	–	–	2250
7. Sodium absorption ratio, Max.	–	–	–	–	2.6
8. Boron, mg/l, Max.	–	–	–	–	2

Min. minimum level desired Max. maximum allowable value

- If the coliform is found to be more than the prescribed tolerance limits the criteria for coliform shall be satisfied if not more than 20 percent of samples show more than the tolerance limits specified and not more than 5 percent of samples show values more than 4 times the tolerance limits. There should be no visible discharge of domestic and industrial water into class 'A' water. In case of class 'B' and 'C' the discharges shall be so regulated/treated as to ensure maintenance of the stream standards.
- If the ambient water quality of the rivers is examined in the light of the tolerance limits prescribed, the classification arrived at on the basis of a single parameter may not necessarily be the same as that based on other parameters. In such cases the lowest class scored in respect of any one of the criteria should normally indicate the water quality status of a particular reach of the river.

A: Drinking water sources without conventional treatment but after disinfection.

B: Organised outdoor bathing

C: Drinking water source with conventional treatment followed by disinfection

D: Propagation of wild life and fisheries

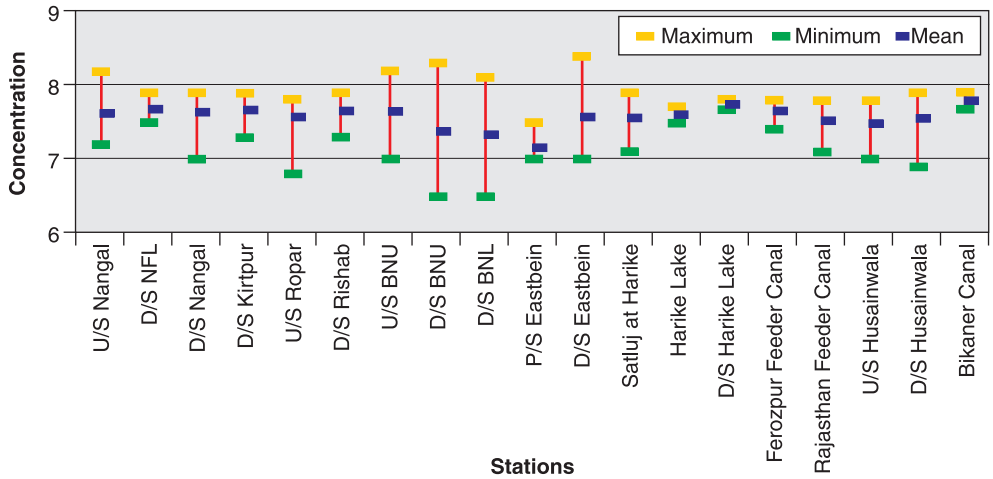
E: Irrigation, industrial cooling and controlled water disposal

Box 1.2 Classification of water quality for use in irrigation

Utility for Irrigation	Electrical Conductivity (EC)	Residual Sodium Carbonate (RSC)
Fit	< 2000 mmhos	< 2.5 mg/l
Marginally fit	2000- 4000 mmhos	2.5- 5.0 mg/l
Unfit	>4000 mmhos	> 5.0 mg/l

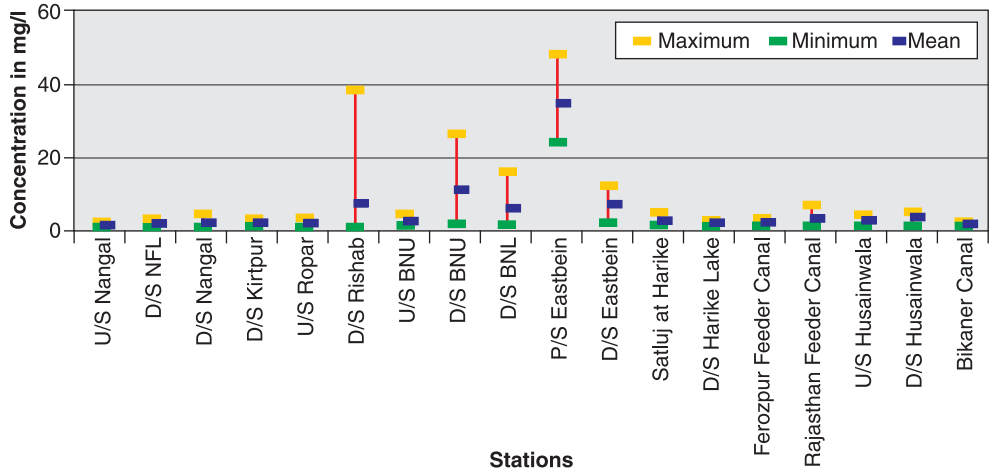
These micronutrients are monitored only once in a year i.e in April. Parameters like (pH, BOD, DO and feacal coliform) indicate that the water quality is poor downstream Ludhiana upto Harike (Figs. 1.14 to 1.17).

Fig. 1.14 pH range at different monitoring locations at river Sutlej (1988-2005)



Source: PPCB, 2007

Fig. 1.15 BOD range at different monitoring locations at river Sutlej (1988-2005)

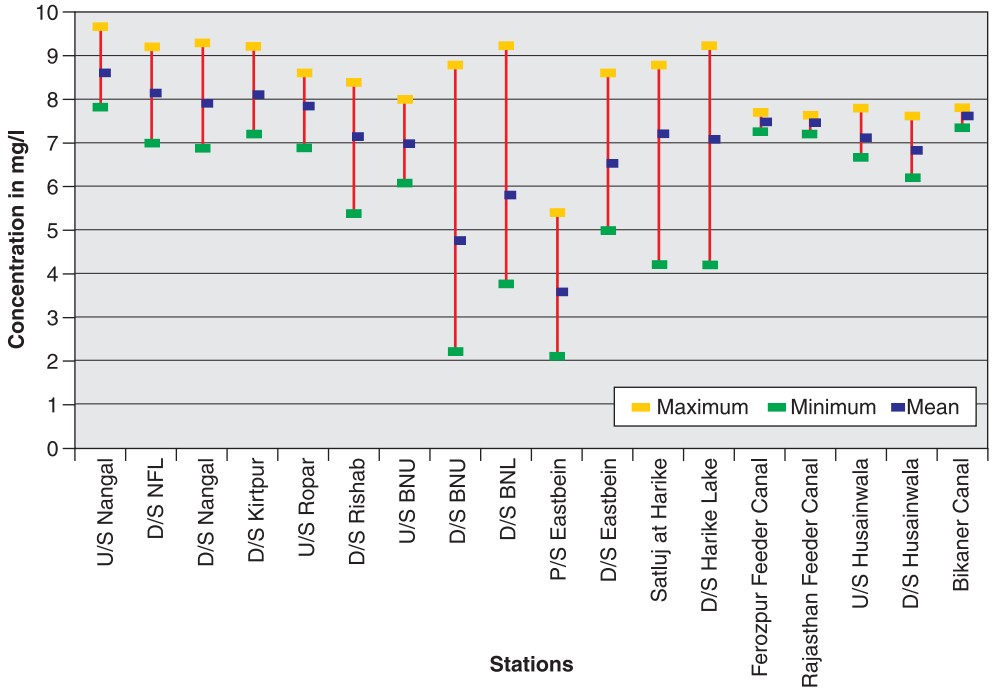


Source: PPCB, 2007

Further, the feacal coliform bacteria in Sutlej indicate an increasing trend from 1988 onwards.

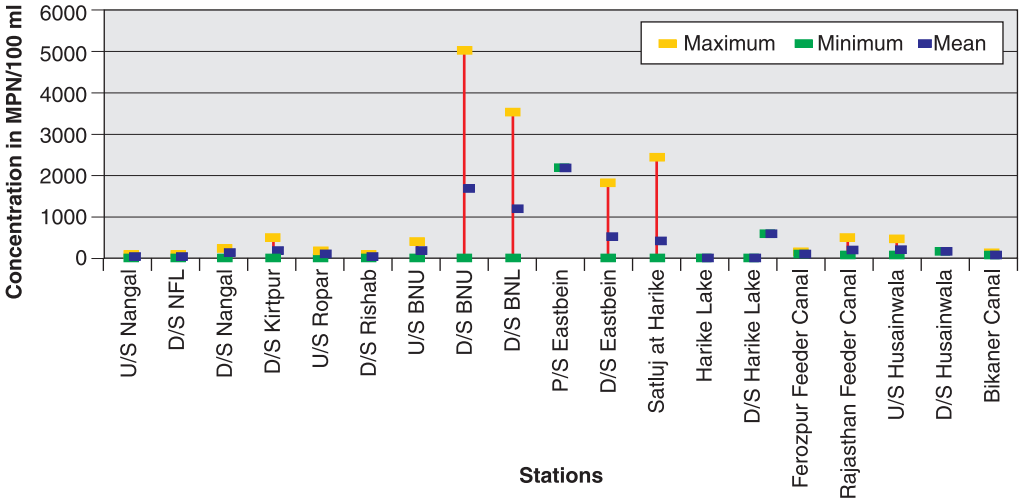
The data for heavy metals (Fig. 1.18) and pesticides (1.19) also indicate higher concentrations of Fe, Zn, Cr, Cu, Pb & Ni and pesticides like DDT, BHC, Endosulfan and Aldrin in water.

Fig. 1.16 DO range at different monitoring locations at river Sutlej (1988-2005)



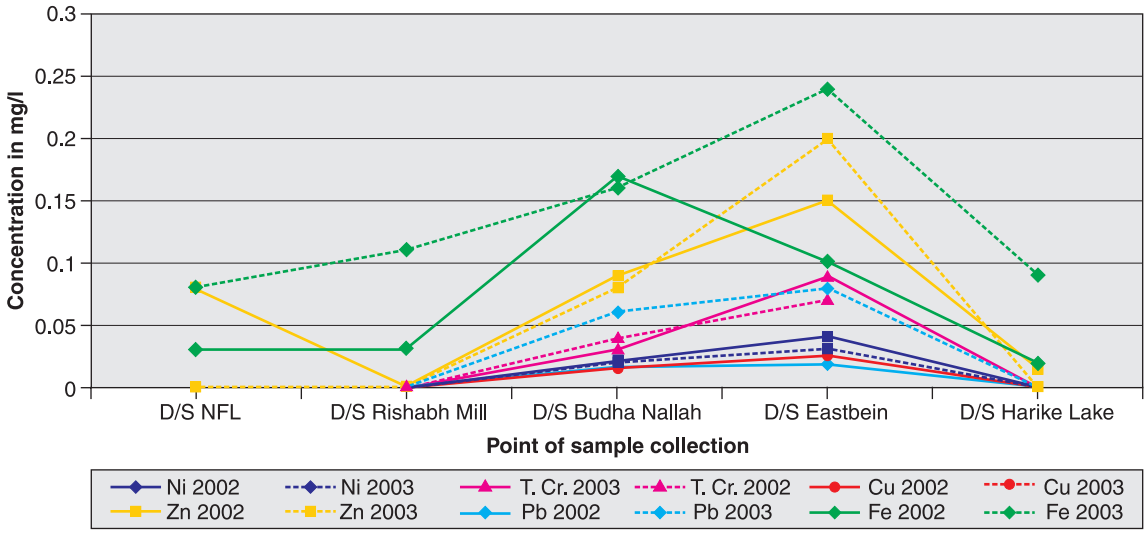
Source: PPCB, 2007

Fig. 1.17 Range of feacal coliform at different monitoring locations at river Sutlej (1988-2005)



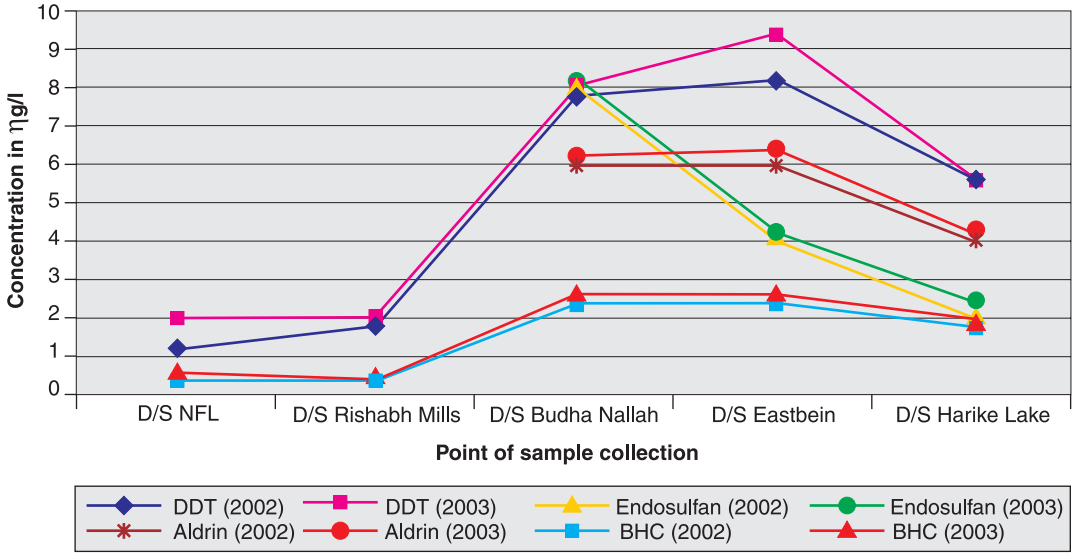
Source: PPCB, 2007

Fig. 1.18 Concentration of heavy metals in water samples at different monitoring locations at river Sutlej (2002 & 2003)



Source: PPCB, 2005

Fig. 1.19 Concentration of pesticides in water samples at different monitoring locations at river Sutlej (2002 & 2003)



Source: PPCB, 2005

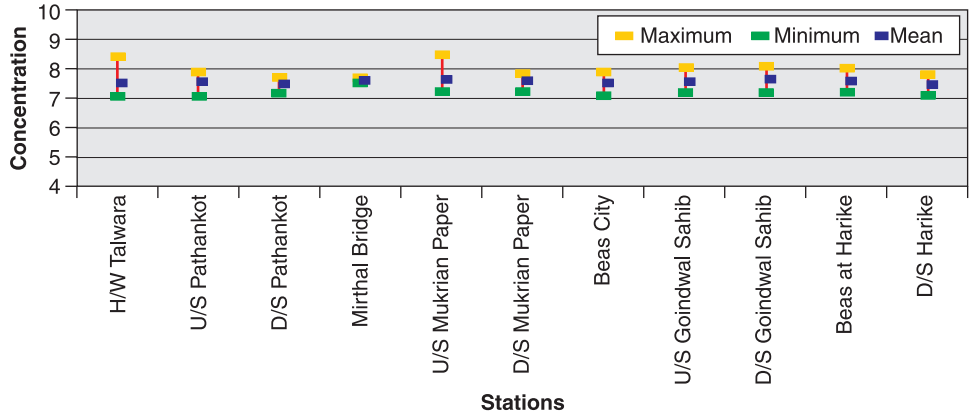
River Beas

The important towns situated along the banks of river Beas are Talwara, Mukerian and Beas town. The variations in major physico-chemical parameters of river Beas have been depicted in Figs. 1.20 to 1.23.

Data indicates that the quality of water of river Beas when it enters Punjab at Talwara is fairly good (class 'A'). The river has sufficiently high dissolved oxygen content (between 7 to 9 mg/l) and a well-buffered pH system at this point. The quality of water remains so till it receives effluents and sewage from Mukerian town where it drops down generally to Class C and sometimes to Class D due to high BOD.

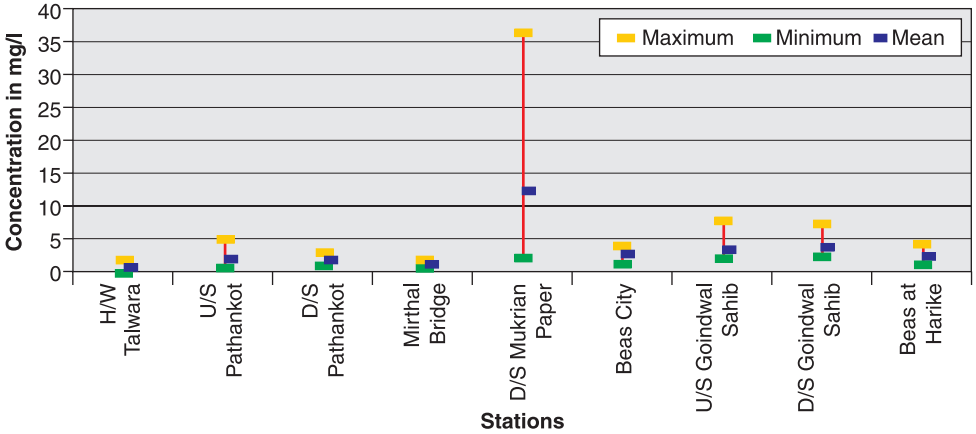
However, water quality improves due to self-purification upstream Beas town but is again affected by the sewage from the town. Further downstream, the water quality deteriorates to Class C/D due

Fig. 1.20 pH range at different monitoring locations at river Beas (1988-2003)



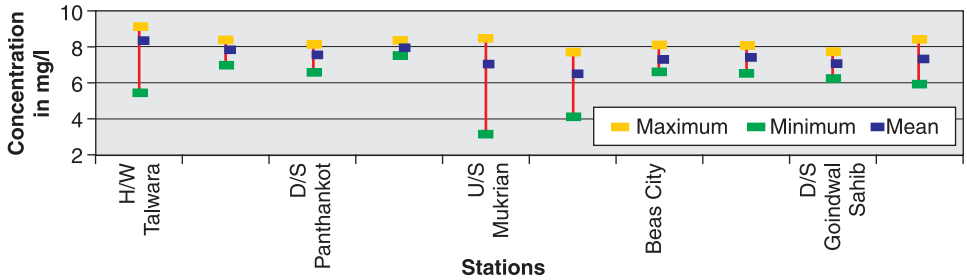
Source: PPCB, 2005

Fig. 1.21 BOD range at different monitoring locations at river Beas (1988-2003)



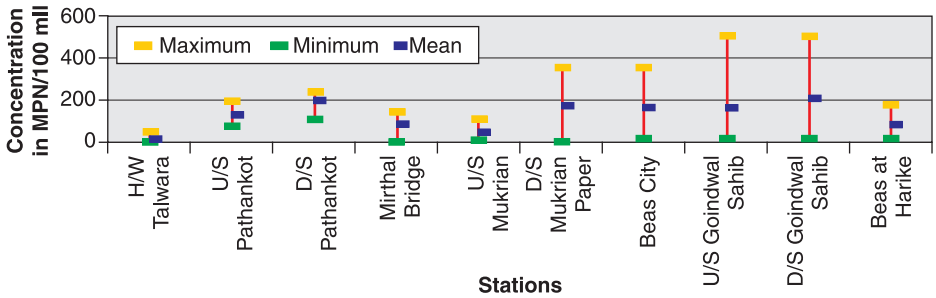
Source: PPCB, 2005

Fig. 1.22 DO range at different monitoring locations at river Beas (1988-2003)



Source: PPCB, 2005

Fig. 1.23 Faecal coliform range at different monitoring locations at river Beas (1988-2003)

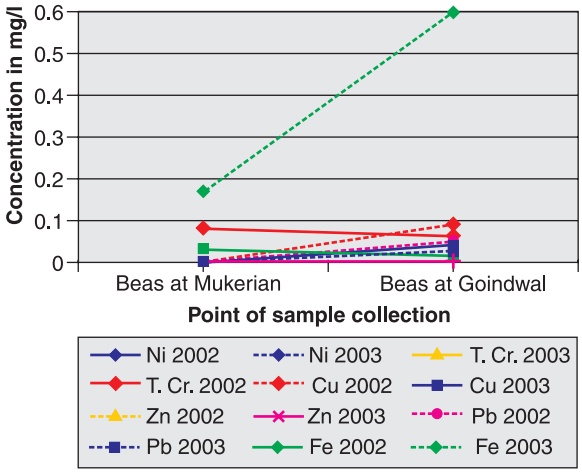


Source: PPCB, 2005

to discharge of industrial effluents and sewage from Goindwal town and industrial complex. However, the quality of water improves once again by the time it reaches Harike. Summer/ winter average data, however, indicate a general improvement in the water quality of the river over the years, especially from 1999 onwards probably due to diversion of waste water from Mukerian Paper Mills for agriculture. Further, the Faecal Coliform concentration is also low as compared to river Sutlej.

The Board has also initiated monitoring of heavy metals and pesticides once in a year at two locations at Mukerian and at Goindwal along the river (Figs. 1.24 & 1.25). Data indicates high concentration of Iron near Gowindwal.

Fig. 1.24 Concentration of heavy metals in water samples at different monitoring locations at river Beas (2002 & 2003)



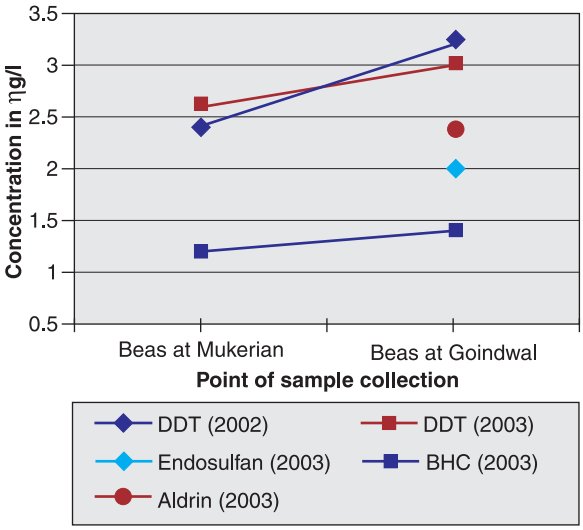
Source: PPCB, 2005

River Ravi

There is only one sampling station U/S Madhopur Head Works, Gurdaspur on this river. The variations in physico-chemical parameters of river Ravi have been depicted in Fig. 1.26. The water quality of the river is more or less similar along its entire length. The water quality predominately conforms to A or B class as per designated best use classification of CPCB.

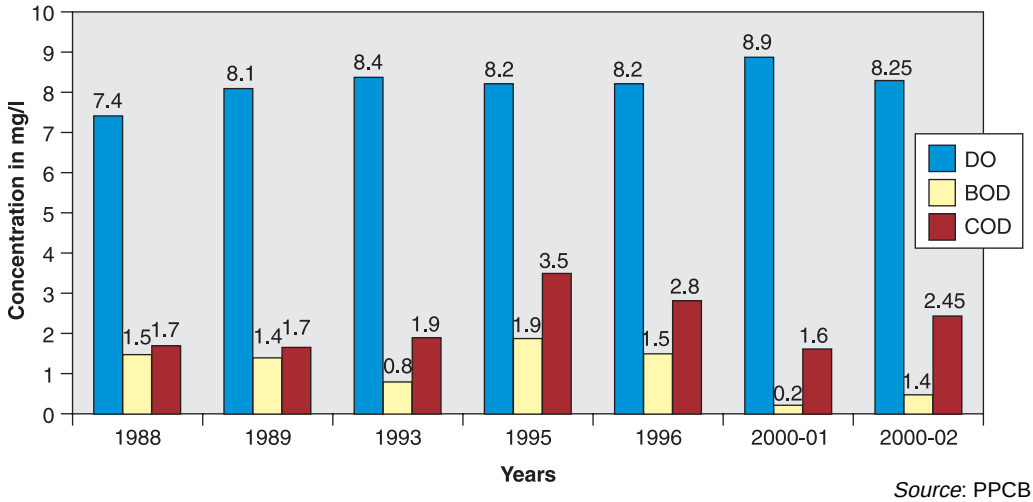
The physico-chemical analysis of water at Madhopur suggests that the water is clean and almost free from pollution. The concentration of salts, ions and nutrients are well within permissible limits (1993-1997 data as per CPCB). The water is slightly alkaline and well aerated. DO is high and BOD and COD contents are low. The total and faecal coliform are also low.

Fig. 1.25 Concentration of pesticides in water samples at different monitoring locations at river Beas (2002 & 2003)



Source: PPCB, 2005

Fig. 1.26 The annual average concentration of DO, BOD and COD in river Ravi



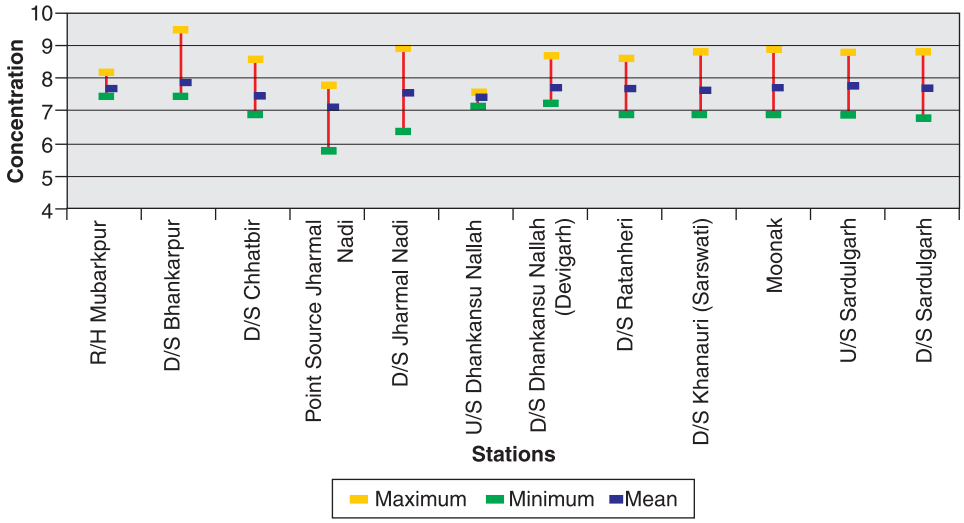
Source: PPCB, 2005

River Ghaggar

This river is a predominantly monsoonal stream. There are 12 sampling locations on the river. A general increasing trend in the BOD and COD values is observed since 1995 onwards indicating increase in pollution over the years. The feacal coliform values are also very high at times crossing

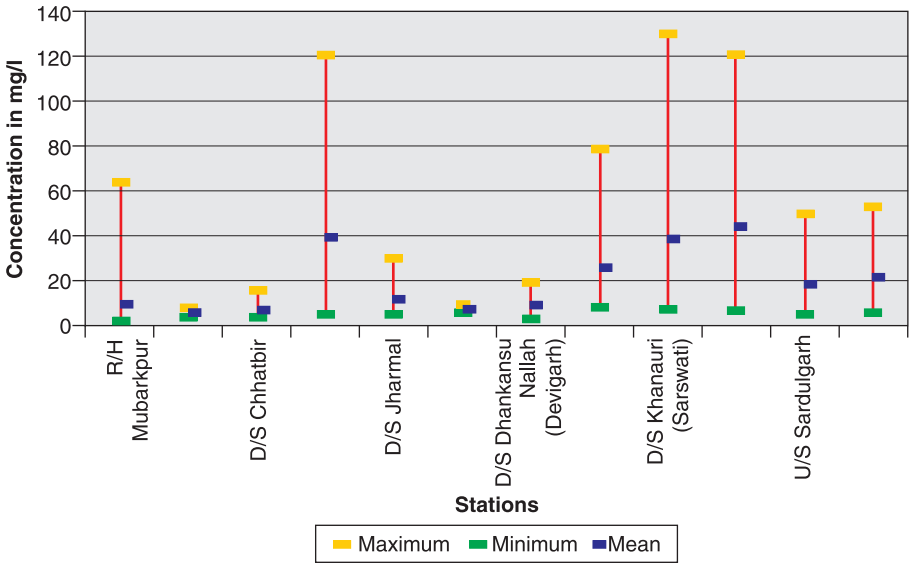
the 5000 MPN/100ml limit specified for 'Class-C' quality water. The physico –chemical parameters are depicted in Figs. 1.27 to 1.30. These indicate high pollution near Jharmal Nadi and downstream Dhankansu nallah.

Fig. 1.27 pH range at different monitoring locations at river Ghaggar (1988-2003)



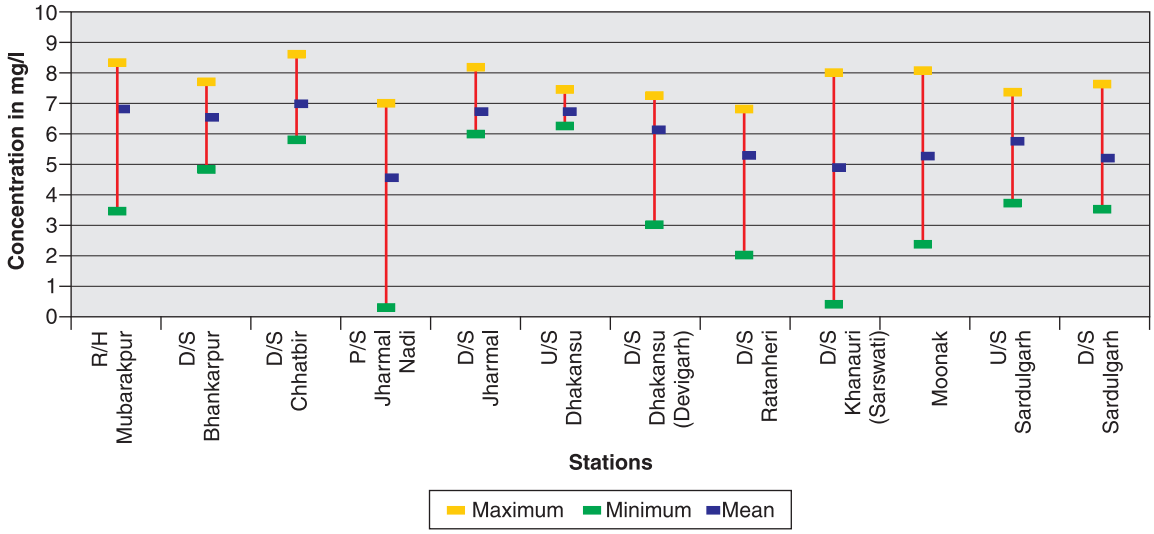
Source: PPCB, 2005

Fig. 1.28 BOD range at different monitoring locations at river Ghaggar (1988-2003)



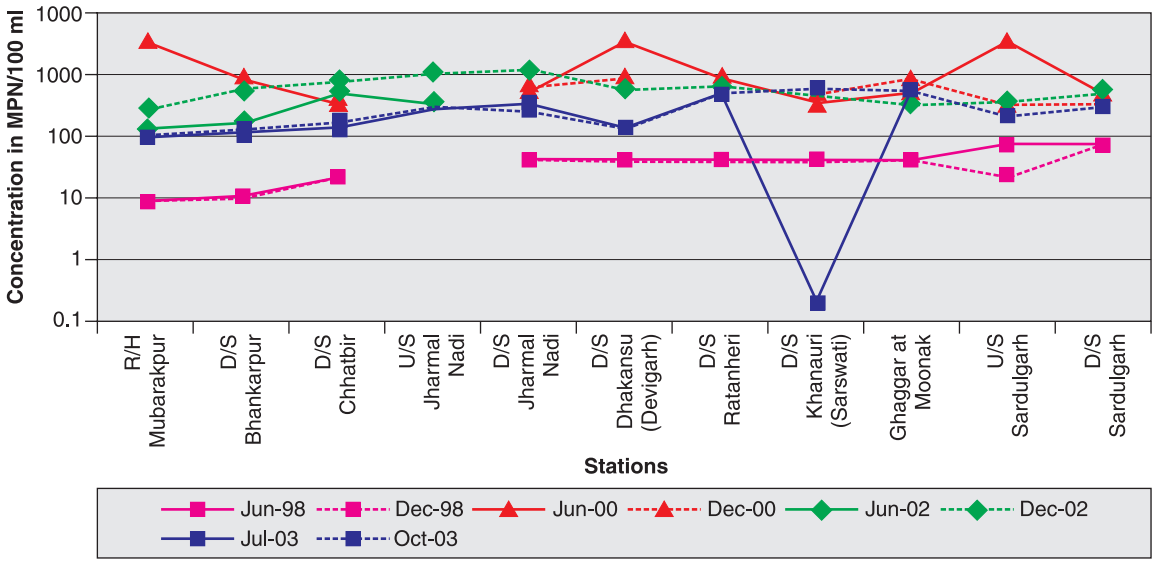
Source: PPCB, 2005

Fig. 1.29 DO range at different monitoring locations at river Ghaggar (1988-2003)



Source: PPCB, 2005

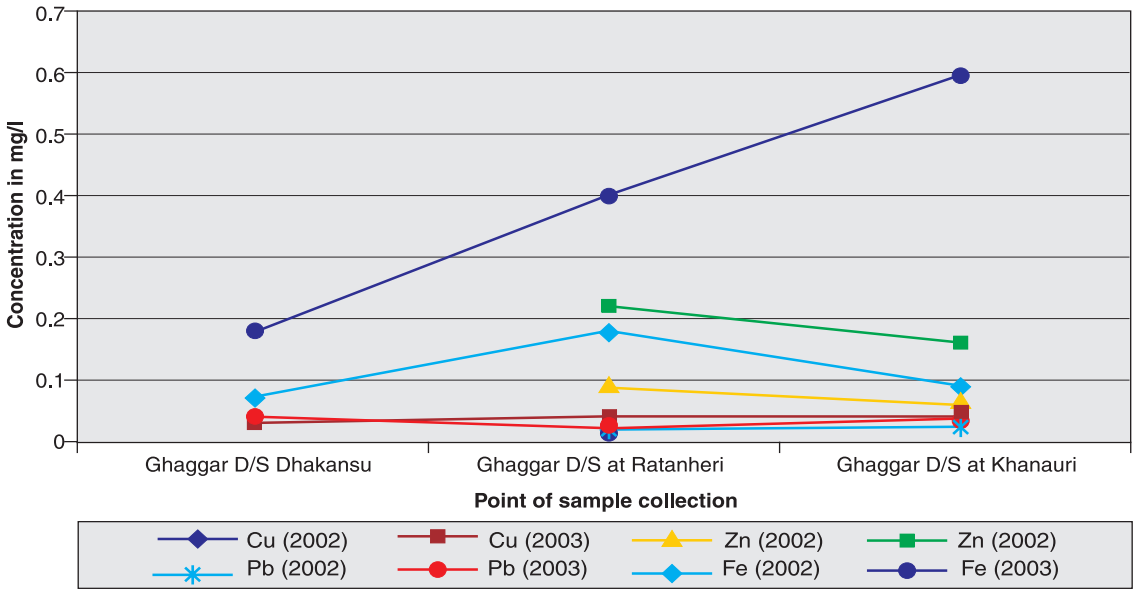
Fig. 1.30 Yearwise summer/winter average concentration of feacal coliform at different monitoring locations at river Ghaggar



Source: PPCB, 2005

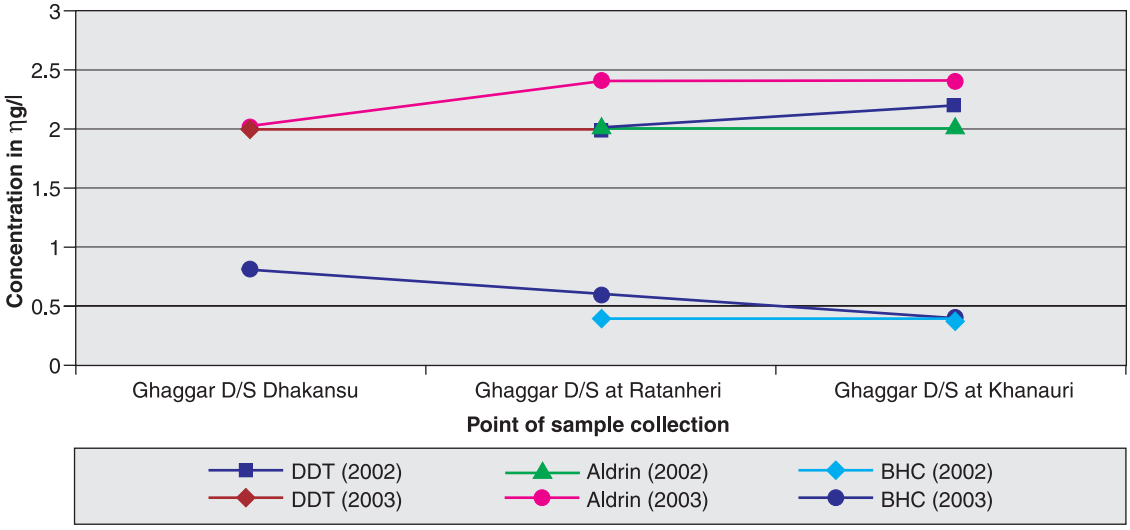
The Board has initiated heavy metal and pesticide monitoring in the river at three locations i.e. D/S Dhakansu nallah, D/S Ratanheri and D/S Khanauri since 2002. Further, with regard to pesticides, high values have been reported D/S Khanauri, in water (Figs. 1.31 & 1.32).

Fig. 1.31 Concentration of heavy metals in water samples at different monitoring locations at river Ghaggar (2002 & 2003)



Source: PPCB, 2005

Fig. 1.32 Concentration of pesticides in water samples at different monitoring locations at river Ghaggar (2002 & 2003)



Source: PPCB, 2005

Ground water quality

The quality of ground water is also deteriorating due to industrial and agricultural activities especially in districts Jalandhar, Ludhiana, Kapurthala, Patiala, Sangrur, etc. High TDS has been reported for these areas. Further, shallow ground water in some villages of districts Nawan Shehar and Hoshiarpur have high Selenium content. Another problem in South West Punjab is that of water logging and salinity. The issue has been discussed in detail in 'State of Environment: Punjab, 2005' (Tiwana, *et. al.*, 2005) and in Chapter 2.

STATUS OF BIODIVERSITY

Biological diversity or biodiversity refers to the wide variety of life on earth in terms of plants, animals and microorganisms. It includes diversity at the genetic, species and ecosystem level. The major ecological components especially w.r.t. biodiversity of Punjab are as follows:

The crop land ecosystem

The crop land ecosystem forms the dominant ecosystem in the state and can be divided into three categories (Table 1.5).

Table 1.5 Categories of crop ecosystems in Punjab

Category	Type	Districts	Major crops
Zone-I	Sub mountan-ous undulating Plains	Gurdaspur, Hoshiarpur, Ropar	Wheat in Rabi & Rice-Maize in Kharif season
Zone-II	The central Alluvial Plains	Amritsar, Kapurthala, Jalandhar, Tarantaran Nawan Shehar, Ludhiana, Fatehgarh Sahib, Patiala, Sangrur & Mohali	Wheat in Rabi and major rice growing area in Kharif season
Zone-III	South Western dry zone	Bathinda, Faridkot, Ferozpur, Mansa, Moga, Mukatsar & Barnala	Ground water is saline & unfit for irrigation. Cotton is an important Kharif crop but is being replaced by rice

The forest ecosystem

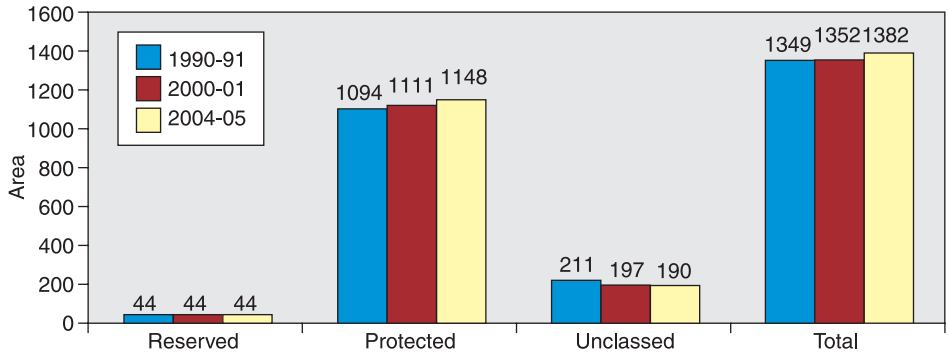
The state has only 6% area under forest cover. Fig. 1.33 shows the distribution of government owned forest area (sq km) in Punjab from 1990 to 2005. The major forest areas in the state are:

- **Shivalik Forests:** Districts Ropar, Gurdaspur & Hoshiarpur
- **Bir Forests:** District Patiala and a small area in district Kapurthala
- **Mand Forests:** Districts Amritsar & Kapurthala.

The existing floral and faunal diversity in the state is presented in Tables 1.6 & 1.7.

The diversity of domesticated flora & fauna is discussed in Chapter 2.

Fig. 1.33 Distribution of government owned forest area (sq km) in Punjab from 1990 to 2005



Source: Statistical Abstract of Punjab, 2005

Table 1.6 Number of floral species recorded from Punjab

Group	No. of reported species	Reported By
Algae	397	Pandhol & Grover (1974), Rattan & Sarma (1989),Sarma & Kanta (1978), Sarma & Rattan(1990), Majeed (1935), Dhillon *et al.,*(1996) and Gupta & Singh (2003)
Fungi	948	Singh & Bedi (1970), Singh & Chohan (1975 & 1971), Singh & Garcha (1974), Singh & Bedi (1976), Sawhney & Aulakh(1979), Prashar & Singh (1980), Singh & Jhooty (1984), Gulati & Madan (1982), Kaur & Sandhu (1982), Chawla & Singh (1986), Sahejpal & Singh (1987) Sharma & Rajpal (1995); Atri, *et al.,*(1992a & b, 1995, 1996a & b), Saini, *et al.,*(1988, 1989a & b, 1991,1992,1997), Saini & Atri (1995) and Sharma & Das (2003)
Lichens	21	Rana & Chadha (2003)
Bryophytes	34	Kashyap (1929) and Singh *et al.,* (2003)
Pteridophytes	48	Sharma (1990, 1997) Khullar (2000), Deva (2001), Sharma *et al.* (2003) and Singh *et al.* (2003)
Gymnosperms	21	Parker (1915) & Sharma (1990) and Sharma *et al.*, (2003)
Angiosperms	1879	Nair (1978), Sabnis (1940), Sharma (1990) and Sharma *et al.,* (2003)

Source: As Cited in Tiwana *et al.,* 2005

Conservation efforts to protect the state's biodiversity include:

- 10 Wild Life Sanctuaries and one Protected Area covering 316.74 sq km area.
- Birs and Rakhs covering 18.75 and 13.16 sq km area, respectively.
- Three internationally important wetlands - (Ramsar sites) Harike, Kanjli & Ropar.
- Identification of biodiversity rich pockets in Shivalik area in the state (in Ropar, Hoshiarpur & Gurdsapur districts).
- Constitution of Punjab Biodiversity Board as a statutory body under The Biological Diversity Act, 2002. The Board was notified in December, 2004 to:
  - Advise the State government on biodiversity conservation,
  - Ensure sustainable use of biodiversity components,
  - Regulate commercial utilization of bioresources by granting appropriate approvals,
  - Endeavour to create awareness & training on issues related to biodiversity in the state,
  - Ensure equitable sharing of benefits arising out of commercial utilization of biological the resources,
  - Constitute Local Biodiversity Management Committees (BMCs) and
  - Prepare & maintain People's Biodiversity Registers (PBRs).

Table 1.7 Number of faunal species recorded from Punjab

Group	No. of Reported species
Invertebrates	
Protozoa	86 *
Platyhelminthes	41
Nematoda	188
Annelida	56
Arthropoda	1389 *
Mollusca	94
Vertebrates	
Pisces	131
Amphibia	20
Reptilia	43
Aves	>500
Mammalia	97

*All groups are not covered

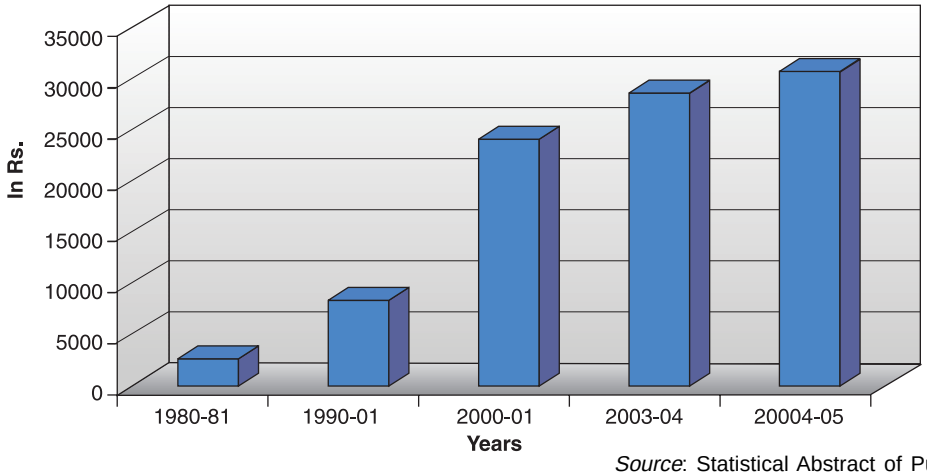
Source: Tiwana *et al.*, 2005

ECONOMY & INFRASTRUCTURAL FACILITIES

The state has one of the highest per capita incomes in the country. The growth in per capita income is presented in Fig. 1.34. The gross and net state domestic products at current price are Rs. 883.5 billion and Rs. 790.09 billion respectively, with the primary sector being the largest contributor. Over the years, however, the contribution of the primary sector in the economy has decreased where as the contribution of secondary and tertiary sectors has increased (Fig 1.35).

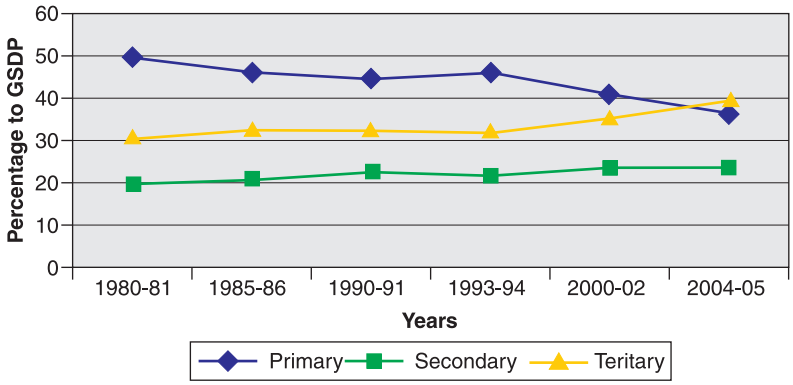
Infrastructural facilities are quite well developed in the state. The total road length is 51321 km (2004-05) with 99.24% villages linked with metalled roads. There has also been an increase in production of electricity through development of hydro, thermal and, off late, renewable energy. However, there is still a wide gap between demand and supply (Table1.8). Industries are the largest consumer of power (40%) followed by agricultural (28%) and domestic sectors (23%) (Fig.1.36).

Fig. 1.34 Increase in per capita income in Punjab at current prices



Source: Statistical Abstract of Punjab, 2005

Fig. 1.35 Percentage distribution of GSDP at factor cost by sectors in Punjab at current prices



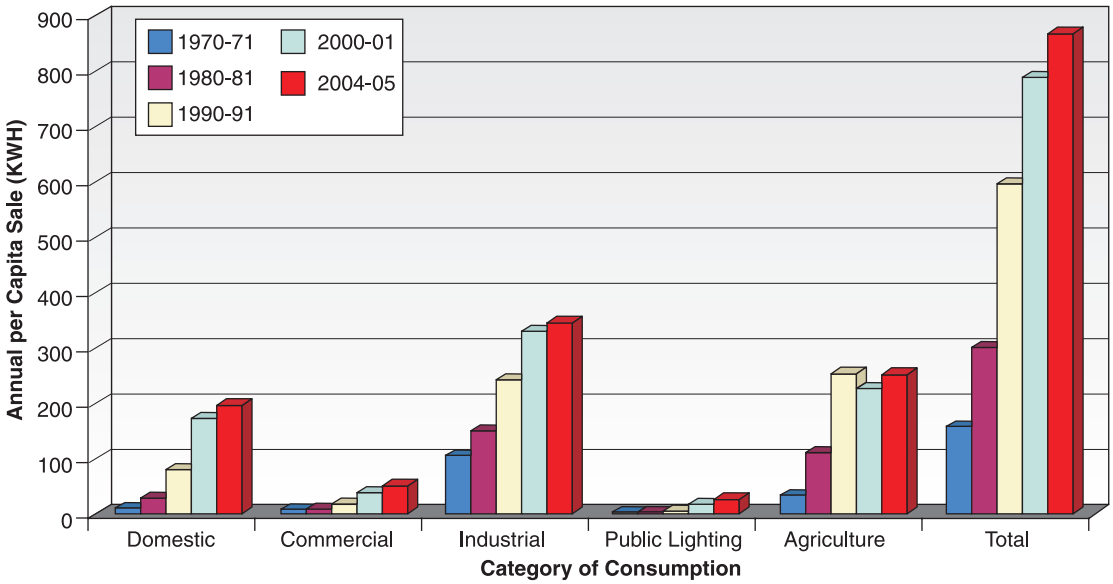
Source: Statistical Abstract of Punjab, 2005

Table 1.8 Connected & pending elecricity load (MW) in Punjab in 2003-04

	General	Industrial	Agricultural	Others	Total
Connected	8510	4978	3482	229	17199
Pending	51029	128469	989703	15543	1184744

Source: Punjab State Electricity Board, 2004

Fig. 1.36 Category wise annual per capita sale of electricity in Punjab (KWH)



Source: Statistical Abstract of Punjab, 2005

Providing electricity for agriculture

EDUCATION

Punjab has a literacy rate of 69.95%. With growing pace of industrialization, the main stress has been on expansion, modernization and reorientation of technical education and industrial training system so as to match it with emerging technologies for ensuring quality manpower availability to the industrial sector. For this, new engineering colleges, polytechnics and Industrial training centres in the emerging areas are being opened up. There are over 13,352 primary schools, 2503 middle schools, 2283 high

schools, 1697 senior secondary schools, 212 colleges, 24 B.Ed colleges, 105 ITIs, 19 polytechnics, 27 engineering colleges, 6 medical colleges and 7 universities in the state (Statistical Abstract of Punjab, 2005).

Environmental Education is also being promoted in the state through both formal and non-formal/ informal means, to foster understanding, skills and values in society.

Formal Environment Education

To assess the status of environment education at primary, secondary, senior secondary, university and professional college level in Punjab, a study was conducted by Punjab State Council for Science and Technology (PSCST) in the year 1992. The study pointed out that Punjab School Education Board (PSEB) was following NCERT pattern and the environment content in the syllabus of primary education was adequate. However, environment education was generally inadequate at secondary, senior secondary and higher education level. Subsequently in 2003, following the instructions of Supreme Court of India to introduce environment education as a mandatory part of curriculum, the PSEB included environment education on the pattern given in Table 1.9. Environment education has also been introduced as a compulsary course at undergraduate level in all universties of the state. Table 1.10 shows other environment education courses offered in universities of Punjab.

Table 1.9 Status of Environment Education in Punjab schools

Class	Status of Environment Education
I-V	As a separate subject
VI & VIII	As a part of science subject
IX-X	Included in science & geography
XI-XII	As a compulsory subject of 50 marks

Source: PSEB, 2006

Table 1.10 Environment Education courses in universities of Punjab

University	Name of Department	Course	Duration
Punjab University, Chandigarh	Centre for Environment and Vocational studies	M.Sc. (Environment) & M.Sc. (Solid Waste Management)	2 years
GNDU, Amritsar	Botanical Science	M.Sc. (Hons.) Environment Science	2 years
PEC, Chandigarh	Environmental Engineering	ME (Environment)	2 years
Thapar Institute of Engineering & Technology Patiala	Biotechnology & Environmental Sciences	M.Tech (Environmental Science & Technology)	2 years
Punjabi University, Patiala	Geography	Environment Geography	As a subject in M.Sc. Geography

Non formal Education

The state is also promoting non - formal environment education activities along with formal educational system on a large scale. This includes awareness and trainings which play a significant role in encouraging and enhancing people's participation in activities aimed at conservation, protection and management of the environment, essential for achieving sustainable development. Some of the major programs undertaken in this regard are:

- National Green Corps (NGC)
- National Environment Awareness Campaign (NEAC)
- UNDP GEF/CCF Small Grants Programme
- Environment Education in School System

These programs have been under taken with the financial help of Ministry of Environment & Forests, Government of India. The Punjab State Council for Science & Technology is the nodal agency for the former three programs where as the State Institute of Science Education & Punjab School Education Board are nodal agencies for Environment Education in School System.

Besides these, several projects are being taken up with the help of UNESCO, UNDP, Centre for Environment Education, etc. for development of resource material and promotion of environmental trainings.

Information about the state's environment is also being disseminated by the ENVIS (Environmental Information System) Centre which has a dedicated website (www.punenvis.nic.in) to provide information in English & Punjabi to general masses, Government, R & D bodies, etc. The present report is also an effort in this direction.

It is hoped that armed with information about the status & problems of the state's environment the state will be able to tread on the path of sustainable development.

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2

Agriculture & Environment

2

Agriculture and Environment

Agriculture is the art and science of crop and livestock production. The word 'Agriculture' consists of two latin words: *Agri* (field), and *cultura* (cultivation or tillage), which means tillage of soil. It plays a key role in the overall economic and social well being of a country. In modern usage, agriculture includes all activities and the entire range of practices and techniques associated with the production of useful products from plants and animals, including soil cultivation, crop and livestock management, and the activities associated with preliminary processing and marketing.

Punjab, the most stunning example of green revolution in India, is now at the crossroads. During the mid-sixties, the green revolution transformed the state's agriculture and economy and contributed significantly in making the country self-reliant in food. Food grain production in the state increased from 3.16 million tons in 1960-61 to 25.66 million tons in 2004-2005 (Source: Statistical Abstract of Punjab, 2005), thus contributing more than 50% of grain into the central grain pool leading India from a famine affected and grain importing country to a self reliant, self sufficient and export surplus nation.

However, the present agricultural system in Punjab has become unsustainable and non profitable. The state's agriculture has reached at the highest production levels possible under the available technologies and natural resource base and its growth has stagnated. The gains resulting from the success of ever increasing food production over the span of last four decades, have not been without their consequent environmental and social costs. Over intensification of agriculture over the years has led to water depletion, reduced soil fertility and micronutrient deficiency, non-judicious use of farm chemicals & problems of pesticide residue, reduced genetic diversity, soil erosion, atmospheric and water pollution and overall degradation of the rather fragile agro ecosystem of the state. Moreover, high cost of production and diminishing economic returns in farming are adversely affecting the socio-economic conditions of farmers in Punjab.

POLICIES

The following national and state policies & plans focus on the various goals and methods of agricultural production in Punjab.

- Agriculture Price Policy, 1965
- State Industrial Policy, 1996, 2003
- State Water Policy, 1997
- National Agricultural Policy, 2000
- New and Renewable Sources of Energy (NRSE) Policy, 2001
- National Water Policy, 1987, 2002
- National Fertilizer Policy, 2002
- National Seed Policy, 2002
- National Environment Policy, 2006
- Various Five Year Plans (1951-2007)

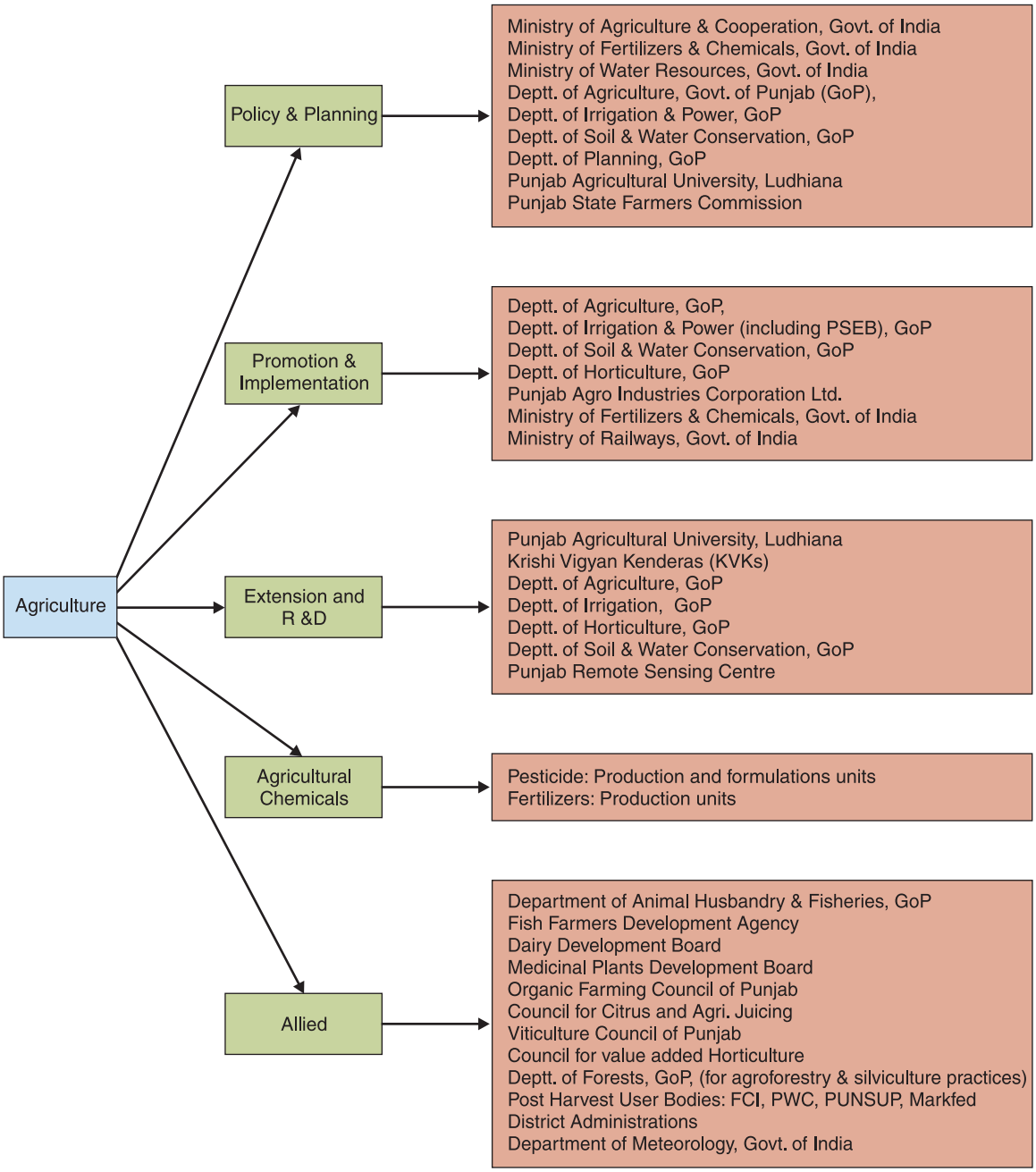
ACTS AND RULES

There are many international, national and state level Acts and Rules, which govern the agricultural production patterns, natural resources, agricultural inputs and its trade and marketing related aspects in Punjab. These include:

- The Land Acquisition Act, 1894
- Destructive Insects and Pests Act, 1914
- Punjab Fisheries Act, 1914
- Prevention of Food Adulteration Act, 1954
- Essential Commodities Act, 1955
- Punjab Agricultural Produce Markets Act, 1961
- Seed Act,1966
- Insecticides Act, 1968 and Rules 1971
- Water (Prevention And Control of Pollution) Act, 1974
- Punjab Agricultural Credit Operations and Miscellaneous Provisions (Banks) Act, 1978
- Air (Prevention and Control of Pollution) Act, 1981
- The Dangerous Machines (Regulation) Act, 1983
- Fertilizer Control Order, 1985
- Environment Protection Act, 1986
- Ozone Depleting Substances (Regulation and Control) Rules, 2000
- The Protection of Plant Varieties and Farmer's Rights Act, 2001
- Biological Diversity Act, 2002
- Plant Quarantine (Regulation of import in to India) Act, 2003
- Biological Diversity Rules, 2004
- World Trade Rules (WTO), 2005
- Notification for Banning the Use of Monocrotophos on Vegetables, 2005
- Special Economic Zones Act, 2005
- Herd Registration Act, 2006

INSTITUTIONAL FRAMEWORK

Agricultural activities in the state are managed by various government departments and institutions:



DRIVING FORCES

The major driving forces which affect the natural agro ecosystem and agriculture practices in state are:

Population growth and increased demand of food grains

As already mentioned in Chapter 1, the state harbours 2.4% population of the country in 1.56% area. Hence, it accommodates more people than its capacity. Even though Punjab has made a remarkable progress over the last three decades towards feeding the population of state and the country, but the rate of growth of population is already much higher than that of production/availability of foodgrains. The population of India and Punjab is expected to reach over 1.26 billion and 0.29 billion, respectively in the year 2011. In the last 15 years, India has added more than 270 million more mouths to feed (33% increase in population), but has increased its food production only by 13%. Similarly the production of food grains in Punjab has increased by 2% in last 5 years as against 8.6 % rise in population. Percentage increase in population and foodgrain production in Punjab from 1951-2005 is given in Table 2.1. Since population growth is a major determinant of increase in food demand, there are indications of the beginning of an imbalance in supply and demand.

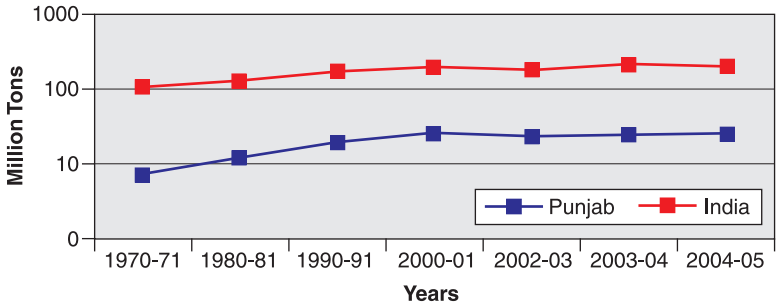
Table 2.1 Percentage increase in population and foodgrain production in Punjab (1951-2005)

Year	Population (lac)	% Decedal Increase in Population	% Decedal Increase in Food Grains Production
1961	111.35	21.56	60
1971	135.58	21.70	128
1981	167.89	23.89	63
1991	202.82	20.81	61
2001	243.89	20.10	24
2005	264.93	8.64	2

Source: Statistical Abstract of Punjab, 2005 & Punjab State Farmers Commission, (Kalkat *et al.*,) 2006

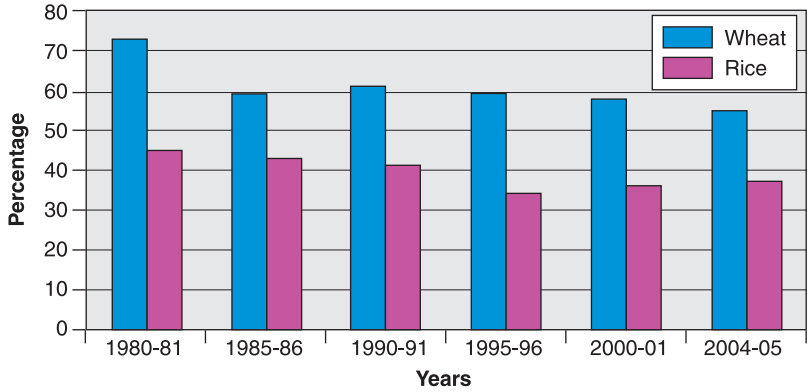
Food production depends on two fundamental resources: land and water. With increase in population the per capita availability of these two is decreasing. The production of foodgrains (cereals and

Fig. 2.1 Production of foodgrains (cereals and pulses) in Punjab and India from 1970-2005



Source: Deptt. of Agriculture, Govt. of India & Statistical Abstract of Punjab, 2005

Fig. 2.2 Percentage contribution of wheat and rice in central pool by Punjab



Source: Statistical Abstracts of Punjab, 1993 & 2005

pulses) in Punjab and India from 1970-2005 (Fig. 2.1) also indicates that a platue is being reached with respect to productivity and would require interventions in technology and management in agriculture to improve the same.

The Central Government encouraged the strategy of enhancing foodgrains production in state, particularly wheat and rice, for meeting the emergent food demand in the country. Punjab leads other states in terms of contribution of wheat and rice to central pool. It contributed 55 percent of wheat and 37.2 percent of rice to central pool in 2004-05. The total contribution of wheat and rice to the central pool has increased from 6.8 million tons in 1980-81 to 18.35 million tons during 2004-05 consisting of 9.24 million tons of wheat and 9.11 million tons of rice. However its contribution is declining over the years (Fig. 2.2).

Government of India's empahsais on National Food Security

In 1950-60s, India was importing food grain to feed its millions. During 1964-65 drought conditions, India imported 13 millions tons of food grain. This had put heavy drain on foreign reserves of the country. Therefore, the country was obliged to adopt agricultural policies that promoted food grain production for National Food Security. The Government of India then decided to explore the areas where production of food grains could be increased at the maximum rate at least cost. It invested more than Rs. 70 million to promote agriculture in Andhra Pradesh, Tamil Nadu, Gujrat, Ganganagar district of Rajasthan and combined Punjab. The hardworking and innovative farmers of Punjab were at the forefront of ushering in Green revolution in 1969. Thus, Punjab became the hub of agricultural activity.

By 1984, farmers in Punjab had brought 1800 thousand hectares(th ha) land under paddy and 2800 thousand hectares land under wheat cultivation causing serious glut in the markets of Punjab. A study taken up in 1985 (Box 2.1) recommended that 20% area under paddy crop should be replaced by other crops. However, Government of India in the interest of National Food Secuirty increased

Procurment & storage of grain by Government

Rotting of grain due to improper storage

Mimimum Support Price, fertilizer subsidy, improved irrigation facilities and promoted HYVs and intensive agriculture development programme. The natural response of the farmers of Punjab to this lucrative price, secure crops, secure technology and high production was to bring more area under paddy and wheat cultivation. This resulted in bringing 3400 th ha and 2600 th ha area under wheat and paddy, respectively by 2002. However, the two crop systems repeated year after year on intensive scale made the agro-ecosystem of the state extremely fragile in the context of water depletion, pest & crop diseases, soil health, human health and overall living environment. Subsequently, the Advisory Committee on "Agricultutal policy and restructuring, 2002" recommended crop diversification (Box 2.1).

Agrarian economy

Agriculture and allied activities occupy the most prominent place in Punjab's economy. About 70 percent of the people are engaged in agriculture. As against an all India average of 51 percent, it has 85 percent of its area under cultivation and 97 percent of its cultivated area is irrigated. According to 2004-2005 quick estimates agriculture and allied activities (primary sector) contributed 37.07% of Gross State Domestic Product at constant prices (1993-94) and 36.47% at current prices. The Gross State Domestic Product (GSDP) contributes about 3 percent of the gross domestic product of the country. Being primary sector, agriculture had been the major contributor in state's GDP until 2001-02. As the contribution of agriculture to the state's GDP has been declining over the past 12 years due to slowing down of agricultural growth, the services (tertiary) sector has overtaken from agriculture with the largest share of 39 percent in Punjab's GDP. The industrial sector (secondary) is relatively smaller, accounting for 24 percent of the GDP. The share of agriculture to GDP had declined from

Box 2.1 Committees on Agricultural Diversification in Punjab

Committee on "Diversification of Punjab Agriculture", 1985: The promotion of rice and wheat cropping pattern on a extensive scale for fifteen years (from 1970 to 1985) has made the agro-eco system of the state extremely fragile in context of soil health, weeds & pests and human health. There were serious difficulties regarding the marketing and procurement of especially paddy. The farmers also agitated for higher MSP. Realising the gravity of the problem of rice – wheat crop rotation, Punjab Government constituted an expert Committee on " Diversification of Punjab Agriculture" in 1985 under the chairmanship of Dr. S.S. Johl. In its report submitted in 1986, the committee suggested a diversion of at least 20% area under wheat and paddy to other crops. However, despite the recommendations, the area under rice and wheat increased steadily, mainly due to assured remunerative prices offered for these crops (reaching 3400 th ha and 2600 th ha respectively for wheat & paddy in 2002).

The committee reported that no crop enterprises at the existing level of production technology and product price could compete with wheat in rabi and paddy in kharif even then. The suggested alternative crops required improvement in technology and prices by about 13% to 52% to compete with paddy in kharif and from about 41% to 61 % to compete with wheat in rabi. The committee also suggested that the major possibility existed in terms of livestock/dairy enterprise, which would have brought some 17% of total cropped area under fodder crops by the year 2000. Although, dairy enterprise has maintained higher growth rate till date, but the area under fodder in 2000-01 was only 10 % of the total cropped area. Clearly, the committee's recommendations received inadequate consideration from government, as well as, from the farming community.

Advisory Committee on "Agriculture Policy and Restructuring", 2002: The main issue tackled by the Crop Diversification Committee in 1985 was the failure of effective marketing support mainly for paddy. But by 2002, the agriculture scenario in state had become complicated. Apart from procurement problem of paddy, the increased area under paddy and wheat also led to overexploitation of ground water in central and northern districts of the state and net returns of state farming community decreased sharply.

The Government of Punjab, therefore, set up an Advisory Committee on "Agriculture Policy and Restructuring" in 2002 under the chairmanship of Dr. S.S. Johl to suggest suitable production pattern adjustments with a view to conserve the natural resources of the state, as well as, to improve the economy of the farmers. The report has proposed the replacement of 1 million hectare area under rice - wheat rotation with other crops like oil seeds and pulses, which have less water requirement and are ecology and soil friendly. According to the recommendation of the report a subsidy of Rs. 12,500 per ha should be given to farmers who take to crops other than wheat and paddy. For this a huge sum of Rs. 12.8 billion per year would be required from the Central Government. As per report, it should not be difficult for the central government as it will make a savings of Rs. 50 billion by not procuring rice and wheat produced from 1 million ha area. The Government of India has, however, sanctioned only Rs. 240 million for small scale implementation of the "income support" to compensate for not sowing paddy during 2006.

Source: Punjab State Farmers Commission, (Kalkat *et al.*,) 2006

46.13% in 1993-94 to 37.07% in 2005 (Table 2.2 and Figs. 2.3 and 2.4). At all India level also, the contribution of primary sector to GDP has declined from above 50% in 1950 to less than 25% in the year 2004-05 (Source: Department of Agriculture, Government of India, 2006).

Agricultural growth rate in Punjab has also slowed down from 5.0% in 1980s to 2.4% in 1990s and to 1.9% in 2000s. The productive gains in the rice-wheat cropping pattern system have slowed down, reaching a plateau. Cotton as the third most important crop has been facing severe pest attacks in late 1990s and gave negative yield growth. The growth in livestock sector though was significant at 5.7% in 1980s and 5.2% in 1990s, but it has also come down to 2.5% in 2000s. (Source: Punjab State Farmers Commission, 2006). During this downslide, which started in mid 1990s, Punjab lost its position as the highest per capita income state in 2000-01, which it had maintained over the past four decades to Maharastra and Delhi (Gul *et al*., IFPRI, 2006).

Table 2.2 Percentage distribution of Gross Domestic Product at factor cost by primary sector in Punjab at constant prices (1993-94)

Sector	1993-94	2000-01	2001-02(R)	2002-03(R)	2003-04(P)	2004-05(Q)
Agriculture	33.06	26.95	26.57	24.00	24.46	24.54
Livestock	12.74	12.55	12.48	12.69	12.13	11.17
Forestry & Logging	0.13	0.14	0.12	0.12	0.12	0.12
Fishing	0.19	0.39	0.42	0.49	0.56	0.62
Mining & Quarrying	0.01	0.00	0.01	0.02	0.02	0.02
Percentage of Total GSDP	**46.13**	**40.03**	**39.60**	**37.31**	**37.29**	**37.07**

Revised (R), Provisional (P), Quick Estimates (Q)

Source: Statistical Abstract of Punjab, 2005

Fig. 2.3 Sector wise contribution to state GDP in 1993-94 at constant prices

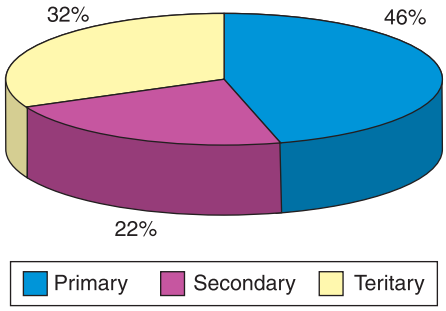
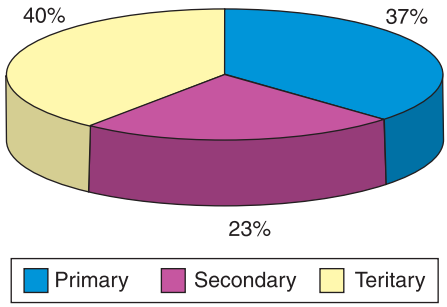


Fig. 2.4 Sector wise contribution to state GDP in 2004-05 at constant prices (1993-94)



Source: Statistical Abstract of Punjab, 2005

Box 2.2 Red alert for farm sector in Punjab

A study by International Food Policy Research Institute (IFPRI) has put out the red alert on the farm sector in Punjab. The study has warned that Punjab needs to diversify from wheat and rice, urgently, otherwise the food bowl of India could well turn into a begging bowl by 2030.

The study, '*Withering Punjab Agriculture: Can it regain its leadership?*' carried out in August, 2006 by IFPRI, India has warned that Punjab is in the middle of a serious agricultural crisis. The study reports that Punjab's agricultural economy has lost its place among the fastest growing in the country, surpassed by a number of other states including Karnataka, Madhya Pradesh, Maharashtra, Rajasthan and West Bengal.

The state's agriculture sector, the study maintains, has reached a point where it must make significant changes if it wants to move forward and regain its leadership. Conversely, if it does not rationalise incentives and increases investments significantly, it will suffer declining income and employment and irreversible environmental degradation.

The study emphasises that indiscriminate subsidies on power and water cost the state government 6.8% of agriculture SDP compared to expenditures of only 1.9% (2.2% for all India) for public capital investments and precursor of future growth and only 2.7% (lowest among agricultural states) for current expenditures which fund irrigation, research & extension and other key needs.

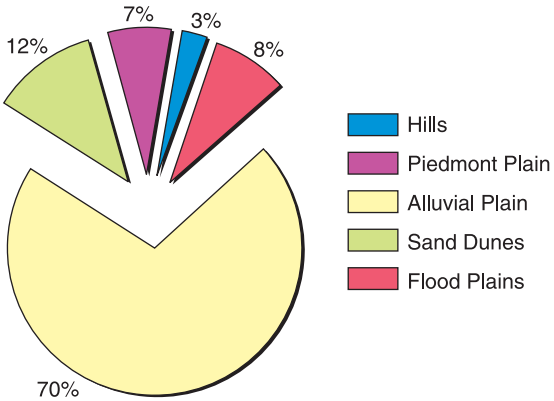
As per the study, the yield of rice has almost stagnated in Punjab, going up only by 0.02% annually in the 1990s and wheat has slowed significantly (down from 2.96% annual gain in 1980s to 1.96% in the 1990s compared to all India average of 3.2%). Overall, the crop sector grew only by 1.3% per annum in the nineties compared to 4.8% per annum in the eighties. Rice production has come, at the expense of other crops too.

Source: The Economic Times (10th Oct, 2006)

Suitability of Land for Agriculture

Land is the fundamental basis for most of the human or natural activities and is one of the major natural resources on earth. Agricultural productivity is entirely dependent on the availability of suitable land. The availability of vast tracts of fertile land was a major factor responsible for the agricultural success of Punjab. The state of Punjab is part of Indo Gangetic plain formed by the alluvial deposits by rivers of Indus system and their tributaries. The Indo-Gangetic Plain is a rich, fertile and ancient land encompassing most of northern and eastern India. The state can be divided into 5 major land forms like, Hills (Shivaliks), Piedmont plains, Alluvial plains, Sand dunes and Flood plains. The alluvial plains including sand cover comprise around 70% geograhical area of Punjab. The area under each form is presented in Fig. 2.5.

Fig. 2.5 Area (%) under different land forms of Punjab



Source: State of Environment, Punjab 2005

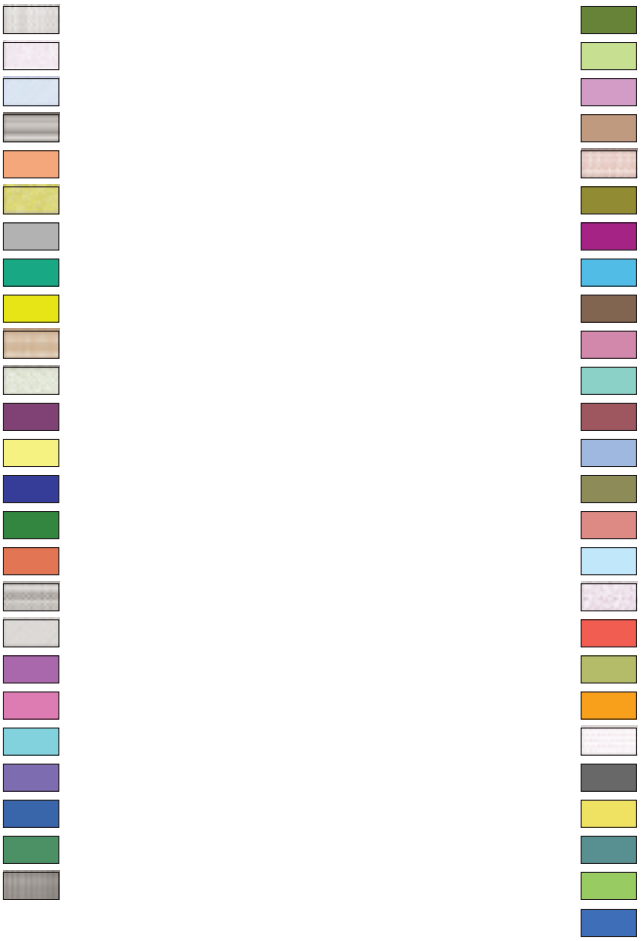
As a consequence of diversity in the natural environment like climate, topography, parent rocks, drainage and vegetation cover spread over a span of time, the soils of Punjab developed largely on alluvium, vary widely and show difference in their nature, properties and profile development. The major soil types of state are shown in Map 2.1. Based on the latest satellite data, field survey and merging of similar units, Punjab Remote Sensing Centre (PRSC) prepared detailed soil map in December 2000 (Map 2.2) published by National Bureau of Soil Survey and Land Use Planning.

Map 2.1 Soil map of Punjab

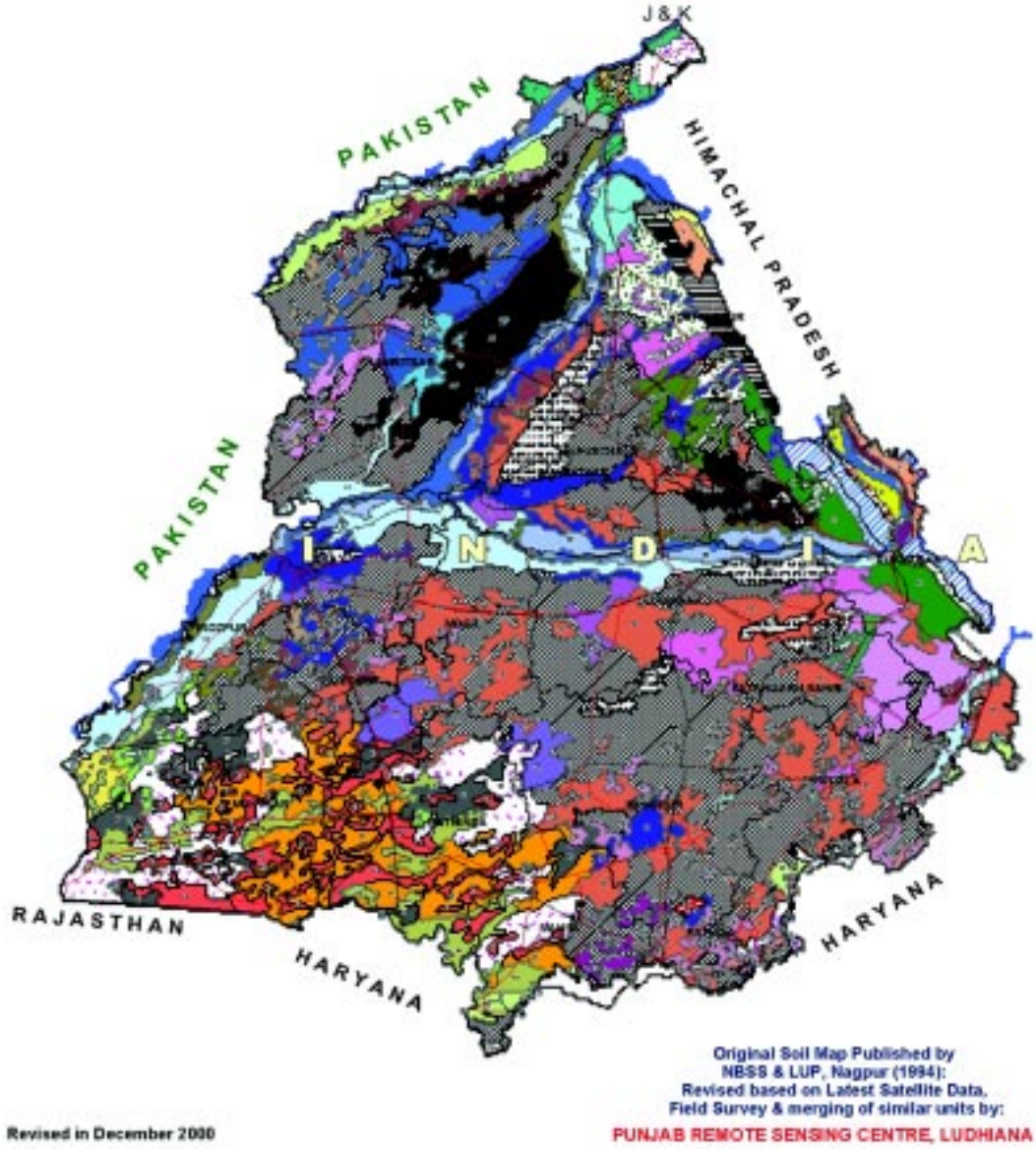
(LGP: Length of growing period)

Source: Deptt. of Soil & Water Conservation, Punjab

Legend (Map 2.2)



Map 2.2 Major soil types of Punjab



DESCRIPTION OF CODES

FAMILY PARTICLE SIZE CLASS
C.L. Coarse Loamy
F.L. Fine Loamy
F.S. Fine Silty
S.Sk. Sandy Skeletal
L.Sk. Loamy Skeletal

CALCAREOUS CLASSESS
Cal. Calcareous
(other units are non-calcareous)

SOIL DRAINAGE
Dr2 Poorly Drained
Dr3 Imperfectly Drained
Dr4 Moderately Well Drained
Dr5 Well Drained
Dr6 Somewhat Excessively Drained
Dr7 Excessively Drained

SOIL EROSION
e1 Slight Erosion
e2 Moderate Erosion
e3 Severe Erosion

SIOL SALINITY (EC dS/m)
S1 Slight Salinity (0.8-1.6)
S2 Moderate Salinity (1.6-2.5)
S3 Strong Salinity (2.5-5.0)

SOIL SODICITY (pH 1:2)
N1 Slight Salinity (8.7-9.2)
N2 Moderate Salinity (9.2-9.8)
N3 Strong Salinity (>9.5)

FLOODING (% AREA FLOODED)
F1 Slight Flooding (>25%)
F2 Moderate Flooding (25-50%)

General Legend
——— Major Roads
++++ Railway line
District Boundary

Source: PRSC, Ludhiana

Further, 83.4% (4200 thousand hectare) of the total land is under agricultural activities with cropping intensity of 189%. This is double the average percentage (43%) of land under agriculture in the country as a whole. The State has the highest percentage of net sown area in India.

The continuous emphasis on increasing the cropping intensity & yield and extensive agriculture practices coupled with faulty cropping patterns over the years have severly affected soil health and its fertlity in the state. With nutrient deficiency, loss of fertility and decline in organic matter soil quality has become a serious challenge in the agriculture sector of Punjab. Details are discussed subsequently.

Green Revolution

Punjab led the country's Green Revolution of the 1960s and earned for itself the distinction of becoming India's 'bread basket'. India has changed from a food-deficit country in early sixties, when we had to import foodgrains, to a food surplus country largely because of the agricultural transformation of Punjab. During the 1960s a fundamental change occurred in the institutional and economic infrastructure in state due to massive public investment, which led to development in irrigation and power, agricultural research and extension services, and the strengthening of the co-operative credit structure. Already, consolidation of land holdings and the predominance of owner farmers had created crucial pre-requisites for Green Revolution.

The Green Revolution introduced a new technology of production in agriculture. The technology consisted of packages of inputs, such as, high-yielding varieties, chemical fertilizers, pesticides, machines like tractors, threshers, pumpsets/motors, combine harvesters/reapers and others. High-yielding dwarf varieties of wheat from the International Centre for Maize and Wheat Improvement (CIMMYT), Mexico, were introduced leading to bumper crops. The availability of assured irrigation for fertile lands provided a conducive environment that enabled the dynamic farmers of the state to

Green revolution in Punjab

accept innovations in seed technology. These initial innovators were immediately imitated by other farmers, irrespective of the size of their holdings, when they observed sudden jumps in per hectare yield.

The impact was spectacular and between 1965-66 and 1970-71 the per hectare yield of wheat doubled, from 1104 kg/ha in 1965-66 to 2238 kg/ha in 1970-71(Source: Shiva, V, 1989). Following the success of the new technology in wheat production in the mid 1970s, a breakthrough was achieved by introduction of dwarf rice varieties from International Rice Research Institute (IRRI), Manila. After wheat, paddy provided a major push to agricultural prosperity in the state. By the mid 1980s, except for the southern parts of Punjab, the state began to follow a wheat-paddy rotation pattern in cultivation, and, as a consequence Punjab became the food bowl of the country.

The Green Revolution technologies worked very well until the beginning of the 1980s. But subsequently agriculture began to show signs of fatigue and sluggish growth. Productivity slowed down and stagnation set in. It has now been recognized that the Green Revolution, which helped Punjab to make a break through in crop production, is not all that green. The present cropping pattern and production system seems to be environmentally unsustainable and economically unviable. The Green Revolution technology had put great pressure on the ecological system of the state, leading to a fall in the level of ground water table, soil resources deterioration and environmental pollution from farm chemicals. Thus, the initial prosperity that the farmers achieved is diminishing at a very rapid rate.

Change in distribution of land holding

The consolidation of land holdings in early 1960s and the predominance of owner farmers had created crucial pre-requisites for Green Revolution in the state. In the first phase (upto 1980-81), the average size of holding per farmer increased from 2.94 ha in 1970-71 to 4.07 ha. This was mainly due to consolidation of holdings of marginal farmers resulting in increase in medium and semi medium holdings. Higher-sized holdings showed a modest increase during this period. These changes occurred primarily due to three reasons. First, with the onset of the green revolution technology, crop production activities became economically attractive, which created an active land-market for leasing and selling land. Secondly, progress of agriculture under the green revolution created employment opportunities in the non-farm sector like food procurement, processing, marketing and other service sector. It also allowed more spare time and money to pursue the same. This encouraged many marginal farmers to sell/lease their land to earn higher incomes from non-farming jobs. Finally, new agricultural technologies turned out to be more attractive for the large farmers and were uneconomic for use in smaller-sized farms (due to mechanization of farming) (Source: Punjab Development Report, 2002).

In the second phase beginning from 1980-81, while population continued to increase (24%) but profitability in farming started falling and as growth of employment opportunities in the non-farm sector became limited, the absolute number of holdings in the state increased again. Consequently, the average holding size in the state fell sharply from 4.07 ha in 1980-81 to 3.61 ha in 1990-91. However, subsequently, with lower production levels, lower profitability and disillusionment with agriculture (especially amongst youth) farmers with marginal holdings again started leasing/selling their land resulting in increase in land holding size to nearly 3.80 ha in 1995 and to 4.03 in 2001

(though it is still below the level attained in 1980-81). In 1995-96, except marginal and small farms, all other categories of farms considerably increased. As a result, the average operating land base for all categories of farms declined, except for the marginal ones. The size-class distribution of holdings in various districts for the year 1995-96 revealed that concentration of small and marginal farmers was the highest in the sub-mountane region, while concentration of large and medium farmers was the highest in the southwest region. Central districts were at the top in concentration of semi-medium holdings. The distribution of operational land holdings in the state from 1970-2001 is presented in Table 2.3.

Table 2.3 Distribution of operational land holdings in Punjab (1970-2001)

Category	Farm Size (ha)	1970-71 (%)	1980-81 (%)	1990-91 (%)	1995-96 (%)	2000- 01* (%)
Marginal	< 1	37.63	19.21	26.48	18.65	12.34
Small	1-2	18.91	19.41	18.25	16.78	17.35
Semi Medium	2-4	20.44	27.99	25.85	29.31	32.90
Medium	4 -10	18.02	26.02	23.41	27.98	30.19
Large	>10	5.00	7.19	6.01	7.28	7.22
Total Holdings (No's)		13,75,392	10,27,127	11,16,951	10,93,073	9,97,000
Avg. size of holding (ha)		2.94	4.07	3.61	3.79	4.03

Source: Statistical Abstract of Punjab, 2005 and *Department of Agriculture, Govt. of Punjab. 2005

At present, there are about 1 million operational holdings in state. The number of small holdings of up to 2 ha, which was about 45% in 1990-91 came down to 35% in 1995-96 and further to 30 % in 2000-01. Out of about 1 million operational holdings, about 63% are smaller than 4 ha and cover about 30% (1215 thousand ha) of the total cultivated area of the state. The marginal farmers are leasing out their land in distress as fragmented small land holdings are insufficient to make both ends meet. Although per hectare productivity has increased since early 1970s, the per farm family income has decreased due to subdivision of land holdings and rising cost of cultivation. With increasing pressure on land for more production per-unit area through adoption of modern technologies and use of capital inputs, marginal and small farmers are unable to keep pace with the rapid technological advances in crop production.

Initial avialabilty of water

Punjab, as the name suggests, is the land of rivers and water. It is endowed with good quality surface water resources through rivers and streams and also has sufficient underground water reservoirs. The three perennial rivers, namely the Sutlej, Beas and Ravi, flowing through the state have a water potential of about 14.54 Million Acre Feet (MAF). Besides these rivers, there is a network of six major canals, some built during British times and others later on. These are the Upper Bari Doab Canal; Bist Doab Canal; Sirhind Canal; Bhakra Main Canal; Bikaner Canal and Ferozepur Canal Circle. In addition, there are several important water drains and nallahs. Details have already been

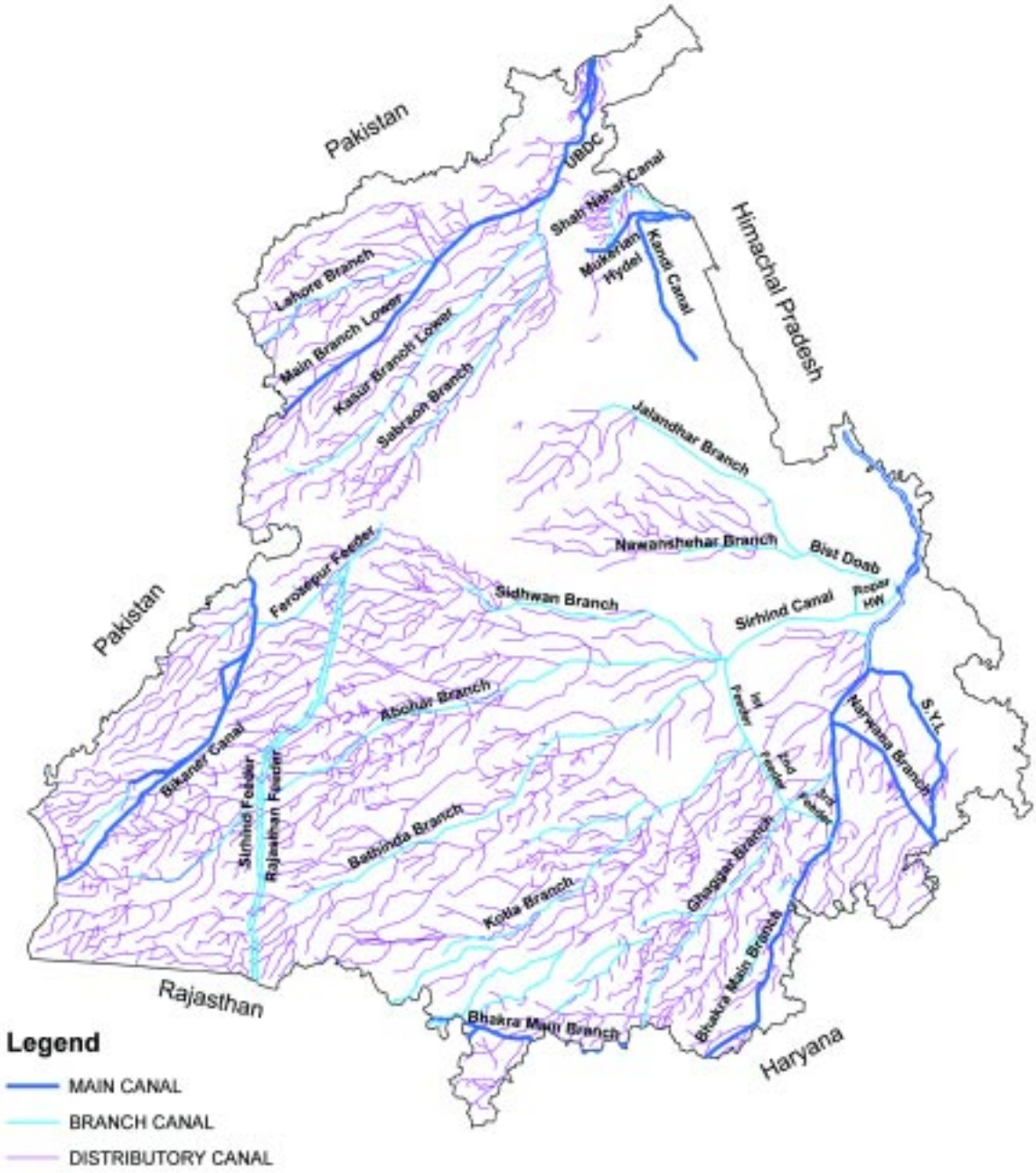
published in State of Environment Report: Punjab, 2005 (Tiwana, *et al.*, 2005). Irrigation sector is the major user of water resources and accounts for about 85% of water consumption in the state (Source: Irrigation department, Punjab). Out of the total area of 4.2 million ha under agriculture in state, an area of 3.95 million ha (94%) is getting irrigation from one or other sources. The state has about 14.5 thousand (th) km long canal network and about 0.1 million km of water courses providing irrigation to an area of 1.6 million ha. The canal and drainage network of Punjab is presented in Maps 2.3 and 2.4.

Most of the canal irrigated area of Punjab lies in Upper bari Doab (from Ravi river) and malwa region which include the Sirhind, Bhakra and Bikaner canals from river Sutlej. The State also has an 8 th km long drainage network .The major seasonal drains of the state are, White Bein, Kali Bein, Sakki and Kiran Nallah, etc. Numerous *choes* of the sub shiwaliks or the Kandi area are the ephemeral drains. These drains help in quickly dealing with heavy run off in monsoons and in preventing water logging.

The state surface water resources are being fully utilized through the well organized canal irrigation system in sustaining the intensive agriculture practices. However, there has been a reduction of over 35 percent in canal irrigated area in the state since 1990 and area irrigated by centrifugal tubewells has been increasing (Fig. 2.16). This is due to increased demand of water, reduction in canal capacity due to siltation and the easy credit facilities provided by the state Land Development Bank for tubewell installation with some subsidy, besides liberal facilities for electrification of tubewells. As per estimates, there are 1.168 million tubewells in Punjab (2004-05). Hence, the ground water is being over exploited to meet the increasing demands of water for irrigation intensive agricultural practices.

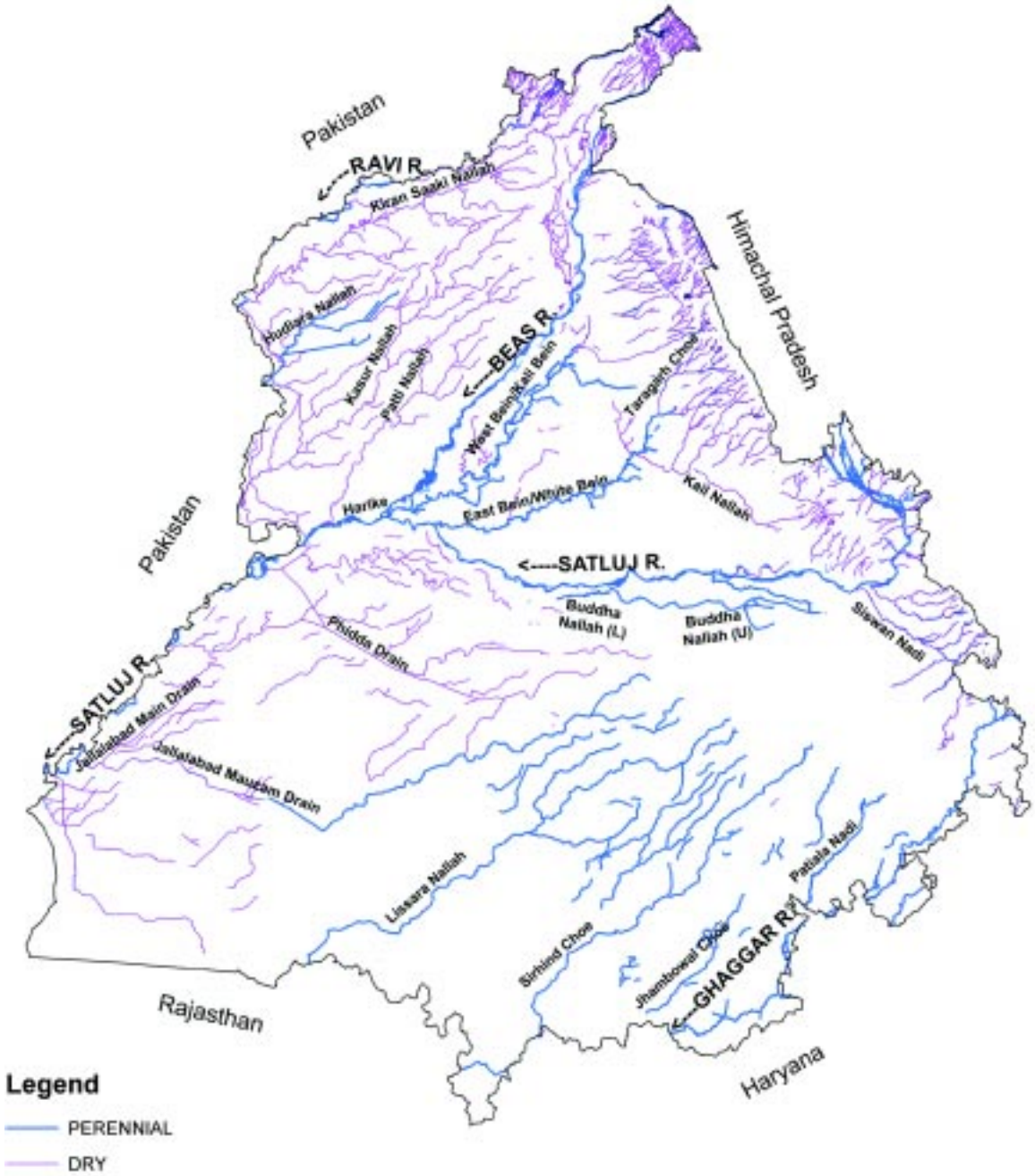
Well developed canal systems

Map 2.3 Canal network of Punjab



Prepared by: Punjab Remote Sensing Centre, Ludhiana

Map 2.4 Drainage network of Punjab



Prepared by: Punjab Remote Sensing Centre, Ludhiana

The demand of water for irrigation was low in the early 1960s due to diverse cropping pattern and cultivation of less water demanding traditional varieties of food crops. But after the onset of green revolution, the irrigation demand started increasing sharply due to cultivation of irrigation intensive HYVs of wheat and paddy in mid 1970s. Even though the available water resources of the state came to point of saturation in early 1990s owing to ever increasing demand of irrigation for increasing area under wheat-paddy rotation, still water resources of state had acted as a major driving force in sustaining water intensive agricultural practices in state for a period of three decades.

Minimum support prices and procurement facilities for certain selected crops

The Government of India introduced minimum support price (MSP) system under the Agriculture Price Policy since 1965. The minimum support prices are announced by the Government with a view to encourage food grains production, ensuring remunerative prices to the farmers for their produce on the basis of the Commission for Agricultural Costs and Prices (CACP) recommendations. The MSP is essentially a floor price set by government in an effort to stabilize the income of farmers and include full cost of production plus incentives for production. The cost of production is estimated through collection of farm level data in various states by cost accounting method. The sample size for Punjab is 300 farmers in 30 cluster villages (Source: Kalkat *et al*., 2006).

These prices are announced by the Government at the commencement of the season to enable farmers to pursue their efforts with the assurance that the prices would not be allowed to fall below the fixed level. It is now widely recognized that the minimum support price policy has been one of the key instruments, along with application of modern technology, to make the country self sufficient in production of foodgrains. However, currently in the wake of economic liberalisation, there are some confusing perceptions about the relevance of minimum support price policy. The Government of India every year announces the minimum support prices for 24 different commodities, though effective public procurement is operative only in case of wheat and paddy. The MSP of various crops related to Punjab from 1970-71 to 2006-07 is given in Table 2.4.

In Punjab, the MSP of wheat and paddy crops were effectively implemented. This encouraged farmers to make investment on large scale on land and water development and increase the area under HYVs of these two crops. In case of other crops, there had been hardly any procurement and the market prices in many cases have ruled lower than the MSP. Since 2000-01, the MSP for even wheat and paddy has been announced with meager increments. However, the area under these two crops continues to be at peak with little fluctuation not withstanding because of lack of effective market support and low profitability of alternative crops. Hence, despite decline in the margin of profit in wheat and paddy over the last 5 years, these crops are still more popular among farmers of Punjab due to their hassle free marketing. The cultivation of wheat and paddy crop rotation is causing irreparable damage to state's ecology especially depletion of ground water table, deterioration of soil health and environmental pollution, but it is very difficult to break this rotation under the present circumstances.

Table 2.4 MSP of various crops related to Punjab from 1970-71 to 2006-07 (Rs/Qt)

Com: Common Grade, A: Fine or A Grade
*Drought relief was given year 2002-03 on all crops except wheat
**An additional incentive bonus of Rs 50 per qt was given for wheat in 2005-06
^An additional incentive bonus of Rs. 50 per qt was given for paddy in 2006-2007

Source: Deptt. of Agriculture, Govt. of Punjab and Govt. of India

Availability of loans (credit)

The availability of cheap and timely credit is crucial for realizing the full potential of agriculture as a profitable activity. Agricultural credit has significantly contributed in development of agriculture in Punjab by enabling meeting of capital needs of farmers for making investment in irrigation, land development, purchasing machinery and purchasing farm inputs like seed, fertilizers and pesticides. Formal credit institutions, such as co-operative societies, co-operative banks, land mortgage banks, regional rural banks and commercial banks are supposed to meet the credit requirements of most agriculturists in Punjab. As on March, 2005, there are about 4000 primary agriculture cooperative societies with a membership of more than 2.1 million, 87 state agricultural development bank branches with a membership of more than 0.8 million and more than 1000 bank branches of scheduled commercial banks with more than 0.7 million farmers accounts (Statistical Abstracts of Punjab, 2005). As compared to other states, the spread of the co-operative credit network along with commercial and regional rural banks, is fairly well developed in Punjab. There are 50 bank branches per thousand square km in the state as compared to 21 in Maharashtra, 18 in Andhra Pradesh, 19 in Gujarat and 20 for the whole of India (Source: Punjab Development Report, 2002). Institutional sources had outstanding advances of more than Rs. 120 billions to farmers as of March 31, 2006 (Source: Kalkat *et al.*, 2006).

Besides institutional credit, a substantial amount of credit flows to the farmers from non-formal channels, i.e. commission agents, money lenders or arhtias. The non formal credit sources meet more than 50% credit needs of the farmers in the state. These money lenders charge higher interest rate in range of 24-36 % as compared to 9-12% charged by financial institutions. Non-productive long-term loans are mostly taken from private money-lenders. It has been observed that small and marginal farmers, mostly depend on money lenders for their agricultural and social credit requirements (due to speedy supply of credit without much of paper work and formalities at short notice), whereas, farmers with large holdings mostly enjoy institutional credit facilities provided by various banks (because of their ability to provide guaranty of repayments).

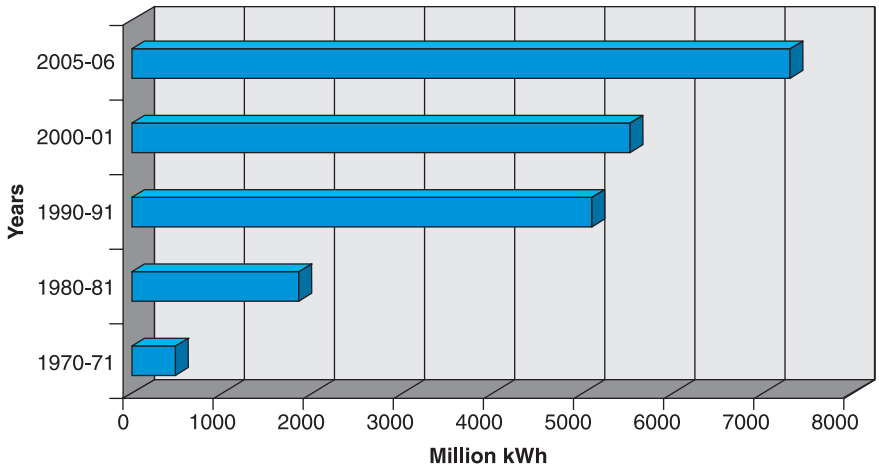
Keeping in view the limitations and inefficiencies of the formal credit system, and heavy dependence of farmers on arthias, the Central Government introduced a scheme of Kisan Credit Cards (KCC) in 1998-99. It aims at adequate and timely support from the banking system to farmers for their agricultural needs, particularly for crop production and short-term loans. The KCC has a provision of flexibility in withdrawing money at any time according to the farmer's requirements while the borrowing limit is fixed according to the net worth of the farmer, which is determined by district-level technical committees. The number of KCCs in Punjab has increased from at 62,624 as in September 2000 to 13,40,696 as on 30th June 2004. The cooperative banks have provided more than 60% of total Kisan Credit Cards in state (Source: Planning Commission, 2002 and Deptt. of Agriculture, Govt. of India).

Availability of electricity

Energy in the form of electricity plays a key role in performance of agriculture sector in Punjab as it is used most importantly in pumping ground water for irrigation purposes apart from other farm operations. The performance of all important sectors in the economy ranging from agriculture to commerce and industry depends on the availability, cost and quality of power. After Gujrat (271.74 Kwh) and Haryana (249.09 Kwh), Punjab has the highest annual per capita consumption of electricity in agriculture sector (247.76 Kwh) among all states and UTs in India (average 81.20 Kwh) (Source: Statistical Abstract of Punjab, 2005). The demand for energy in agriculture in Punjab has increased from a meager 463 million Kwh units to 7314 million Kwh units from 1971 to 31st March, 2006 mainly due to ever increasing area under water guzzling paddy crop (Fig 2.6). This is peak demand of electricity in the state as it is unlikely that area under paddy would increase further. Further, though the net consumption of electricity in agriculture sector has increased over the years, however, the percent share has declined (The agriculture sector of state had consumed 38% of total electricity consumed in Punjab in year 1970-71 followed by 44% in 1980-81, 43% in 1990-91, 29% in 2000-01 and 29% in year 2006) in the light of rapidly increase demand of electricity in industrial and domestic sectors of Punjab.

The sector wise annual per capita sale of electricity in Punjab is presented in Fig. 2.7. The total consumption of electricity in Punjab has increased from 19345.93 million kWh in the year 2001 to 24192.49 million kWh in the year 2006. In view of the ever increasing demand for power by agricultural and industrial sectors of state, the state government is working hard to bridge the gap between demand and supply by resorting to purchase of power from external resources. Punjab's self-generated thermal and hydel power accounts for 75 percent of total power availability and the remaining 25 percent being purchased from outside. For the last four years due to poor monsoon, the state is

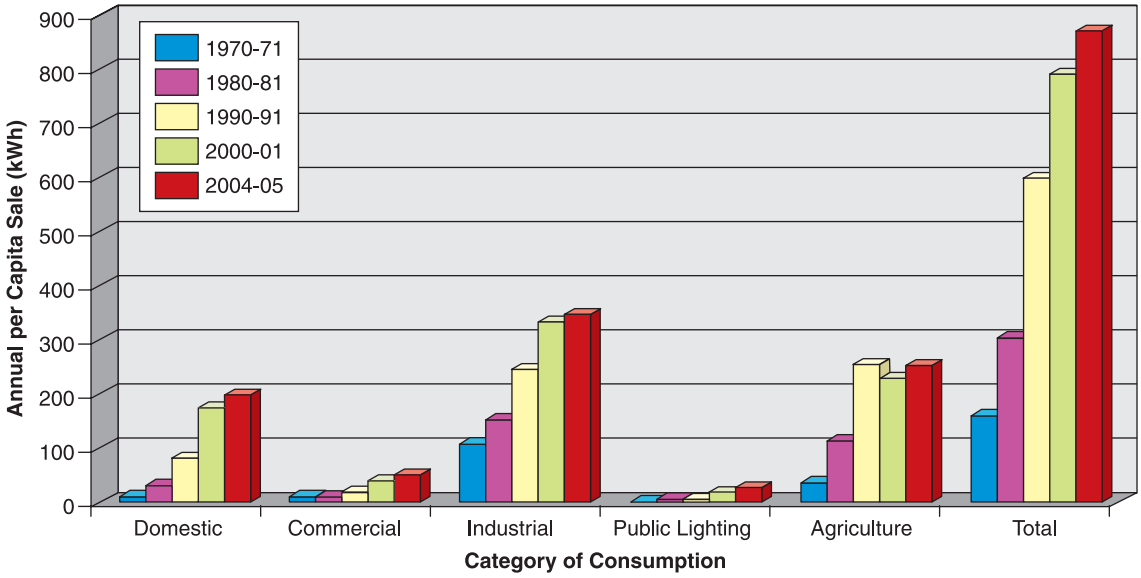
Fig. 2.6 Consumption of electricity by agriculture sector in Punjab (Million kWh)



Source: Punjab State Electricity Board, 2006

buying power from outside sources to provide at least eight hours supply to farm sector especially during paddy season (About 45 % of total demand in the agriculture sector is concentrated in paddy season). There has also been a sharp rise in number of electric operated tubwells in last 30 years [from 2,83,325 in year 1981 to 9,31,209 (330%) in the year 2006]. As on 31st March, 2006, there are

Fig 2.7 Category wise annual per capita sale of electricity in Punjab (kWh)



Source: Statistical Abstract of Punjab, 2005

2,75,820 pending applications for electricity connection from farmers of the state with a load of 9,32,505 kW (Source: PSEB, 2006). The major energy related indicators for agriculture sector of state in last six year are given in Table 2.5.

Further, the power supply to agriculture sector in the state is highly subsidized. It was totally free during the years 1997-2002. The state Government is again providing free electricity to all farmers w.e.f. 1st September, 2005, thereby benefiting them to the tune of Rs. 4320 million. As per PSEB, Punjab has purchased power worth Rs. 51600 million during 2002-2005 from other sources. This is being purchased at nearly Rs. 6 per unit but is provided free to farmers causing economic loss to the state.

Table 2.5 Energy related indicators for agriculture sector in Punjab

Indicator	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06
Growth of Connections (Nos.)	794475	829114	857559	880902	912889	931209
Growth of Connected Load (MW)	2867	3043	3295	3481	4309	4474
Release of New Connection (Nos.)	22713	33413	24384	22886	31212	17422
Release of Connected Load (MW)	137	163	215	179	111	68
Revenue from Sale (Crores)	0	0	151.42	329.22	391.8	203.23

Source: Punjab State Electricity Board, 2006

Moreover, free power to agriculture sector is also contributing to decline of water table. The policy of free electricity to farmers has resulted in excessive mining of groundwater resources used for cultivating water-guzzler crops like paddy. Farmers use water irrationally, over-irrigate their crops and do not care for power economy (as they do not have to pay for it) by using cheap non energy efficient, poor quality, non ISI mark motors. Further, free electricity had made the farmers subservient to governmental favors which has consequently resulted in loss of their spirit of enterprise.

Subsidies on fertilizers

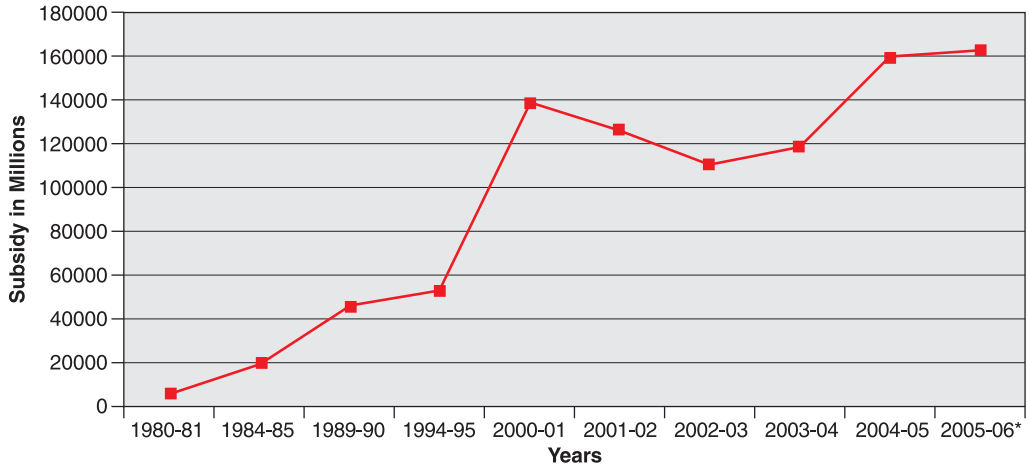
To ensure availability of fertilizers to farmers at affordable prices, the Government of India provides huge subsidies to fertilizer manufacturing industry (especially urea- Nitrogen). The nitrogenous fertilizer segment is regulated through price controls under the Retention Price-cum-Subsidy Scheme introduced vide the Government's resolution dated 1.11.1977. The Government fixes two prices: the price at which the manufacturers should sell to the farmers and the retention price, which the manufacturer should have received from the farmer. The government reimburses the difference in the selling price and the retention price in the form of a subsidy to manufacturing industry in India. Hence, the Government provides indirect subsidies to farmers for the purchase of fertilizers. But how much of the benefit of this subsidy is going to farmers (rather than producers) has been a matter of debate. According to a document of the Finance Ministry in year 2004, only 46 percent of total subsidies provided on fertilizers reaches the farmers, whereas the balance 54 percent goes into subsidising inefficient producers (Source: Report on "Central Government Subsides in India" by Ministry of Finance and Economic Affairs, Government of India, 2004).

The fertilizer subsidies bill in India, including import of urea, has escalated from Rs. 5 billion in 1980-81 to Rs. 162.5 billion in 2005-06 (Fig. 2.8). As a proportion of the GDP, this was 0.41% in 1980-81, reached upto 1.11% in 1989-90 and has been almost constant (ranging between a narrow band of 0.7%) since then.

The policy of subsidy on fertilizers encourages the farmers for excessive use of nitrogenous fertilizers with relative under-utilization of other fertilizers and micronutrients. Unbalanced fertilizer use does not lead to immediately visible harmful effects but it adversely affects soil quality over time. Moreover, the injudicious use of fertilizers can practically cause all forms of pollution i.e. of soil, air and water. The soil pollution load further increases due to their reaction products and residues. Some of the reaction products such as nitrates and phosphates find their way to surface waters and aquifers. The enrichment of surface waters with these nutrients by runoff from agriculture fields and by leaching causes eutrophication. Air pollution is also caused by the gases arising from fertilizer use in soil. The gases *viz*. ammonia, nitrogen dioxide, nitrous oxide, sulphur dioxide, hydrogen sulphide, etc. may not only vitiate air but could also lead to ozone layer depletion and global warming. No specific studies are however available in this respect in Punjab.

A study conducted by Bajwa *et al*., in 1993 indicated that groundwater samples collected from 21 to 38 m deep tubewells located in cultivated fields of Dehlon, Sudhar, Ludhiana, Kartarpur, Jandialaguru and Malerkotla blocks of Punjab (N fertilizers use varying from 258 kg N/ha in Ludhiana to 151 kg N/ha in Malerkotla) contained mean NO_3–N concentration of 3.62 mg/l. Further, 78 and 22 percent samples contained less than 5 and 5-10 mg/l NO_3–N respectively. Higher nitrate concentration in groundwater was observed in areas under rice, maize and orchards. Although observed nitrate-N levels were well below the critical limit of 10 mg/l NO_3–N (WHO), however, once nitrate-N gets into the aquifers, decades will be required for remediation. Further, as per information provided by the experts of Department of Animal Husbandry, Punjab, instances of cattle deaths due to fertilizer residues (especially urea) in fodder (barseem) have also been reported in the state (Source: Personal Communication, Dr. H.S. Gill, 2007).

Fig. 2.8 Subsidy on fertilizers in India from 1980 to 2006 (in millions)



*Budget estimate Upto Nov. 2005

Source: Ministry of Chemicals & Fertilizers, Govt. of India, 2006

PRESSURES

The major driving forces discussed above provoke various changes in overall agricultural production and consumption levels and utilization of natural resources for agricultural activities and thereby exert direct or indirect pressure on natural ecosystem of state. This includes:

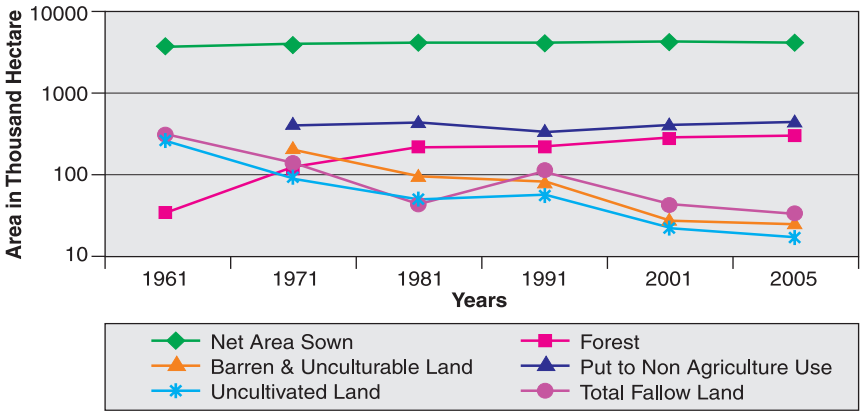
Change in land use pattern

Agricultural development and changes in cropping pattern after the success of green revolution has led to a change in land use pattern of the state. Punjab is a small state with 50362 sq km geographical area, out of which about 83.4% of the total land is under agricultural activities, as compared to national average of 40.38%. This is highest as compared to other agriculturally advanced states like Haryana (78%), Uttar Pradesh (69%), Maharastra (56%) and Karnataka (51.3%) (Source: Calculated as per the figures provided in Statistical Abstract of Punjab, 2005).

Land under agriculture has increased from about 75% in 1960-61 to about 80% in 1970-71 after which it has remained more or less constant. It reached a maximum of 84.4% in the year 2000-01. In contrast, barren, unculturable, fallow and other uncultivated lands have recorded a sharp decline from 1960-61 to 2004-05 (Fig 2.9). The area under barren land in the state has decreased from 4.1% in 1971 to a meager 0.5% in 2005. Similarly, percentage area under uncultivated land including culturable waste, permanent pastures and grazing lands decreased from 5% in 1961 to 0.3% of total area of state. The total fallow land in state has also declined sharply from 6.2% to 0.6% in the last 45 years.

There has been an increase in the area put to non-agricultural (from 6.8% in 1991 to 8.5% in 2001 and 9.1% in the year 2005) use in state during the last 15 years. This is obviously due to increase in developmental activities as more and more agricultural land is being used for industrial zones, housing complexes, transport systems, recreational purposes, etc. The area under forests has also registered an increase in its percentage share from 1960 to 2005. However, more and more area under total fallow land, barren and unculturable land and uncultivated land is being brought under agriculture as a result of which total area under agriculture has remained the same (though its quality is poor).

Fig. 2.9 Land use pattern in Punjab from 1960-2005 (in thousand ha)



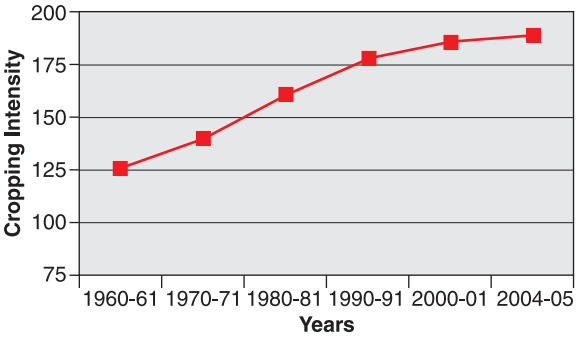
Source: Statistical Abstract of Punjab, 1991 & 2005

Cropping intensity

With adoption of input intensive agriculture by the farmers of the state, cropping intensity, which reveals ratio of net area sown to the total cropped area, has increased manifold in the last four decades. Cropping intensity has been enhanced from 126% in 1960-61 to 161% in 1980-81 and to further 189% in the year 2005 (Fig. 2.10).

As per Ministry of Agriculture, Government of India, statistics for the year 2003, Punjab has the highest cropping intensity in the country followed by 176% of West Bengal, 174% of Haryana, 152% of Uttar Pradesh and 142% of Assam as compared to all India percentage of 132.

Fig. 2.10 Increase in cropping intensity (%) in Punjab (1960-2005)

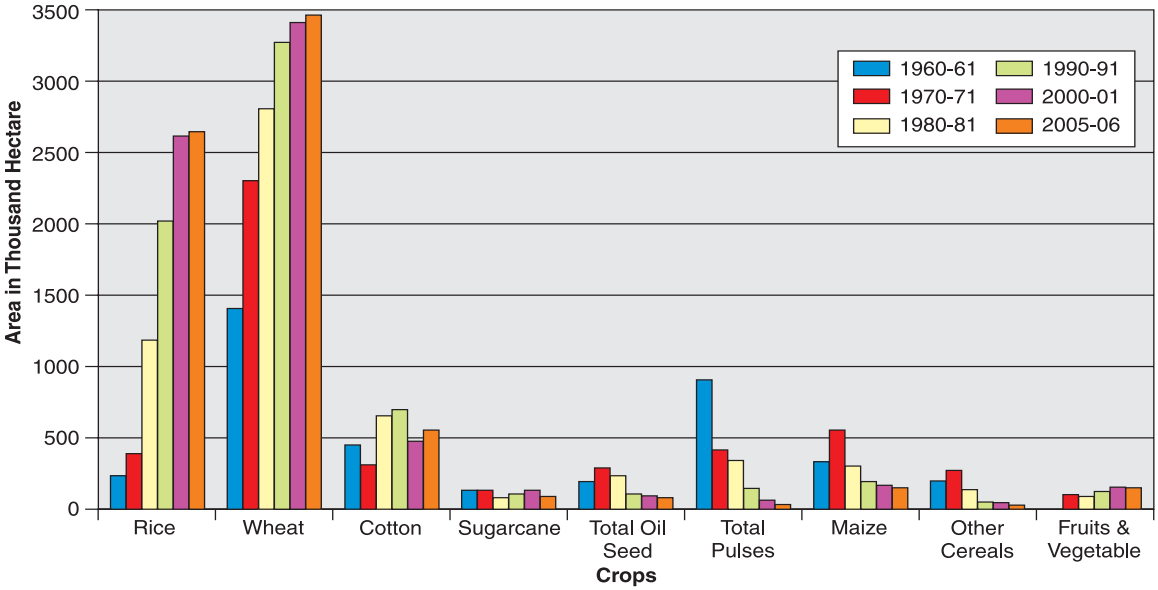


Source: Calculated from Statistical Abstract of Punjab, 2005

Changes in cropping pattern

Cropping pattern refers to the proportionate area under different crops during a crop year. Kharif (July to October) and rabi (October to March) are two main cropping seasons in the state. In the post green revolution era, the state of Punjab has witnessed a considerable change in its cropping pattern. The change of area under cultivation of various crops is presented in Fig. 2.11.

Fig. 2.11 Changes in cropping pattern of Punjab (1960-2006)



*Cotton includes Desi and American; **Other cereals include Bajra, Jowar and Barley; ***Total oilseeds include ground nut, sesame, rape seed, mustard, linseed and sunflower; ****Total pulses include grams, mash, moong, arhar, lentils/peas and massar

Source: Statistical Abstracts of Punjab, 2005 & Department of Agriculture, Govt. of Punjab, 2006

Paddy is a major crop which has made an impact on the agriculture of the state. The area under paddy has increased from 227 thousand hectare (th ha) in 1960-61 to 2642 th ha in the year 2006. In terms of gross cropped area of the state (total area sown once and/or more than once in a particular year), paddy occupied around 4.8 percent of the gross cropped area in 1960-61, increased to more than 25 percent in 1990-91, and then increased further to 33.37 per cent in 2004-05. The increase in area under paddy has led to decline in area under other major kharif crops like maize, bajra, jowar, sugarcane, groundnut, pulses, etc. The area under maize and sugarcane has declined from 9.77% and 2.25% of total gross copped area of state in the year 1970-71 to 1.94% and 1.08% in year 2004-05, respectively.

Wheat has, however, been the dominant crop of the state in rabi season from the very beginning. In 1960-61, 29.58 percent (1400 th ha) of the gross cropped area was under wheat, which increased by about 44 percent in 1990-91 and has thereafter remained almost the same (3468 th ha in 2006). The area under various crops as percentage share to total cropped area of state is given in Table 2.6. The increase in wheat cultivation has been at the expense of cutting down the area under other rabi season crops especially gram, barley, rapeseed, mustard and sunflower.

Punjab also has a potentially productive belt of cotton covering a sizable part of its cultivated area. This belt suffered since mid-nineties due to decline in productivity and pest attacks. The area under desi cotton has decreased from 4.26 percent of total gross cropped area in 1960 to less than one percent in year 2005. However, area under American cotton has been fluctuating around 5 percent of total gross cropped area of Punjab, which is further expected to increase due to introduction of Bt cotton varieties.

Table 2.6 Area under various crops as percentage share to total cropped area of Punjab

Crop	1960-61	1970-71	1980-81	1990-91	2000-01	2004-05(P)*
Rice	4.79	6.87	17.49	26.86	32.89	33.37
Wheat	29.58	40.49	41.58	43.63	42.92	43.89
Maize	6.91	9.77	4.50	2.44	2.08	1.94
Bajra & Jowar	2.72	3.73	1.03	0.16	0.08	0.09
Cotton (American)	5.17	3.73	7.42	8.49	4.51	5.72
Cotton (Desi)	4.26	3.26	2.17	0.85	1.46	0.69
Sugarcane	2.81	2.25	1.05	1.35	1.52	1.08
Total Oil seeds	3.90	3.96	3.52	1.39	1.08	1.13
Total Pulses	19.08	7.29	5.04	1.91	0.68	0.45
Barley	1.39	1.00	0.96	0.49	0.40	0.28
Total Vegetables	-	0.88	0.95	0.72	1.39	1.42
Fruits	-	0.88	0.43	0.92	0.43	0.59
Gross Cropped Area	**4732**	**5678**	**6763**	**7502**	**7941**	**7932**

(P): Provisional

Source: Statistical Abstract of Punjab, 2005

Area under total pulses and oilseeds has reduced sharply. This includes many leguminous crops like groundnut, lentils and guar (nodules on the roots of leguminous plants convert atmospheric nitrogen compounds through nitrogen fixation, that can be used by plants). The area under total pulses recorded a sharp decline from 19 percent in the early sixties to 0.45 percent of total gross cropped area of the state. The total area under oilseeds also declined by more than 70% in the last 45 years.

Hence, after the Green Revolution, the farmers of Punjab abandoned their traditional cropping practices in favour of the government-supported wheat-rice cropping method. However, this is causing degradation of soil including nutrient imbalance, depletion of underground water table (upto 75 cm per year), abuse of pesticides and fertilizers leading to several environmental and health hazards, besides creating economic and social imbalances. It is also creating serious market clearance problems during peak harvesting time. The reduced crop diversity index (Box 2.3) over the years due to monoculture of wheat and paddy has further resulted in resurgence and development of resistance in pests and has also affected the population of natural enemies of pests. Moreover, in the past years, in order to sustain paddy crop, the industrial, domestic and commercial sectors of state have had to face frequent scheduled and unscheduled power cuts to divert electricity to farm sector during June and August.

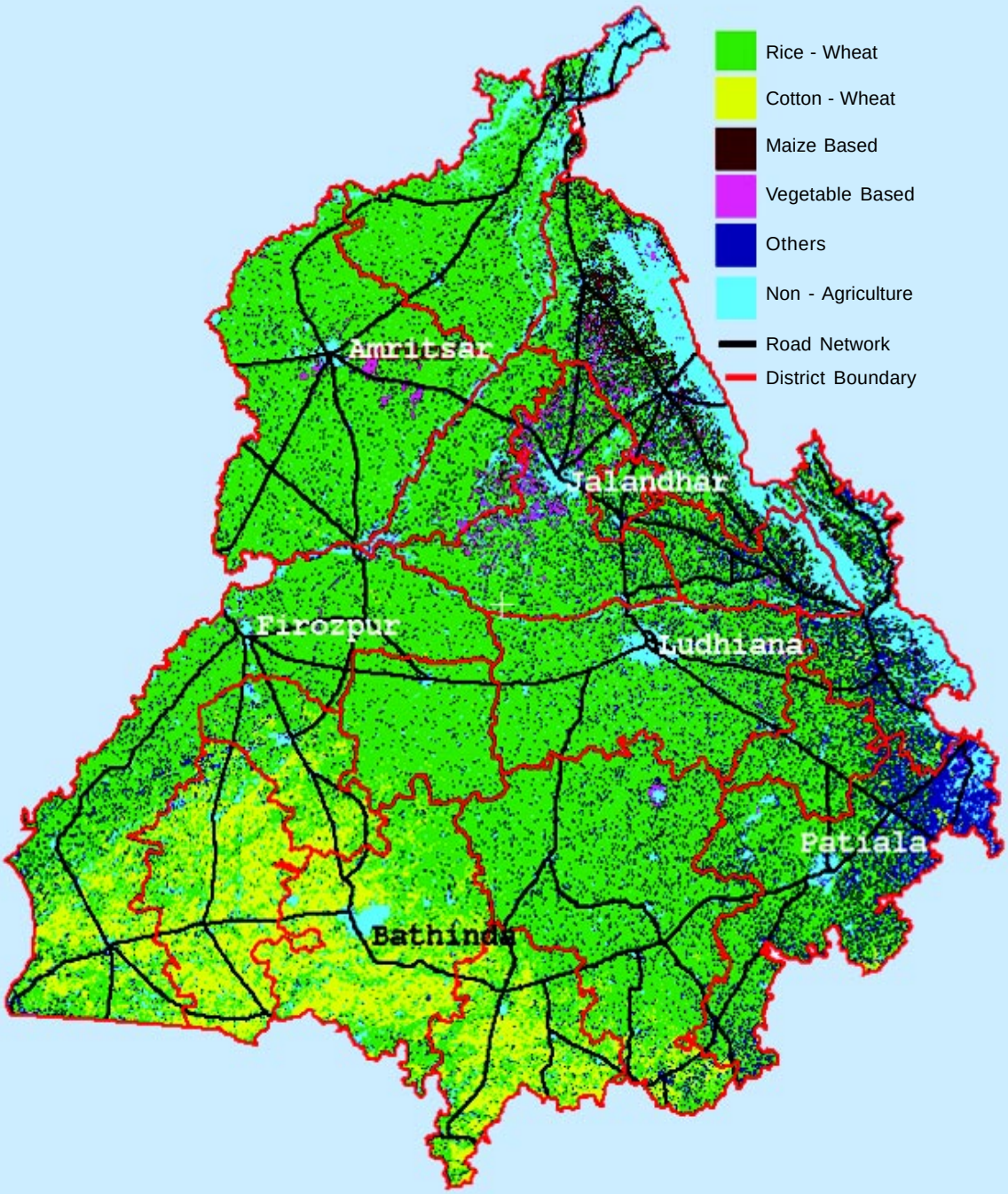
Box 2.3. Crop diversity analysis of Punjab

Crop diversity in Punjab has decreased over the years. This is confirmed by results of a study conducted by Punjab Remote Sensing Centre in collaboration with Space Application Centre, Ahmedabad (Panigrahy *et al*., 2003), for each district of Punjab under the project "Cropping System Analysis in Punjab". In the study, crop rotation and cropping pattern maps (Maps 2.5 to 2.9) of the state were generated from multi-date multi-sensor remote sensing data along with calculating the Area Diversity Index (ADI) for each district.

The rice-wheat and cotton-wheat are major rotations followed in the state (Map 2.5). The vegetable crops are grown around major cities like Amritsar and Malerkotla. Potato based cropping system is generally followed in Jalandhar and Hoshiarpur districts and maize base systems are followed in north eastern parts of Punjab (eg. Hoshiarpur, Rupnagar, Nawanshehar, Gurdaspur, Kapurthala and Jalandhar). Diversity index measures the multiplicity of crops which are planted in a single year. The district level variations were studied using crop area data from three different periods (i.e 1980-81 and 1981-82, 1990-91 and 1991-92 and 1998-99 and 1999-2000) and ADI was analysed with a gap of around 10 years. The kharif season ADI has decreased in the state because in all districts (except Hoshiarpur and Bathinda) rice has become the major kharif crop eliminating all other crops. The average kharif season ADI for the state was 1.512. It ranged from a minimum of 1.039 for Moga district to maximum of 2.082 in Mansa District. A high value of ADI (more than 1.6) was observed in the districts of Bathinda (2.017), Mansa (2.082), Faridkot (1.672) and Mukatsar (1.820) with cultivation of rice and cotton crops (Map 2.8). Low ADI values (below 1.2) were found in the districts Gurdaspur, Amritsar, Ludhiana, Moga, Sangrur and Fatehgarh Sahib, where rice is the dominant crop in Kharif season. For rabi season crops also ADI has decreased slightly in the past 20 years, however it is comparatively lesser than kharif season (Map 2.9). Punjab was traditionally a wheat growing state, but cultivation of other rabi crops like mustard, gram and barley have also decreased. The district wise change in crop diversity is presented in Fig 2.12.

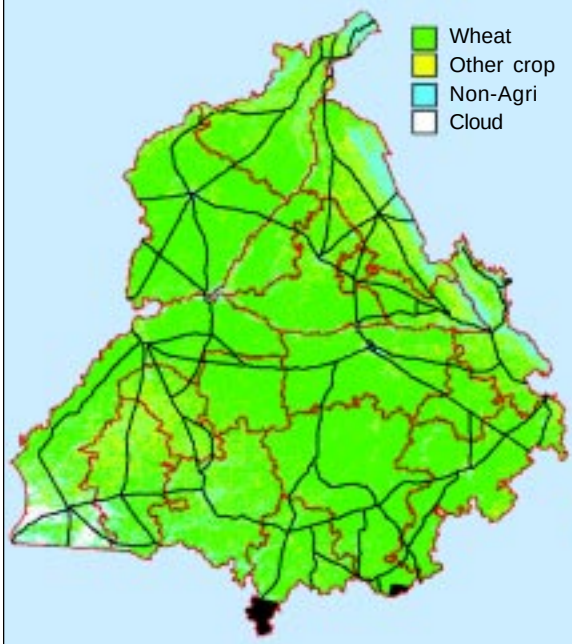
contd...

Map 2.5 Crop Rotation Map of Punjab (1998-99)

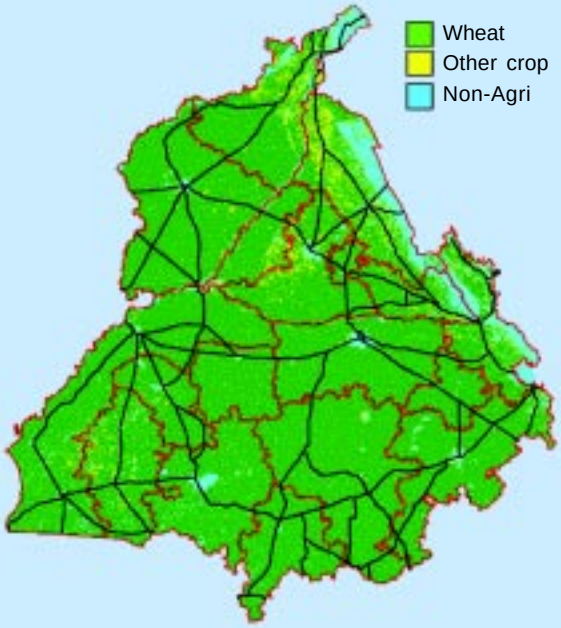


Prepared by: Punjab Remote Sensing Centre, Ludhiana, in collaboration with Space Application Centre, Ahmedabad

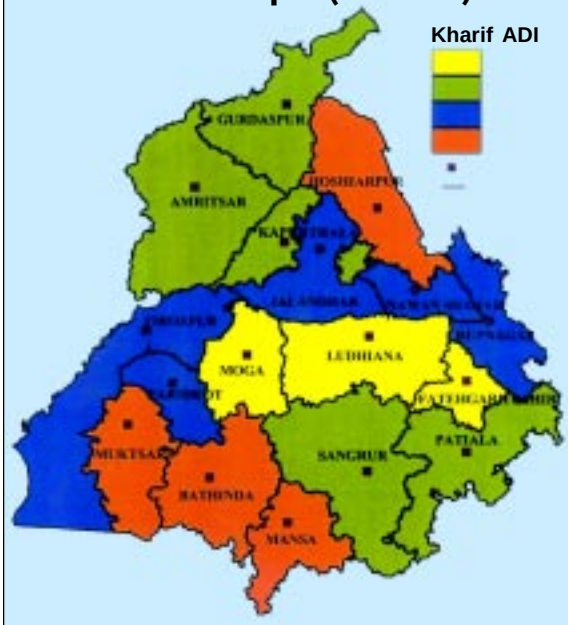
Map 2.6 Rabi cropping pattern map of Punjab (1988-89)



Map 2.7 Rabi cropping pattern map of Punjab (1998-99)



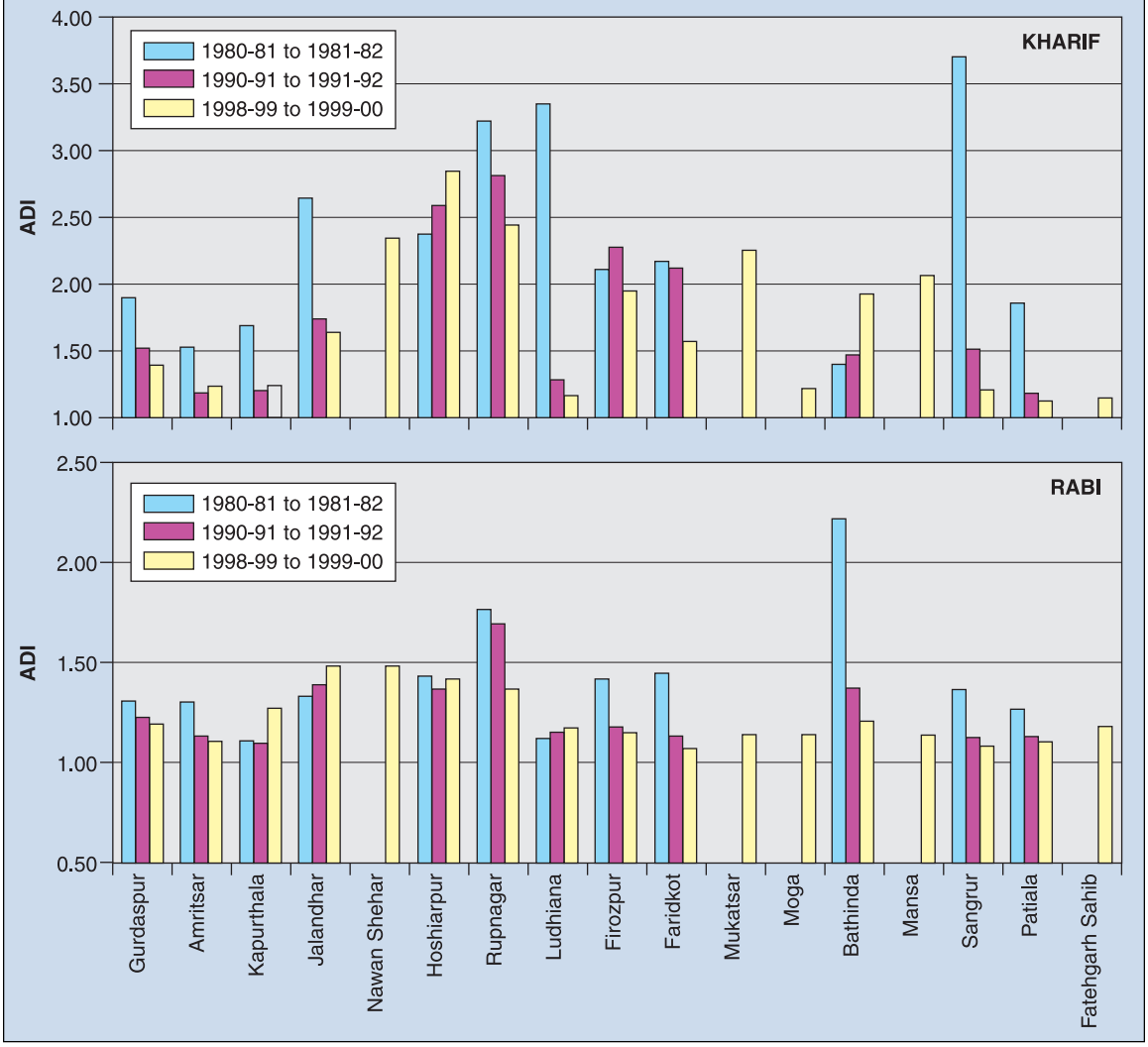
Map 2.8 District level kharif season ADI of Punjab (1989-99)



Map 2.9 District level rabi season ADI of Punjab (1989-99)

Prepared by: Punjab Remote Sensing Centre, Ludhiana, in collaboration with Space Application Centre, Ahmedabad

Fig. 2.12 Change in crop diversity in Punjab from 1980-81 to 1999-2000



Expansion of area under High Yielding Varieties (HYVs)

As discussed earlier, the HYVs of wheat and rice in late sixties and mid seventies had played a key role in making Punjab the food bowl of the country. The area under HYVs of wheat had increased to 69% of total area under wheat in the state in the year 1970-71 and it reached to 100% in the year 2000-01 (Table 2.7). At present only HYVs of wheat are being cultivated. Similarly, area under HYVs of rice comprised 33% of total area under rice in 1970-71. It increased to 95% in 2001 and to 100% in the year 2005. With respect to maize, even though the total area under maize has decreased considerably over the past 35 years, however, the share of area under HYVs of maize kept on increasing (from 9% of its total area in 1970-71 to 94% in the year 2005).

Table 2.7 Total area and area under HYVs of major food crops in Punjab (000 ha)

Year	Wheat		Rice		Maize		Bajra	
	Total	HYVs	Total	HYVs	Total	HYVs	Total	HYVs
1970-71	2299	1589	390	130	555	49	207	126
1980-81	2812	2757	1183	1095	382	127	69	34
1990-91	3273	3271	2015	1906	188	160	12	11
2000-01	3408	3408	2612	2506	165	154	6	5
2004-05	3481	3481	2647	2647	154	145	7	7

Source: Derived from Statistical Abstract of Punjab, 2005

Most HYVs are highly input intensive leading to higher use of irrigation water, fertilizers and pesticides for their optimum growth and yield. However, in the absence of these inputs their performance and productivity is lower than indigenous varieties, thus forcing farmers to follow high input agriculture. Moreover, the expansion of high yielding varieties has resulted in the loss of domesticated biodiversity in the state. The status is discussed by Jerath *et al*. (2002) and Tiwana *et al*. (2005). The HYVs have replaced the multicropping pattern with monoculture of wheat and rice. As reported by Vandana Shiva, the introduced wheat and rice varieties have come from a very narrow genetic base. Of the thousands of dwarf varieties bred by Borlaug, only three were eventually used in the Green Revolution (Shiva, 1989).

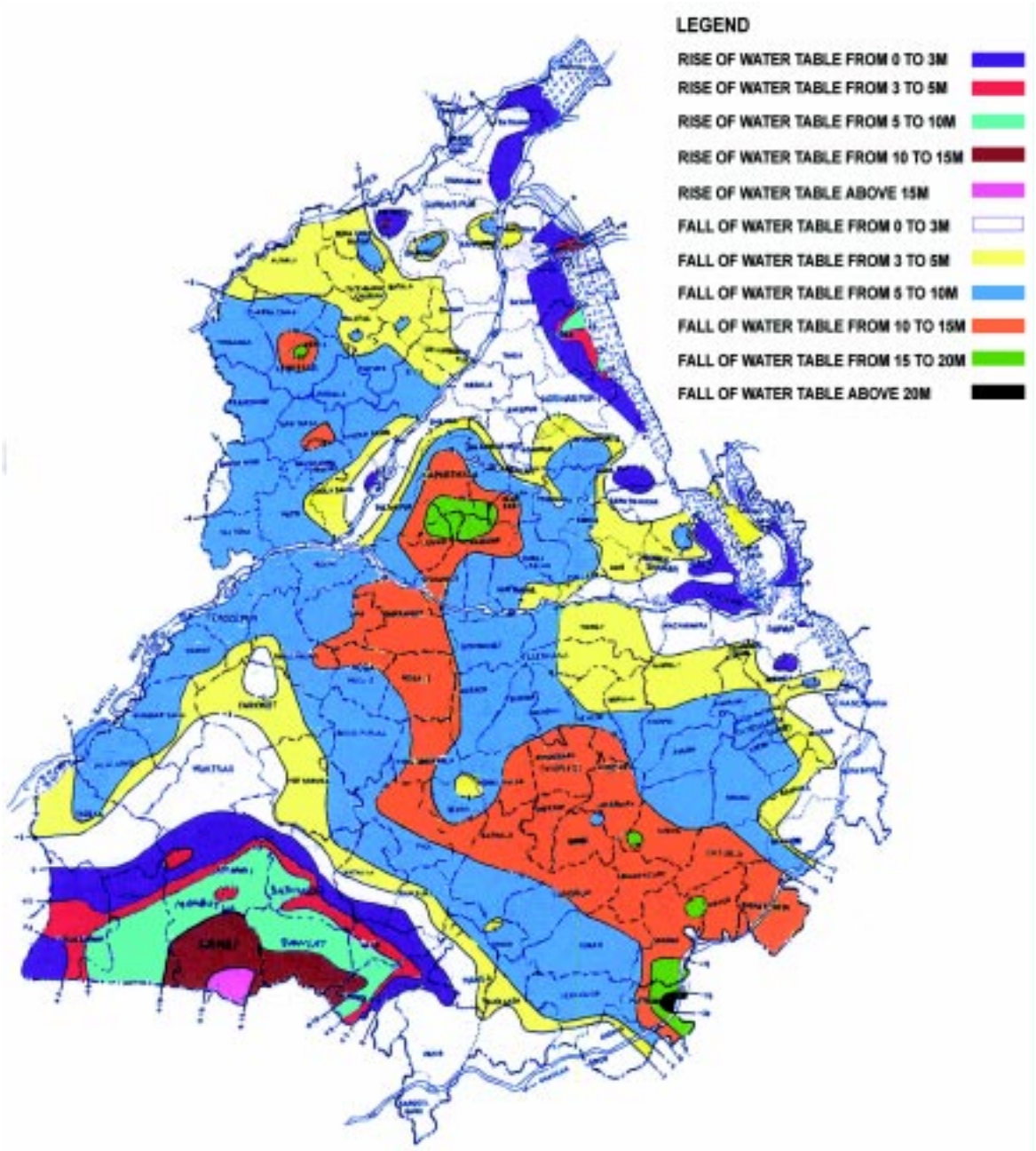
Further, surveys conducted by Punjab Agricultural University have found that more than 87% of the area under wheat is currently using a single HYV, namely, PBW 343 (released in 1995). Similarly, high yielding rice varieties of only PR series-106, 108, 111, 113, 116, 118 are grown through out the state in every kharif season. Thus food supplies of millions is precariously perched on the narrow and alien genetic base and the natural ecologically adapted biodiverse agricultural base is virtually lost.

Exploitation of ground water resources of state

Agriculture in Punjab has a heavy requirement of water for irrigation purposes. The dominance of rice and wheat monoculture cropping pattern over the years has led to overexploitation of ground water resulting in rapid decline of water table in the entire state (except south western part), as ground water is generally sweet and fit for irrigation. However, water table is rising in some south western parts of the state, where water extraction for irrigation purposes is limited due to its brackish and saline quality. The rise and fall in water table in Punjab from 1984 to 2004 is shown in Map 2.10.

As per the guidelines of Ground Water Resources Estimation Committee (GEC), the present ground water development (ratio of gross ground water draft for all uses to net ground water availability) in the state is 145% as on March 2004 as per latest data provided by Central Ground Water Board (CGWB) and Department of Irrigation, Punjab (Source: Report on dynamic

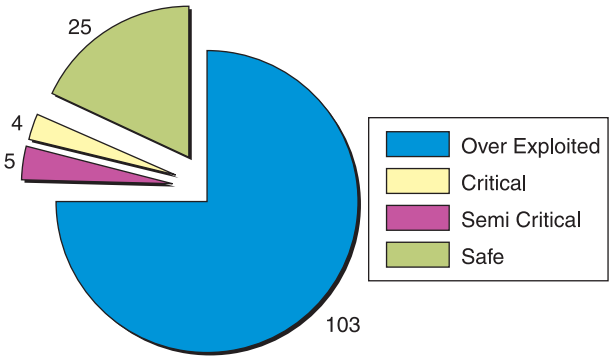
Map 2.10 Fall/Rise in water table (in metres) in Punjab (June 1984 to June 2004)



Source: Directorate of Water Resources & Environment, Punjab, 2005

ground water resources of Punjab, 2005). Out of 137 blocks of the state, 103 blocks are overexploited, 5 blocks are critical, 4 blocks are semi critical and only 25 blocks are in safe category (Fig 2.13).

Fig. 2.13 Categorization of blocks in Punjab based on ground water development

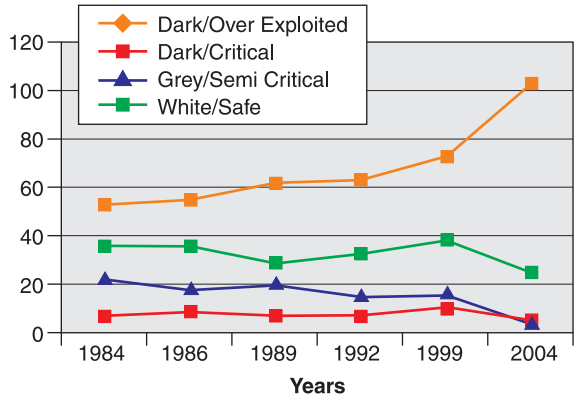


Over exploited: Exploitation > 100%,
Critical: Exploitation > 90% □ 100%,
Semi Critical: Exploitation > 70% □ 90%,
Safe: Exploitation □ 70%.

Source: CGWB & Deptt. of Irrigation, Punjab, 2005

The gravity of the situation can be gauged from the fact that ground water in 75% of total geographical area of the state is over exploited in terms of stage of ground water development, as exploitation is more than 100 percent, 7% area of the state is under the category of critical and semi critical category and only 18 % area of the state is safe for ground water development. However, only a part of this is in kandi area zone. The rest is in south western Punjab and is saline and unfit for use. All the blocks of various districts like Amritsar(16 blocks), Jalandhar (10 blocks), Moga (5 blocks), Kapurthala (5 blocks), Sangrur (12 blocks), Fathegarh Sahib (5 blocks), Patiala (8 out of 9 blocks) and Ludhiana (9 out of 10 blocks) have been found to be over-exploited leading to sharp depletion of the water table in these districts. The increase/decrease in number of various categories of blocks from 1984-2004 is presented in Fig. 2.14. Data indicates that the number of dark/ overexploited blocks have sharply escalated during the period 1992 to 2004.

Fig. 2.14 Increase/decrease in number of various categories of blocks in Punjab from 1984-2004



Source: CGWB & Deptt. of Irrigation, Punjab, 2005

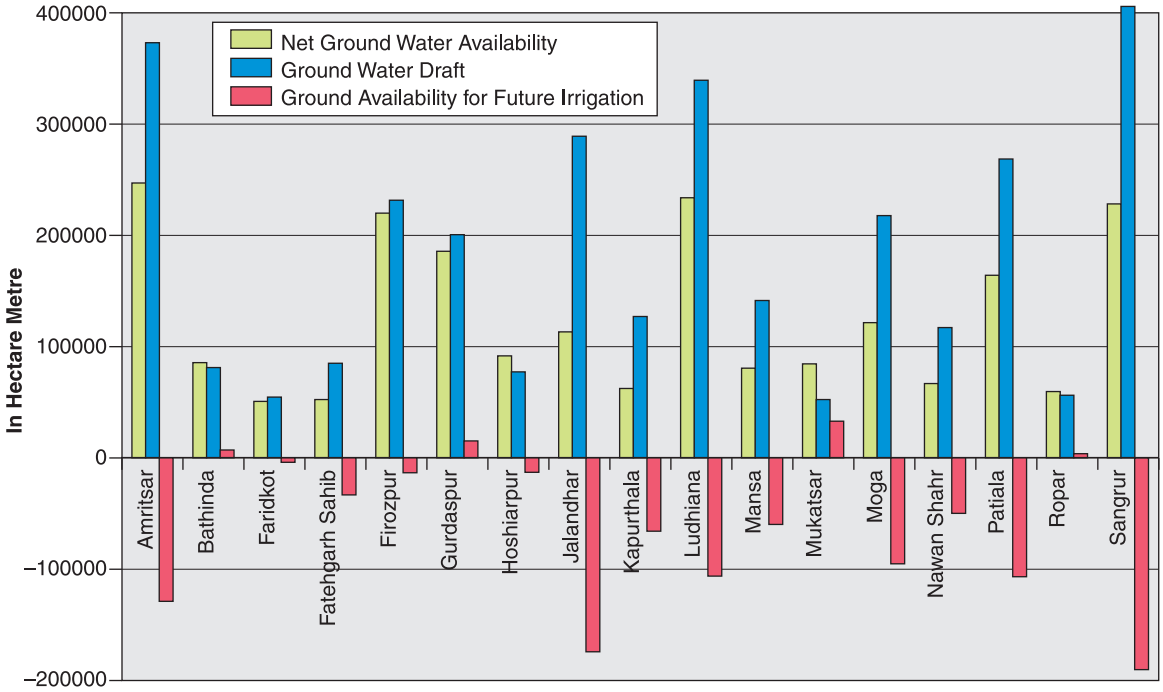
As per PAU, the state has been facing a short fall in water availability to the tune of 1.25 million hectare meter (mham) every year. The total demand of water for agricultural purposes based on cropping pattern and practices of 2000-01 is 4.38 mham against the total supply of 3.13 mham. Out of this surface canals provide 1.45 mham and ground water recharge (rains and canal seepage) provides 1.68 mham of water. The deficit is met through over - exploitation of under ground water reserves through tube wells. Though there is not much change witnessed in the last few years in the surface water resources, the underground water resources have deteriorated to a large extent. Whereas on an average the water table has

receded at an annual rate of 55 cm across the state (between1993-2003), however, the central districts (like Amritsar, Jalandhar, Kapurthala, Ludhiana, Patiala, etc.) recorded a fall of 75 cm. Further, districts like, Moga, Sangrur, Patiala, Jalandhar, Ludhiana and Kapurthala, are the worst hit as the water table depletion beyond 10 m increased from 3 percent area in 1973 to 95 percent area in 2005. Furthermore, it is predicted that in about 66 percent area of the central districts the depth of water table would recede to 50 m by the year 2030 (Hira *et al.*, 2006).

District wise ground water availability, ground water draft and net ground water availability for future irrigation, is presented in Fig. 2.15. Another issue of concern is that water in a large part of the area which indicates positive ground water balance, is saline and hence unfit for consumption.

It is important to take cognizance of the fact that central Punjab has 72% area under paddy cultivation, out of which only 21% area has canal water irrigation facility. The tubewells in the central districts of the state constitute around 70% of total tubewells in Punjab (over 6% of the total tube wells of India are in Punjab), which have increased from 0.192 million (0.091 electric and 0.101 diesel operated) in 1970-71 to 1.168 million (0.880 electric and 0.288 diesel operated) in 2004-05. (Source: Statistical Abstract of Punjab, 2005). The net irrigated area by different sources in Punjab is given in Fig. 2.16.

Fig. 2.15 District wise ground water availability, ground water draft and net ground water availability for future irrigation in Punjab, 2005



Source: CGWB & Deptt of Irrigation, Punjab, 2005

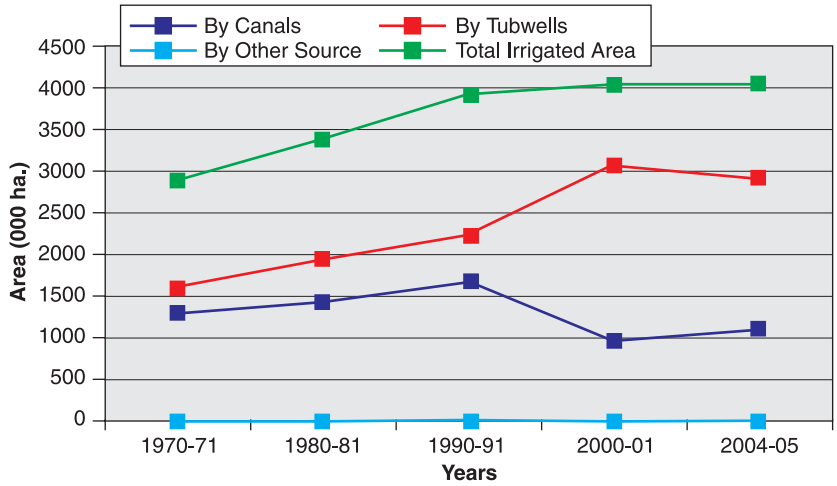
Box 2.4 Reverse flow of water in Moga and Sangrur districts

The groundwater in the state flows from north-east to south-west direction at a gradient of one ft per km. Nonjudicious pumping of ground water through tubwells and continuous decline of water table in central districts has resulted in the reverse flow of water towards Moga and Sangrur districts instead of going downwards towards south western districts. There are indications that sweet water has turned brackish due to reverse flow of saline groundwater from south western zone. Studies by PAU indicated that the proportion of this unfit water in Nihal Singh Wala block has reached to 30 per cent in 2004 as compared to 11 per cent in 1997.

Source: Department of Soils, Punjab Agricultural University, 2006

Hence, the cultivation of high water-demand crops is an important factor contributing towards declining water levels in Punjab. The total water demand of a crop comprises 'water required to meet Evopo-Transpiration (ET) process during the growing season and that required to meet evaporation demand of atmosphere. In the year 2005-06, crop water demand during kharif season was 50.5% of total

Fig. 2.16 Net irrigated area (000 ha) by different sources in Punjab



Source: Statistical Abstract of Punjab, 1990 & 2005

Replacing centrifugal pumps with submersible pumps due to lowering of ground water table

water demand of state, whereas rabi season accounted for 31.3% of total water demand (Table 2.8). Cropwise, paddy has the highest water demand of 37% followed by wheat (31.3%) and around 28 % by other crops including vegetables, fruits, fodder etc. The total ET demand (estimated by multiplying area under given crops with ET per unit area) of area under crops during 2005-06 has been estimated to be 4.56 mham. Thus, there is a water deficit of 1.43 mham (over the total supply of 3.13 mham) in the year 2005-06 (Source: Adapted from Hira *et al.*, 2004).

It can be observed that the present grim ground water scenario in different regions of the state is essentially the outcome of faulty production practices leading to excessive and irrational use of water (particularly for rice crop). Other factors include less than required availabilty of surface water, free power supply to the agriculture sector, support prices and procurement facilities for only some crops and disproportionate installation of tubewells by farmers.

Table 2.8 Annual water requirement/ Evapo-Transpiration (ET) demand for different crops and other non crop uses in Punjab

*Deptt of Agriculture, Govt. of Punjab

Source: Adapted from Hira *et al.*, 2004

Decline in soil fertility

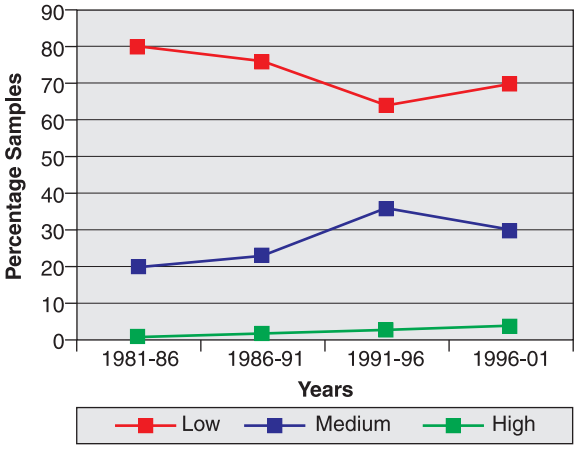
Maintenance of soil fertility is essential to sustain agricultural production. The soils of Punjab are generally low in N content, low to medium in P and medium to high in K except in Kandi belt which has low to medium K content (Department of Agriculture, Punjab). In the past two to three decades, intensive agricultural practices have put a tremendous pressure on the soils and resulted in steady decline in its fertility (nutrient availability), both with respect to macro and micronutrients. Both rice and wheat have high nutritional requirements and the double cropping of this system has been heavily depleting the nutrient contents of soil. For example, a rice – wheat sequence that yields 7 tons/hectare of rice and 5 tons/hectare of wheat removes more than 300 kg N, 30 kg P and 300 kg of Potassium per hectare from the soil. Even with recommended rate of fertilization in this cropping pattern, a negative balance of primary nutrients still exists. (Source: Benbi *et.al.*, 2006). More over, partial factor productivity of NPK in Punjab has

also dropped from 80.9 in 1966-67 to 16.0 in 2003-04. Hence, farmers in the state have been applying higher and higher doses of major nutrients, especially nitrogen for sustaining adequate production levels.

The changes in soil nutrient status like NPK and micronutrients over time in Punjab is discussed below:

Soil Organic Carbon (SOC): SOC is taken as an index of plant available N since it is related with N supplying capacity of soil. SOC has a significant effect on all soil properties related to its fertility potential. Organic carbon content has been reduced to very low and inadequate levels in the state, because of very low or limited application of organic manures and non recycling of crop residues. (Source: Johl *et al.*, 2002). Analysis of more than 180 thousand soil samples at PAU, Ludhiana during 1981-1992 reported that 78% soils of Punjab were low (<0.4% SOC) in organic carbon, 21 % medium (0.4%-0.75% SOC) and 0.5% high (>75% SOC) in soil organic carbon. The districts of Bathinda, Faridkot, Sangrur, Hoshiarpur and Amritsar had more than 80% samples in low categories (Brar *et al.*, 1994). However, various surveys conducted during 1981-2001 indicated 65%-70% soil samples in low carbon category (though it has increased by 5% between 1991-2001, Fig. 2.17).

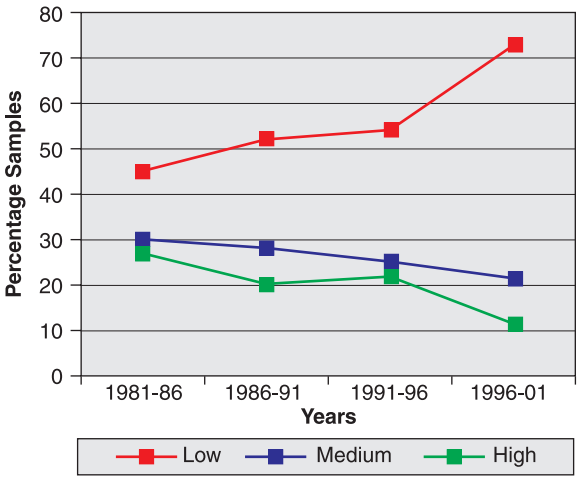
Fig. 2.17 Trends in available organic carbon content in soils of Punjab (1981-2001)



Source: Benbi *et al.*, 2006

Phosphorus (P): Phosphorus is one of the three major elements essential for plant growth. The soils in the state are generally deficient in P, especially the coarse textured soils of Bathinda, Ferozpur and Faridkot. Temporal analysis of the data collected by PAU at five yearly intervals, however, shows that the number of samples in low P categories has increased from 45% during 1981-86 to 70.7% during 1996-2001 (whereas, those in the medium and high categories has declined from 29.4% to 19.3% and 25.6% to 10% respectively) as shown in Fig. 2.18. This indicates a considerable decline in P content in the soils of the state. The decreased

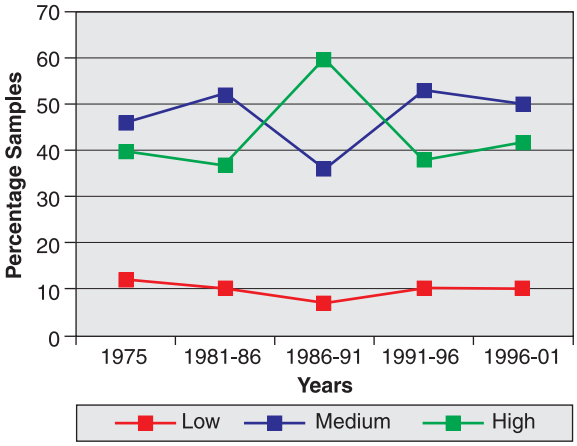
Fig. 2.18 Trends in available P content in soils of Punjab (1981-2001)



Source: Benbi *et al.*, 2006

consumption of the phosphatic fertilizers as evidenced by widening N:P ratio together with increase in the area under rice-wheat system may be the reason for decline in soil P status (Source: Benbi *et al.*, 2006).

Fig. 2.19 Trends in available K content in soils of Punjab (1975-2001)



Source: Benbi *et al.*, 2006

Potassium (K): With respect to available K, the Punjab soils have generally been categorized as medium (138-338 kg K_2O/ha) to high (more than 338 kg K_2O/ha). As a result the consumption of K fertilizers is very low and constitutes about 2% of total fertilizer consumption in the state. Temporal analysis of the data from 1975 to 2001 shows that the potassium deficiency in Punjab soils has not aggravated over the years. Except for the period between 1986-91, percentage samples in the three categories remained remarkably similar over the years (Fig. 2.19) As reported by Benbi *et al.*, 2006, maintenance of K status of soils over the years may be ascribed to the presence of micaceous minerals in the soils and addition of substantial amounts of K through irrigation water. The irrigation water in Punjab contains K ranging from 0.6-124.5 mg/l (average 6.2 mg/l).

Micronutrients: Micronuterients, comprising Zinc (Zn), Copper (Cu), Iron (Fe), Manganese (Mn), Boron (B), Molybdenum (Mb) and Chloride (Cl) though required in much smaller amounts, are as essential for plants as the major nutrients. The present exploitive agriculture laying emphasis on high crop yields has been depleting soils of their limited micronutrient reserves leading to the emergence of deficiencies of micronutrients in different soils of the state. The extent and nature of this deficiency varies in different soils and crops. A good crop of paddy (with a yield of 6 t/ha) and wheat (4 t/ha)

Box 2.5 Loss of soil fertility due to straw burning

Burning of wheat and rice straw has also contributed to loss of soil fertility apart from causing air pollution. Punjab produces around 23 million tonnes of rice straw and 17 million tonnes of wheat straw, annually. This straw is rich in Nitrogen, Phosphorus and Potassium contents. However, instead of its recycling into the soil by mulching, it is burnt in the fields. This raises the temperature of the soil in the top 3 inches to such a high degree that Carbon: Nitrogen equilibrium in soil changes rapidly. The carbon as CO_2 is lost to atmosphere, while nitrogen is converted to nitrate. This leads to a loss of about 0.824 million tonnes of NPK from soil. This is about 50 percent of total fertilizer consumption in the state. Considering that 90% of rice and 30% of wheat straw is available for recycling, it will be equivalent to recycling of 0.56 million tonnes of nutrients worth Rs. 4 billion. Moreover, agriculture experts also maintain that fire in the fields kills friendly pests and bacteria (which increase the fertility of soil).

Source: Deptt. of Soils, PAU, 2006

remove on an average 350g/ha of Zn, 50g/ha of Cu, 3000g/ha of Fe and 550 g/ha of Mn from the soil (Source: Nayyar *et al.*, 2001). The deficiency of Zn, Fe, and Mn in Punjab soils was reported in the late 60s, a few years after the introduction of HYVs in the state. A survey conducted at PAU by Nayyar *et al.*, (1990) showed that 49% soils in Punjab were deficient in available Zn and 17% in available Fe. The deficiency of Mn and Cu in the state was negligible as only 3% and 2 % percent soil samples were found deficient in the two nutrients.

Table 2.9 Changes in micronutrient status in various districts of Punjab (1970-2004)

Source: Sharma *et al.*, 2004

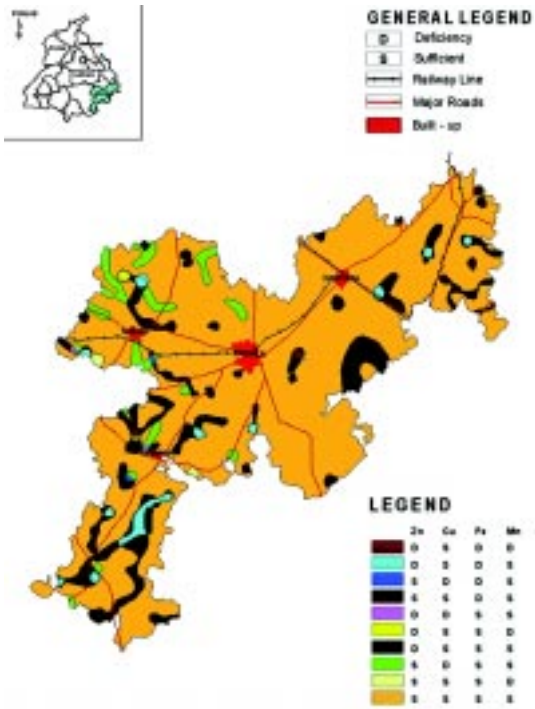
Results of the analysis of soil samples collected from various districts in Punjab over a period of time revealed that while the deficiency of Zn has decreased that of Fe and Mn has increased. The changing status of Micronutrients in the state is presented in Table 2.9. Awareness amongst the farmers about Zn deficiency has resulted in increased use of Zinc Sulphate and subsequently, the extent of zinc deficiency has declined throughout state. As far as Fe and Mn are concerned, the increase in deficiency may be due to shift in cropping pattern towards rice particularly in coarse textured soils. (Source: Benbi *et al.*, 2006). The multi nutrient status maps of Patiala, Amritsar, Ludhiana Mukatsar and Hoshairpur districts (Maps 2.11 to 2.15) indicate that the deficiency of two or more micro nutrients at a particular place is less prevalent than the deficiency of individual nutrients.

Excessive use of chemical fertilizers and pesticides

As discussed earlier, the food grain production in Punjab has increased from 3.16 million tons in 1960-61 to 25.66 million tons in 2004-2005 (Source: Statistical Abstract of Punjab, 1990 and 2005). Whereas, the initial increase in production was mainly due to increase in the area under cultivation, a spectacular rise of 18.36 million tons in food grain production from 1971 to 2005 can be largely attributed to intensive use of inputs like fertilizers, pesticides, insecticides, herbicides, etc.

Fertilizers: Fertilizers are an important component of agricultural technology. Whereas initially organic fertilizers were mainly used in the fields, however, chemical fertilizers have played a very important role in enhancing the agricultural production in the state. Since the introduction of high

Map 2.11 Micronutrient deficiency in Patiala district

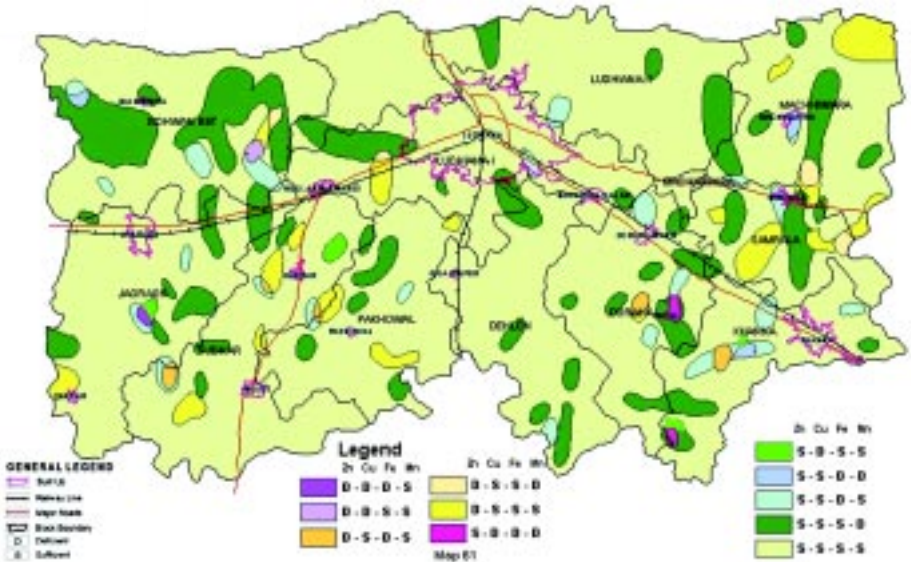


Prepared by: Punjab Remote Sensing Centre, Ludhiana

Map 2.12 Micronutrient deficiency in Amritsar district

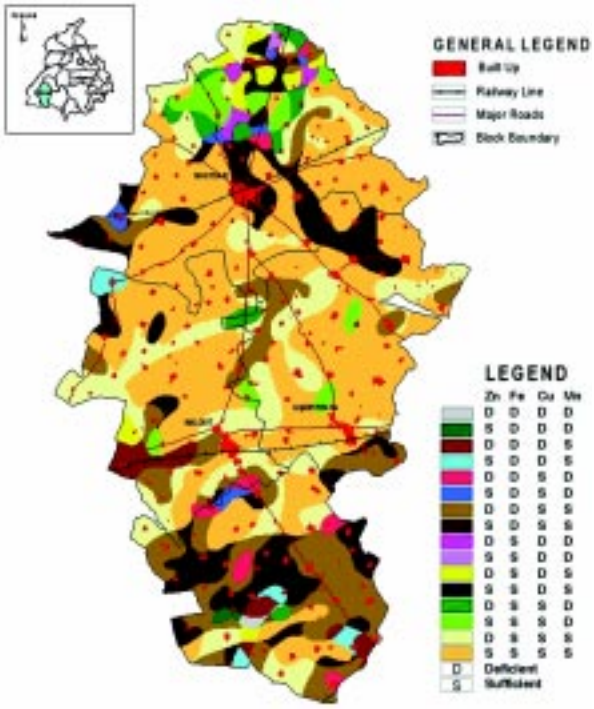
Prepared by: Punjab Remote Sensing Centre, Ludhiana

Map 2.13 Micronutrient deficiency in Ludhaina district



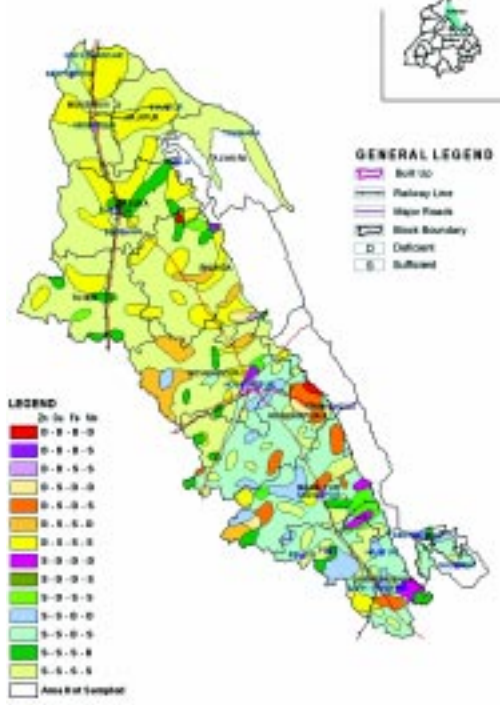
Prepared by: Punjab Remote Sensing Centre, Ludhiana

Map 2.14 Micronutrient deficiency in Mukatsar district



Prepared by: Punjab Remote Sensing Centre, Ludhiana

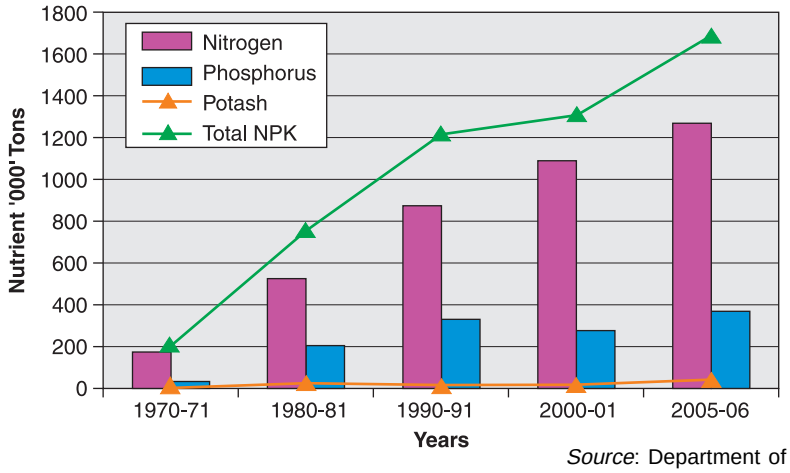
Map 2.15 Micronutrient deficiency in Hoshiarpur district



Prepared by: Punjab Remote Sensing Centre, Ludhiana

yielding varieties, the consumption of chemical fertilizers has been increasing steadily. It has increased more than 8 times in the past 35 years from 213 nutrient thousand tons in 1970-71 to 1694 nutrient thousand tons in 2005-06 (Fig. 2.20).

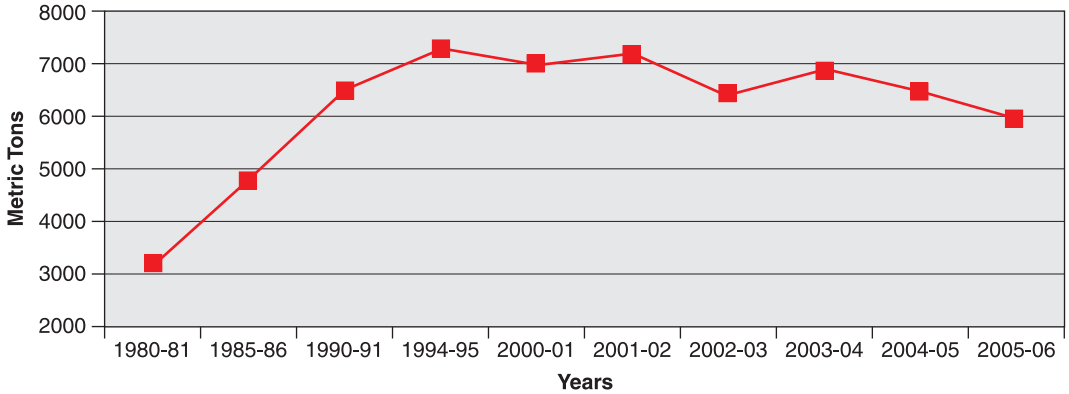
Fig. 2.20 Consumption trend of chemical fertilizers in Punjab (1970-2006)



Source: Department of Agriculture, Punjab

Pesticides: The state of Punjab is one of the highest user of chemical pesticides especially after the ushering in of green revolution. Pesticide consumption in India has increased from 2353 MT in 1955 to 40672 MT in 2005 (Source: Directorate of Plant Protection and Quarantine, Government of India, 2005). In Punjab this has increased from 3200 Metric tons (MT) in 1980-81 to 7300 MT in 1994-95 but came down to 5970 MT in the year 2005-06 (Fig. 2.21). Currently, the state consumes about 17 percent of total pesticides used in India. Out of these, more than 90 per cent of the pesticide are being used in the cultivation of cotton, rice and vegetables (Source: Singh, 2002). The Malwa region (cotton belt) accounts for nearly 75 percent of pesticides used in the state. The decrease in pesticide consumption since 2003-04, can be attributed to the introduction of Bt cotton in the state (which requires lesser number of sprays) as well as, better awareness among farmers as state government is now promoting biopesticides (Department of Agriculture, Government of Punjab). The broad classification of pesticides based on their composition is given in Box 2.6.

Fig. 2.21 Consumption trend of technical grade pesticides* in Punjab (1980-2006)



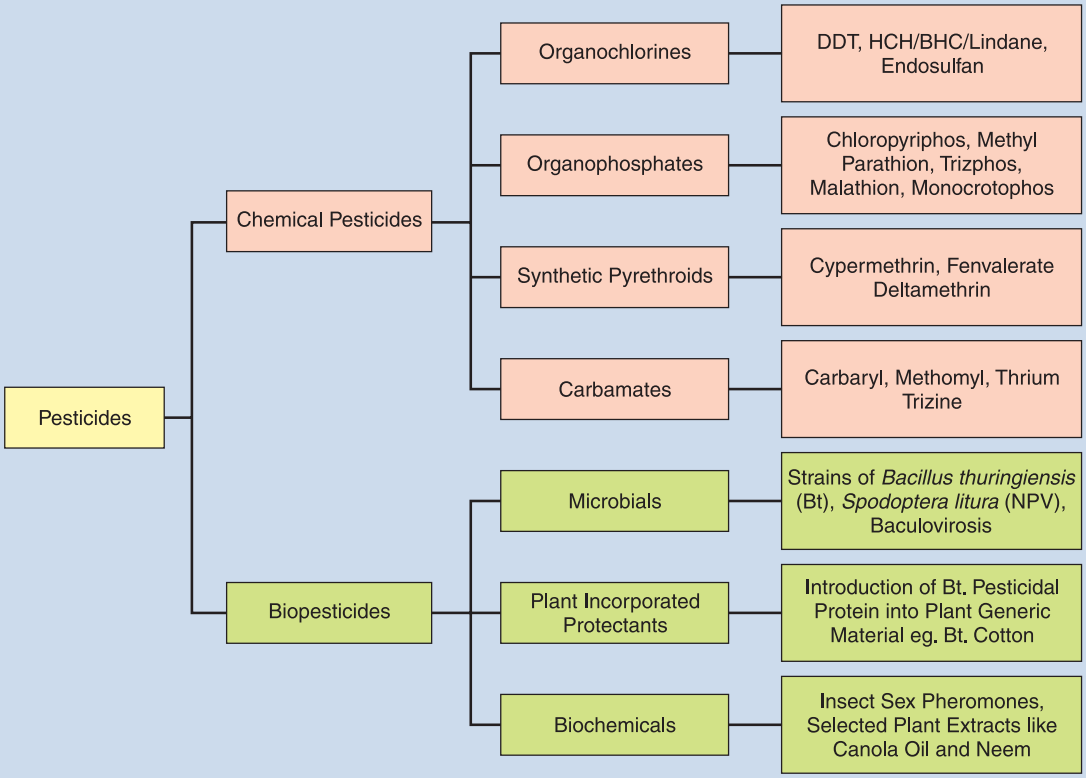
*including insecticides, weedicides, fungicidies and rodenticides

Source: Department of Agriculture, Punjab

Large scale pesticide spraying without adequate precautions

Box 2.6 Classification of pesticides

"A pesticide is any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any pest. Pests can be insects, mice and other animals, unwanted plants (weeds), fungi, or microorganisms like bacteria and viruses". Though often misunderstood to refer only to insecticides, the term pesticide also applies to herbicides, weedicides, fungicides, and various other substances used to control pests. As shown below there are mainly two types of pesticides available in the market:



Increase in farm machinery

Punjab is an agriculturally progressive state and use of modern farm machinery like tractors, electric motors, combines, cultivators and seed drills, etc are highly prevalent. The rapid adoption of green revolution technology in Punjab also led to a sharp increase in farm mechanization. In 1960-61, there were seven tractors per thousand hectare of land, which shot up to 96 in 1998-99. On an average, there was one tractor for every eight hectare of net cultivated land in the year 2001 (in some districts the area operated by a tractor is even lower). As per information provided by Punjab State Farmers Commission, the state has double the number of tractors it requires. The average use of tractors per annum in the state is barely 450 hours, which is much below the minimum 1,000 hours of productive use in agriculture. This is leading to over capitalisation in farm mechanisation and its under-utilisation due to decrease in farm size. This leads to higher cost of production and lower net income to farmers, making it economically unviable.

In contrast, at the all-India level, the area operated by a tractor is above 66 hectare (Punjab Development Report, CRRID, 2002). As per 2004 estimates of Department of Agriculture, Government of India, 14% of total population of tractors in India plough the fields in Punjab. Excessive use of tractors also causes damage to physico-chemical characteristics of soils, particularly where puddling is done for rice cultivation. With the loss of soil characteristics, biological activities are also impaired and in the long run, such soils are likely to become unproductive. Soil compaction by agricultural machinery is also recognized as being a significant contribution to decreased soil fertility and increased erodability. Soil compaction increases resistance of soil to penetration by roots and emerging seedlings, limits gaseous exchange between roots and atmosphere and reduces water infiltration, altering soil moisture and accelerating runoff and erosion.

The growth in farm machinery in Punjab is presented in Table 2.10. It has now reached to a saturation point. Upto mid eighties, bullock-operated ploughs, wells, carts and cane-crushers dominated the agricultural scene. By mid nineties, these implements had virtually disappeared. Use of harvester-combines for wheat and paddy has been on the increase. Their use leaves uncut straw and stubble in the fields, which is often burnt, causing air pollution apart from declining soil fertility. Approximately more than 20 million tons of wheat and paddy straw are thus lost every year, which could have otherwise been used as feed for cattle or ploughed back into the soil to improve some of its characteristics. As per Benbi *et al.* (2006), Carbon loss due to straw burning in state is equivalent to a carbon dioxide load of more than 1.83 million tons per year, which is of concern not only for soil fertility but also for the environment of the state.

Table 2.10 Growth of farm machinery in Punjab (in thousands)

Source: Deptt. of Agriculture, Punjab, 2006

Combine harvesting

Open field burning of stubble

Farm mechanization, no doubt, has been beneficial for the intensive use of land and has helped considerably in overcoming the risk of unfavourable effects of weather on maturing crops. But this has also directly or indirectly affected the natural environment due to increasing use of fossil fuels, gaseous emissions and direct impact on soil. The agriculture sector consumes around 30% of total High Speed Diesel (HSD) consumed in the state and it has increased from 626 Thousand Metric Tons (TMT) of HSD in the year 2002 to 685 TMT HSD in the year ending 2005 (Table 2.11). Gaseous emissions from agriculture machines also cause air pollution by addition of unburnt hydrocarbons in the air in rural areas.

Table 2.11 Consumption of HSD in agriculture during the years 2001-2005

As per figures provided by Indian Oil Corporation

Source: Deptt of Agriculture, Punjab

STATE

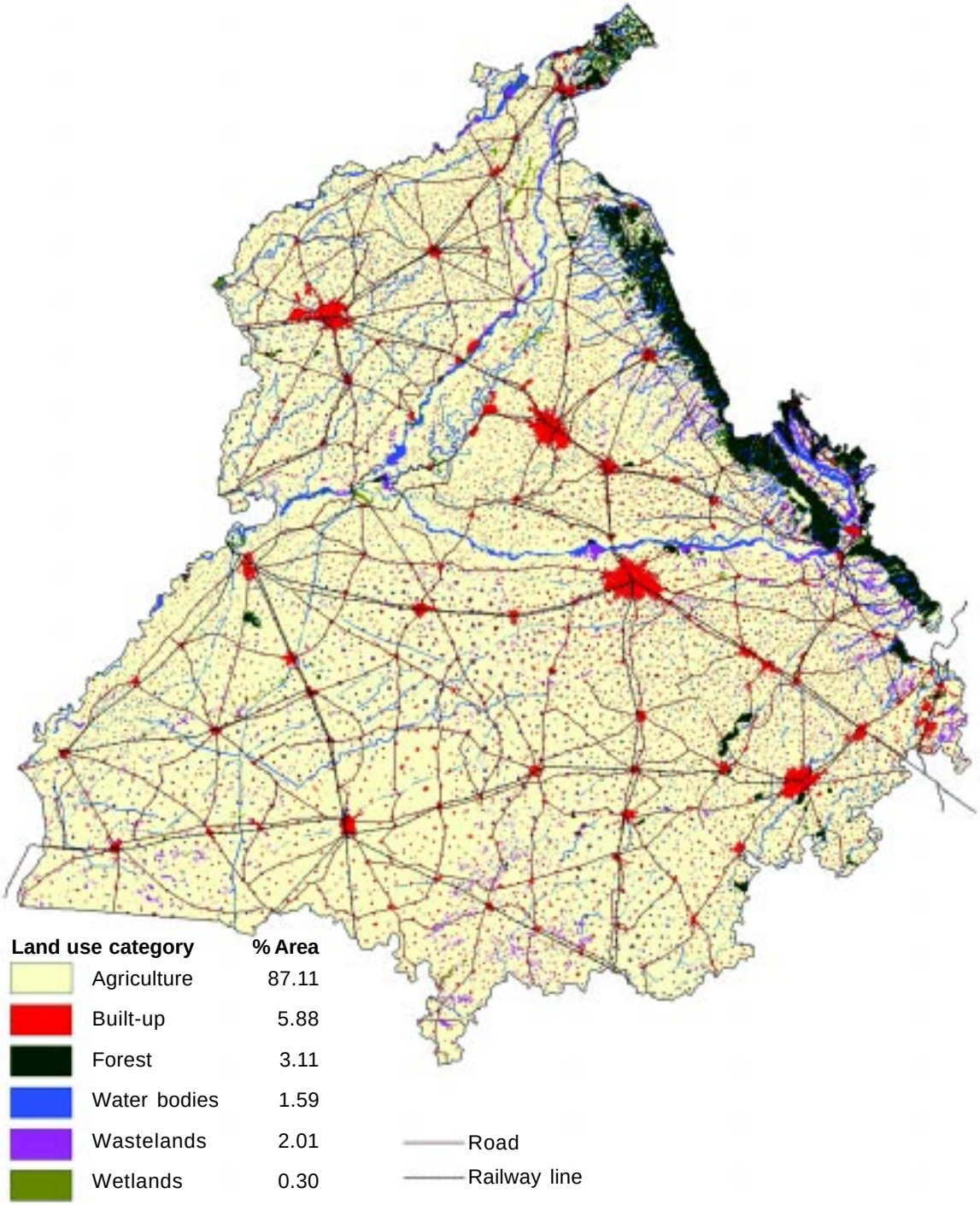
Land use pattern

Land is the most important natural resource on which various developmental and environmental conservation activities are based. The land use pattern in the state as per revenue records has already been discussed in this chapter (Fig. 2.9). However, as per remote sensing data, 2004, provided by Punjab Remote Sensing Centre (PRSC), Ludhiana, 87.1% of total area of state is under agriculture including horticulture and agroforestry plantation (against land record of 84.4%) and 5.88% is under built up land category (Map. 2.16). The area recorded under forest is only 3.1% (only notified/ reserve forest area). Besides, area under agroforestry plantation including orchards is 0.37%. However as per Forest Department this amounts to 5.9%, probably due to the fact that the forest department. includes areas under strip plantation along canals and roads also into forest area. The water bodies and wetlands comprise an area of 1.59% and 0.30% respectively. The wastelands occupy 2.01% area of the state.

District wise data reveals that Bathinda district has maximum (95.22%) area under agriculture followed by Sangrur (93.37%), Mukatsar (93.28%), Faridkot (92.93%) and Firozpur (92.89%), whereas Rupnagar has least area under agriculture(55.19%) followed by Hoshiarpur (69.41%) and Nawanshehar (80.36%). Ludhiana district leads in the state with 10.5 % of its area under built up land as compared to other districts like, Patiala (9.7%), Jalandhar (9.5%) and Fatehgarh Sahib (7.24%). The districts of Hoshiarpur (4.51%), Gurdaspur(3.41%) and Nawanshehar (3.38%) have the highest area under water bodies in state. In forest category, Rupnagar has 23.42% of its total area under forest closely followed by Hoshiarpur (20.46%).

The state also had a large area under various categories of waste lands two decades ago (as per Wasteland Atlas of India, 2003, “the land which is degraded and is presently lying unutilized except current fallow due to different constraints” is called wasteland). However, at present only 2.33%

Map 2.16 Land use pattern of Punjab (2003-04)



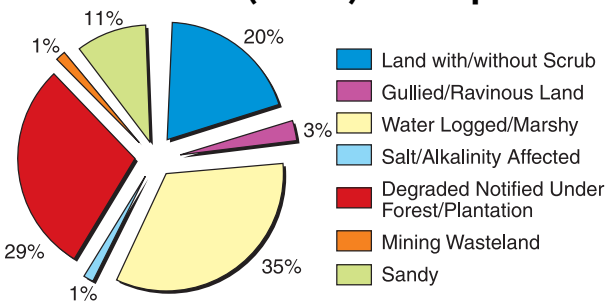
Prepared by: Punjab Remote Sensing Centre, Ludhiana

(1172.84 sq km) of total area of the state is under various categories of wastelands (Source: Wasteland Atlas of India, 2003). Mukatsar district has highest area (186.8 sq km) under waste lands, followed by Ferozpur (148.1 sq km), Bathinda (144.4 sq km) and Gurdaspur (94.5 sq km).

A comparison with other states indicates that Punjab has the smallest area categorised under wastelands. Other agriculturally progressive states like Haryana (7.39%), Uttar Pradesh (7.05%), Karnataka (7.06%) and Maharashtra (12%) have large areas in this category. At national level, 17.45% of total geographical area of the country is categorized as waste/degraded lands.

The details of percentage area under different categories of degraded lands in the state is presented in Fig. 2.22. Prior to reorganization of the state there were long belts of sand dunes in Kapurthala, Jalandhar, Ludhiana, Sangrur and in cotton belt of Bathinda, Mansa and Faridkot. These sand dunes have been cleared/ leveled by farmers to bring them under irrigated agriculture. During the past 20 to 25 years farmers have also reclaimed the salt affected soils. Due to the construction of dams over various rivers, large areas in flood plains have also been brought under cultivation with the initiation of various watershed development programmes during past 15 years. The problem of water logging has also been controlled in several areas by constructing large number of drains.

Fig. 2.22 Percentage area under different categories of degraded/ wastelands (2.33%) in Punjab



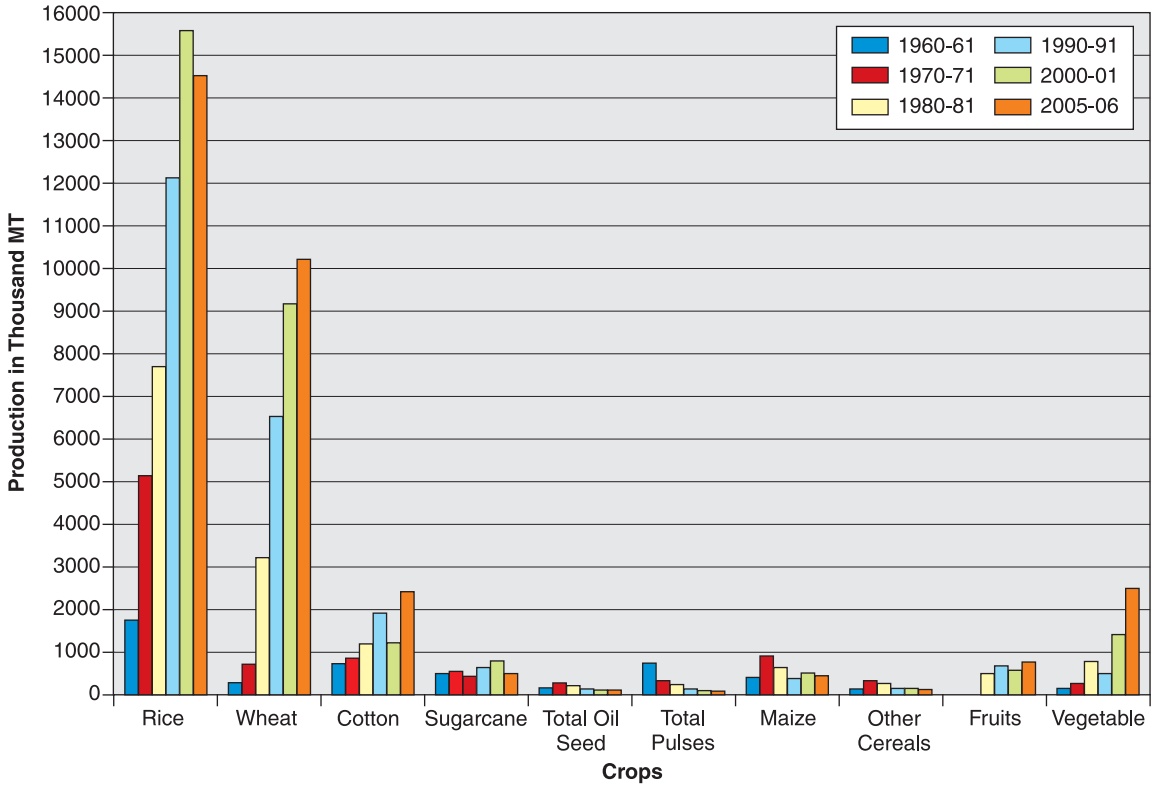
Source: Wasteland Atlas of India, 2003

Agricultural productivity

The production of various crops like wheat, rice, cotton, fruits and vegetables in the state has increased significantly over the last few decades, especially in the post green revolution period (Fig. 2.23). The area under various crops has already been discussed (Fig. 2.11). Wheat and rice have been playing a major role in pushing up agricultural production in the state over the years. The production of wheat which was 5145 thousand metric tons (th MT) in 1970-71 rose to 14493 th MT during 2005-2006 registering an increase of 181%. Similarly, the production of rice, which was 688 th MT in 1970-71 increased to 10200 th MT in 2005-2006 showing an increase of 1382%. The production of cotton (cleaned) increased from 818 th MT in 1970-71 to 2395 th MT in 2005-2006 showing an increase of 193 percent. The increase in production is due to increase in yield of this crop. The production of various fruits in the state has also increased by 73% in past 35 years.

However, the production of sugarcane (in term of Gur) decreased from 527 th MT in 1970-71 to 486 th MT in 2005-2006 registering a decrease of 8%. The production of oil seeds and pulses have shown a decreasing trend from 233 th MT and 305 th MT in 1970-71 to 92 th MT and 26 th MT in 2005-06, registering decrease in production by 60% and 90%, respectively. The production of other cereal crops in the state like maize, bajra, barley and jowar have been decreasing sharply mainly due

Fig. 2.23 Production of various crops in Punjab (1961 -2006)



Note:
- Cotton includes Desi and American
- Other cereals include bajra, jowar and barley
- Total oilseeds include ground nut, seasum, rapeseed, mustard, linseed and sunflower
- Total pulses include gram, mash, moong, arhar, lentils/peas and massar
- Data for fruits for the year 1960, 1970 is not available
- For vegetables only potato & dry chilles upto year 2001 and all vegetables for 2006

Source: Statistical Abstract of Punjab, 2005 and Department of Agriculture & Horticulture, Punjab

Sugarcane crop

to decrease in the area under these crops. But in light of state government's emphasis on shift in cropping pattern from wheat-paddy domination to other crops, the production of oilseeds, pulses, maize, bajra, etc, is expected to increase in future.

Diversity of agriculture crops

Considerable varietal changes have taken place since the introduction of green revolution in the state. The introduction of new High Yielding Varieties has led to loss of natural varieties and diversity of the indigenous agricultural system (which had contributed to ecological stability and ecosystem productivity) due to shift from multiple cropping pattern to monoculture. Modern varieties are the outcome of scientific breeding and characterised by a high yield and a high degree of genetic uniformity. In contrast, farmer's varieties (landraces) are the product of breeding or selection carried out by farmers and represent higher levels of genetic diversity.

Prior to the green revolution, 41 varieties of wheat, 37 varieties of rice, four varieties of maize, three varieties of bajra, 16 varieties of sugarcane, 19 species/varieties of pulses, nine species/varieties of oil seeds and 10 varieties of cotton were reported to be in use in Punjab and propagated through pure line selection by various workers. However, the number of varieties in use by farmers has decreased since then. The status of pre and post green revolution crop varieties is presented in Tables 2.12 and 2.13.

Table 2.12 List of Pre Green Revolution varieties of major crops sown in Punjab

Crop	Varieties
Wheat	Pusa 4, C285, Type 9, Type 11, Type 8A, Sharbati, Darra, Safaid Pissi, Lal pissi, Gandausi, Lal kanak, Bansi, Katia, Khandwa, Malwi, Pakwani, Dawat khani, Type 9D, C518, C591, C228, C217, C281, C250, C263, C286, C295, C273, C253, Mayo 64, Sonara 63, Lerma Rojo 64, Pusa 12, WG 377, WG 112, Safed Lerma (S307), Choti lerma (S331), C306, Sonalika, Ist Punjab, Lal Bahadur
Rice	Jhona 349, Palman 34,Suffaid 246, Mushkan 7, Mushkan 41, Basmati 370, Sathra 78, Mahlar 346, Jhona 20, Jhona 277, Basmati 217, Jhona kasarwala, Palman suffaid, Palman lal, Mahlar, Dhud Malai, Son pattar, Sathra
	For plains: Son pattar, Palman, Mushkan, Hans raj, Begam narot, Jhona 277, Jhona kasarwala, Jhona kasarwala 269, Basmati 217, Basmati 213
	For hills: Rohni, Hachhu, Suffaid nakanda, Kalu khurd, Kanora, Manjnoo, Begami haldoon, Lal basmati, Desi basmati
Maize	Punjab Hybrid No. 1, Ganga Hybrid No. 101, Ganga Hybrid No. 3, Ganga Hybrid No. 5
Bajra	A1/3, G61/21, T55
Oilseeds	Brown sarson selection A, Yellow sarson selection A, Toria selectionA, Raya L18, Yellow sarson Punjab 24, Brown sarson Haryana 1, Improved taramira selection A, Groundnut No. 1, C 501
Sugar-cane	Katha, Dhaulu, C205, Co.L.29, Co.L.9, Co.312, Co.285, Co.421, Co.313, Co.J.46, Co.J.58, Co.975, Co.1158, Co.J.39, Co.1148, S 449-64
Cotton	Mollisoni, Sanguineum, 4F, LSS variety, 216 F, H 14, 32oF, J34, 231R,G 27
Pulses	Pb. No.1, Pb. No.7, Pb. No.17, G 130, G 24, Gs 26, C 214, C 1234, C 235,C 104, No. 48, Mash 1-1, L 35-5, No. 54, No. 305, M L 1, No. 9-12, G 65, Lentil variety, No. 9-12

Source: PAU, Ludhiana

Table 2.13 List of Post Green Revolution varieties of major crops sown in Punjab

Crop	Varieties
Wheat	Lerma ROJ064, Sonora, C306, PV 18, Kalyan-sona, Sonalika, WG357, WG377, HD2009, WL 711, KSML 3, WL 410, WL 1562, DWL 5023, TL 419 (triticale), WL 2265, PBW12, HD2285, *TL, 1210 (triticale), SKAML 1, PBW 54, PBW34 (durum), HD2329, PBW120*, PBW138, PBW65, PBW154, *PBW 175, PBW226, PBW222, PBW215, *PBW 299, CPAN 300, *WH542, *PBW343, *PDW 233, *PBW373, *RAJ3765, PBW396-PBW 502*, PDW 291, PDW 274, PDW 233* (Durum), TL 2908, PBW 509, PBW 527
Rice	TN 1, Jhona 351, *IR 8, *Jaya, HM 95, Palam 579, RP 5-3 (sona), *PR 106, *PR 103, PR141, *PR108, PR 109, PR 110, *PR 111, -PR 113*, PR 114, PR 115, PR 116, PR 118 *Basmati, Punjab Basmati No. 1, *PUSA Basmati 1, *Basmati 385, *Basmati 386, *Super Bsamati, *Basmati 370, Pusa Sugandh
Pulses	**Moong bean:** ML1, ML 5, ML131, ML337, ML267, ML 613, G 65, SML 32*, SML 134*, SML 668*, ML 818*, PBW 1, **Urd Pea**: Mash 1-1, Mash 218, Mash 338, Mash 218*, Mash 414, Mash 1008*, **Pegion Pea:** T 21*, AL 15*, AL 201*, PPH4*, **Rice bean:** RBL 1, RBL 6*, **Gram:** C 235*, C 214, G 130, Hare chhole, L 550, G 543, GL 769*, PBG 1*, L 551 (Kabuli), GPF2*, PDG 3*, PBG 5*, GPF 2*, PDG 4*, BG 1053 (Kabuli)*, L 550 (Kabuli) **Lentil:** L9-12, LL56, LL 147*, LL 699* **Field pea:** T 163, PG 3*, Field pea 48*
Sugar-cane	Co 1148, Co J58, Co 975, Co 1158, CoJ 67, CoJ 81, CoJ 767, CoJ 84*, CoJ 83,CoJ 82, CoJ 85*, CoJ 64*, CoJ 88*, CoS 8436, CoJ 89, Co 1148
Maize	Comp. Vijay, Hyd Ganga 5, Comp. Rattan, Comp. Makki Safed 1, Comp. Ageti-76, Comp. Partap, Comp. Navjot*, Comp. Partap*, Comp. Parbhat*, Comp. Kiran, Hyd. Sartaj, Comp. J1006*, Comp. Megha*, Comp. Kesri*, Pb. Sathi 1*, Pearly Popcorn*, Hybrid Paras*, Hyd. Parkash*, PMH 1*, F 9572 A*, BIO 9637*, PMH 2 (SVAC), JH 3459
Bajra	S530, HB 1, PHB 10, PSB 8, PHB 47, PCB 15*, MH 179*, PCB 138*, PCB 141*, PHB 2168*, PCB 164*,
Oilseeds	**Raya:** RLM 198, RLM 514, RLM 619, RLM 1359, *RBR 91,— PBR 210* , PBR 97* **Toria:** *TL 15, TLC 1, *PBT 37, **Gobhi Sarson:** *GSL-1, *GSL-2, PGSH 51, (African Season) Pc5, GSC 5 (canola)*, Hyola PAC 401*, **Taramila:** TMLC 2*, **Sunflower:** SFH 8, PSFH 67, *Jawala Mukhi, Mega 363, *GKSFH 2002, NSFH 592, SH 3322, PSFH 118*, SH 88*, **Groundnut:** Rainfed conditions M-145, M 37 Irrigated conditions- MB, M 197, M 335, *SG 84, *M-522-M 548*, SG 99*
Barley	DL 70, PL 56, PL 172, *PL 426, *PL 419, VJW 201*,
Cotton	J 34, J 205, F 414, LH 372, F 286, LH 900, F 505, LH 886, LH 1134, F 846, F 1054, Fateh, LH 1556, LHH 144, LH 900, LH1134, F846, F 1054, Fateh, LHH144, RCH 134 Bt*, RCH 317 Bt*, MRC 6301 Bt*, MRC 6304 Bt*, ANKUR 651*, White Gold, F 1861*, F 1378*, Desi: Moti*, LD 694*, LD 327*

**Varieties currently in use*

Source: PAU, 2006

Data indicates that 47 varieties of wheat, 19 varieties of rice, 8 varieties of Basmati, 47 varieties of pulses, 16 varieties of sugarcane, 24 varieties of maize, 10 varieties of bajra, 35 varieties of oil seeds, 6 varieties of barley and 32 varieties of cotton including 4 varieties of Bt cotton have been released by the PAU since 1964.These include HYVs developed by PAU and in other parts of the country or abroad. The current number of varieties in use include 13 varieties of wheat out of which HD 2329 released in 1985, PBW 343 released in 1995, PBW 542 released in 1993, PDW 233 (Durum) released in 1995 and PBW 502 released in 2004 are widely used. Similarly, 8 varieties of rice are currently in use out of which PR 106 released in 1976 has found vide acceptance with the farmers. Four varieties of Basmati rice i.e. variety 385 released in 1982, Pusa Basmati-1 released in 1990, Basmati 370 released in 1993 and Basmati 386 released in 1994 are favoured by the farmers. Information provided by farmers indicates that besides these varieties desi basmati and sharbati basmati is also grown by farmers especially in Sangrur area. Parmal variety of rice which was once grown in Punjab is not grown now as the basmati varieties attract better market value.

Amongst maize varieties, 'composite Navjot', 'composite Partap 1' and 'composite Prabhat' released in 1982, 1983 and 1987 respectively are widely grown. As per information provided by farmers, other varieties being used are 'Prakash' and 'Partap' varieties of winter maize and 'Mehkok' and 'Kanchan' varieties of summer maize. However, generally desi maize is favoured by farmers. Bajra is grown in a very small area in the state. Out of 9 varieties released till date 5 varieties are being grown. Information from farmers indicates that desi variety is still being grown in certain areas.

Amongst pulses, 37 varieties of moong bean, urd bean, pigeon pea, rice bean, chikpea and lentils have been released by PAU. Out of these 24 varieties are being grown currently which include 5 varieties of moong bean, 4 varieties of urd bean, 4 varieties of pigeon pea, one variety of rice bean, 7 varieties of chik pea, 3 varieties of lentil and 2 varieties of field pea (Source: Jerath *et al.*, 2002, Punjab State Biodiversity Strategy and Action Plan, 2002). The history of development of major crop varieties is given in Box 2.7.

Box 2.7 History of development of major crop varieties in Punjab

Research on Crop improvement and pure line selection (Anand, 1972; Singh, 1972) in undivided Punjab was first undertaken on Wheat at Lyalpur (now in Pakistan) in 1907 by D. Milne which was followed up by Choudhry Ramdhan Singh in 1925. Subsequently, research on wheat was taken up at Gurdaspur in 1941 and Jalandhar in 1947. Work on pure line selection of rice was started in 1926 but intensified after independence in 1950. Rice research station was established at Gurdaspur which was later shifted to Kapurthala in 1960. A millet section was also established in 1927 for studies on Bajra which was later shifted to Ferozpur. Gurdaspur was the Centre for sugarcane varietal testing in 1911. Work on oil seeds (mustard, linseed and sesamum) was carried out in 1929 at Lyalpur and subsequently on groundnut in 1933 at Samrala. Research on cotton was initiated at Lyalpur in 1912 by Dobbs. With the establishment of Punjab Agricultural University at Ludhiana in 1962 most of the work related to agricultural crops was shifted to PAU.

contd...

A brief information on crop development programmes of these crops carried out in Punjab in pre green revolution era, are given below:

Wheat: Reports (Gill, 1972; Singh, 1972) indicate that D. Milne (1907) surveyed wheat areas and classified the material in to 25 types/varieties out of which 18 belonged to broad wheat (*Triticum aestivum*) , three to compactum group (*Triticum aestivum var. compactum*) and four to Wadanak group (*Triticum durum*). Out of these type 8A had very wide adaptability and 9D was recommended for growing under rainfed conditions. Similarly, varieties C 518 and C 591 (developed by Singh, 1933 and 1934 as cited by Singh, 1972) remained popular for two decades. Further, at that time, varieties commonly grown in fields consisted of mixture of various types of grain. In certain areas both, bearded and beardless wheats were grown together and were given commercial names like, Sharbati, Darra, Safaid Pissi, Lal Pissi, Ghandausi, Lal Kanak, etc. Bansi, Kathia, Khandwa and Malwi were common durum wheats. Varieties such as Pakwani were preferred for making sweet dishes, Dawatkhani for parties and Sharbati for soft chapattis (Anand, 1972). Most of the indigenous wheat's however, were prone to lodging under heavy doses of fertilizers. This led to the introduction of semi-dwarf and dwarf varieties. Some of these indigenous varieties were, however, used by breeders to develop better quality dwarf varieties.

Rice: The work on rice started in Punjab in 1926. As per reports (Saini, 1972; Singh, 1972) more than 37 pure line varieties were propagated in the state before independence. These included 9 varieties specifically suited for hills. The varieties were selected by pure line selection to produce homozygous populations. All Basmati varieties were fine grain varieties (including 2 varieties from hills-Lal basmati and desi basmati) Varieties for medium fertility and low fertility areas were also identified. However, since 1968 emphasis shifted from indigenous tall varieties to high yielding dwarf varieties.

Maize: Research on maize was initiated in 1945 (Khera, 1972; Singh 1972). The native varieties were identified as sweet corn, flour corn, waxy corn, etc. but no detailed list of indigenous varieties is available. 4 hybrids were, however, released before green revolution. Similarly 3 hybrids of bajra were released before the green revolution Information on desi varieties from which these hybrids were developed is not available.

Pulses: Pulses have been important crops of Punjab. Mung and mash are Kharif crops whereas gram and lentil are winter crops. Information on local varieties of most of the pulse species is not available. However, as per Singh, KB (1972) and Singh, S. (1972) 19 hybridized varieties were released prior to green revolution. Similarly, Pure Line Selection of 9 varieties of oilseeds were released prior to green revolution. Brown sarson selection A, yellow sarson selection A and toria selection A were developed through mass selection before 1947. Raya L-18 was also a Pure Line Selection released in 1937 and recommended for a long time. Groundnut was first introduced as a field crop in Punjab in village Takhran, Samrala, distt. Ludhiana in 1930 and groundnut No. 1 was developed through Pure Line Selection by Dalal, 1953 (as cited in Singh, 1972).

Sugarcane: Katha and Dhaulu were indigenous varieties of sugarcane reported in Punjab in 1922 (Singh, 1972). These were, however, thin, reed like and with extremely poor yield. Hence, new canes were developed by inter-specific cross between *Saccharum officinarum* and *Saccharum spondaneum* by Barbar in 1914 (as cited in Singh, 1972). Varietal improvement work was taken up subsequently and 7 varieties were released before partition. The emphasis was on high sugar content and early maturing.

Cotton: Mollisoni and Sanguineum were the indigenous desi cotton varieties traditionally being grown in Punjab (Singh T.H, 1972; Singh, S, 1972). Six varieties were developed from indigenous varieties up to 1959. American cotton (*Gossypium hirsutum*) was introduced in Punjab in 1853 in Shahpur district (now in Pakistan). Pure line Selection variety 4F was identified which is the mother of present day varieties of cotton in the state. Up to 1958, eight varieties were developed from the mother variety for release in various areas in the state. Some of these were early maturing varieties (variety 320F selected by Sikka and Sehgal in 1951 and LL 54 developed by Aujla from cross of 45F and L.S.S. in 1958 as cited in Singh, 1972).

Source: Jerath *et al.*, 2002, Punjab State Biodiversity Strategy and Action Plan, 2002

Livestock status

Livestock plays an important role in the rural economy of the state. Its has contributed 11.77 % to the Gross State Domestic Product (GSDP) at constant (1993-94) prices in 2004-05 (Q). Livestock can also be an effective instrument to cope with the problem of low income related to agriculture by supplementing the same and providing employment to small and marginal farmers and land-less agricultural labourers.

As per the 17th livestock census, 2003, the state of Punjab had 1.10% of cattle, 6.12% of buffaloes, 0.36% of sheep, 0.22% of goats and 0.22% of pig population of the country. The poultry population is 2.2% of the country's total poultry population. In numerical terms total livestock population amounts 8.6 million and total poultry population including ducks stand out as 10.78 million. The milk, egg and wool production in state was 8391 thousand tonnes (second in rank among the states), 3.06 billion numbers and 554 thousand kgs, respectively during the year 2003-04. (Source: Department of Animal Husbandry, Punjab). The change in live stock and poultry population in Punjab during the period 1972 to 2003 is given in Table 2.14.

Data indicates that the total livestock in the state has decreased from 9.85 million to 8.60 million during the inter-censal period of 1997 to 2003 and shown an overall decrease of 12.7%. The crossbred cattle has decreased by 16.3% (from 1.828 million in 1997 to 1.53 million in 2003) and indigenous cattle decreased by 37.3% (0.80 million in 1997 to 0.57 million in 2003). Thus an overall decrease of

Table 2.14 Livestock and Poultry (in '000) in Punjab

Year	Cattle	Buffaloes	Horses & Ponies	Donkeys	Sheep	Goats	Camels	Pigs	Total livestock	Poultry
1972	3390	3796	50	65	388	537	102	46	8646	3017
1977	3312	4110	76	61	498	722	74	128	8996	5539
1990	2832	5578	33	36	508	537	43	96	9678	15276
1997	2639	6171	34	23	436	414	30	93	9858	11022
2003	2039	5995	29	5	220	278	4	29	8607	10779

Source: Statistical Abstract of Punjab, 2005

22.7% has been recorded in total cattle population between 1997 and 2003 (Source: Department of Animal Husbandry, Punjab). The buffalo population has also shown a decline of 2.9% during the period. The population of sheep, goats and pigs has also decreased by 49.5%, 32.9% and 69.8% respectively. There has also been a slight decrease (2.2%) in the poultry population in the state during this period. White revolution has been promoted in the state since the nineties. Though the number of cattle and buffaloes has decresed, but with upgradation of germplasm the production of milk and other animal products has increased. Milk production stands at 8.9 millon metric tones (MMT). The cattle in the state is 75% crossbred with high production potential. Decrease in numbers of sheep, goat is due to shortage of grazing areas due to conversion of wastelands into agriculture/ cultivable land.

Diversity of domesticated fauna

The domesticated agricultural faunal diversity of Punjab includes three breeds each of cows, buffaloes and sheep, two breeds each of goats and poultry and five breeds of horse. Out of these Murrah and Nili Ravi breeds of buffaloes, Hariana and Sahiwal breeds of cattle and Beetal breed of goat are indegenous. A summary of the indigenous and threatened breeds of domesticated animals is presented in Table 2.15.

Table 2.15 Indigenous and threatened breeds of domesticated fauna of Punjab

Domestic Animal	Existing breeds	Indigenous breeds	Threatened breeds
Cattle breeds	Hariana, Sahiwal, cross-bred Jersey, Holstein,	Hariana, Sahiwal	Sahiwal*
Sheep	Lohi, Nali, Desi, Cross bred*	Lohi, Nali, Desi*	Lohi
Horse	Bhutia, Thorough Bred (for stud farm)*, Grey Sindhi*, Marwari*, Kathiawari*	Bhutia*	Bhutia, Grey Sindhi*
Buffalo	Nili ravi, Murrah, Murrah graded	Murrah, Nili-Ravi	Nili-Ravi
Goat	Desi, Beetal	Beetal	Beetal
Poultry	White leg horn, Desi	Punjab Brown	–

Source: MoEF, 1998 and *Deptt of Animal Husbandry, Govt. of Punjab, 2007

Only one Desi breed of cow has been reported by the Animal Husbandry Deptt in the state. However, the pure Desi breed is now not available in most of the districts (except the breed 'Sahiwal' which is still reported in certain areas of districts Bathinda, Mansa, and Moga) as it has been cross bred with Jersey and Holstein breeds (exotic) in an effort to increase the fat and milk content respectively. Three out of 8 native breeds of buffaloes reported from India are found to exist in Punjab. These include Nili Ravi (native to north western districts of Amritsar, Gurdaspur and Ferozepur), Murrah (native to southern districts of Bathinda, Sangrur, Patiala, Mansa, Faridkot and Moga) and Desi

Domesticated fauna of Punjab

breed found in central and eastern parts of the state which has now been cross bred with Murrah to develop Murrah graded (found in districts Ropar, Hoshiarpur, Nawanshehar, Fatehgarh Sahib, Ludhiana, Jalandhar and Kapurthala). Out of these Nili Ravi is already reported as a threatened breed. (Jerath, *et al.,* 2002).

One cross bred and three local breeds of sheep namely Lohi, Nali and Desi, are found in the state. Further, cross breeding experiments with exotic Corridale/Rambullet breeds are being carried out to increase the meat content which can affect the population of the local breeds. Lohi has been reported as a threatened breed (MoEF, 1998).However, the best carpet wool is still obtained from Desi breed which is one of the reasons of its propagation in the state. Two local breeds of goat namely Desi and Beetal/Amritsari are being bred in the state in addition to Barhari breed which is native to Uttar Pradesh. In addition, 2 breeds of pigs (Desi and cross-bred), 5 breed of horse and 2 breeds of Poultry (white leg horn and Desi) are also being reared in the state (Source: Deptt of Animal Husbandry, GoP). The white leghorn enjoys a better market and is reared in large poultry farms due to its high meat content and larger egg size. The Desi breed is usually reared in rural areas basically due to the local belief that the eggs of this breed have medicinal properties (Source: Jerath, *et al.*, 2002).

Pisiculture (Fisheries)

Fish farming not only provides diversification from crops but is also highly remunerative. Punjab has very good resources for the development of social fisheries in the form of village ponds, low-lying lands and numerous irrigation dams that had been constructed in the kandi area which could be used for the development of fisheries. Punjab has achieved first position in the country with regard to average fish production of 6 ton per ha which is 3 times more than the national average. The area under fish cultivation has been progressively increasing and already gone up from 2469 ha in 1990-91 to 9032 ha in 2004-05 (Source: Department of Animal Husbandry, Dairy Development and Fisheries, Government of Punjab, 2005). The major fish species which are being promoted for pisiculture in the state are *Labeo rohita* (Rohu), *Catla catla* (Katla), *Cyprinus carpio* (Common carp), *Ctenopharyngodon idella* (Grass carp) and *Hypophthalmichthys molitrix* (Silver carp).

The department is also focusing on propagating culture of fresh water prawns in the state to diversify pisiculture and provide handsome returns to fish farmers. As per information provided by the department, some progressive farmers of the state have taken up cultivation of fresh water prawn in Jalandhar, Patiala and Sangrur districts during 2005 and produced more than 2,200 kg of prawns. Special emphasis has been laid on increasing the production of fish seed at various government fish seed farms.The state has 14 fish seed farms in 14 districts (except Jalandhar, Mukatsar, Moga and Mansa) at Hiyatnagar (Gurdaspur), Katli (Ropar), Bir Shikargah (Kapurthala), Bir Dosanjh (Nabha), Faggan Majra (Fatehgarh Sahib), Dhandua (Nawanshahr), Rajasansi (Amritsar), Hariana (Hoshiarpur), Benra (Sangrur) and at five other places with a production of more than 28.5 million fingerlings during 2003. The ornamental fish production has also been introduced at Government fish seed farm at Ropar to meet exsiting demand of aquarists and develop an interest in aquarium keeping.

Agroforestry

Agro-forestry is ecologically based natural farming system which involves growing trees along with various crops. As recommended by PAU, trees like Poplar (*Populus deltoids*), Kikar (*Acacia nilotica*), Subabul (*Leucaena leucocephala*), Drek (*Melia azaderach*) can be successfully grown with main crops as per agro - climatic conditions of Punjab. Though eucalyptus was popular in the state in early eighties, its cultivation declined due lack of proper marketing and reports about its allelopathic impact on soil, as well as, its adverse affect on soil water. Now, the state's farmers have shown their interest in poplar plantation (mainly because poplar is considered good for intercropping, has high growth rate and gives good economic returns due to better marketing which is further due to demand of several plywood units in the state). Cultivation of potato + fodder crops and sugarcane as inter-crop in the early stages of Poplar plantation has been found to be profitable and better than wheat-paddy rotation (Table 2.16).

As per Remote sensing data for 2004, Punjab has an area of 18.88 thousand ha (0.37% of total geographical area) under agro forestry plantation of mainly Poplar, Safeda (Eucalyptus) and Sheesham/Tahli (*Dalbergia sissoo*), out of which 0.13% area is under poplar. The Gurdaspur, Faridkot and Nawanshehar districts have 0.5-1.05 % area under agroforestry. In the remaining districts, the area under agroforestry plantation is less than 0.5% of their respective geographical

areas (Source: PRSC, 2006). The farmers of the state are usually not willing to block the land for longer periods under agroforestry plantation, but commonly prefer boundary plantation of Poplar, Eucalyptus, Drek, etc. in north south direction, which acts as wind breaks. Along with financial benefits to farmers, agroforestry can play a vital role in balancing our ecology. Pollution can be mitigated by planting good biomass producing trees. Vast potential of agroforestry in different parts of the state needs to be exploited to meet the growing demands of timber, fodder and firewood on one hand and to conserve the much endangered ecological balance by reducing the pressure on reserve forests on the other.

Table 2.16 Economics of Poplar with inter-cropping (annual value in Rs./ha)

Source: Department of Economics and Sociology, PAU, 2000

Floriculture and aromatic plants

Floriculture can play a big role in the diversification of agriculture in Punjab. It has received a big boost in the state during the past few years following awareness about its economic value and promotion of cut flower and flower-decoration culture. Marriage palaces are the major consumers of cut flowers and loose flowers in Punjab. The farmers of Punjab are taking up floriculture as an alternative to traditional crops. The educated farmers of the state are taking up seed production

Poplar plantation under agroforestry

of flowering annuals for export purposes to European countries like Netherlands, Germany and France. Punjab has a climate suitable for flower-seed production especially in winters. Another reason for popularity of cultivation of flowers for seed production is better returns from floricultural crops than the traditionally grown crops. Net returns range from Rs 25,000 to 75,000 per hectare depending on the nature of crop, skill of management and seed collection. (Source: Deptt. of Floriculture, PAU, Ludhiana, 2004).

As per data provided by Department of Horticulture, Government of Punjab, the state had 800 ha area under floriculture plantation of mainly Gladiolus, Marigold, Rose and Carnation during the year 2005-06 with a production of 4914.3 tons of loose flowers and 14587.7 tons of flower sticks. The area under flower plantation in the state has increased by 31% as compared to the year 2004-05 (610 ha). Out of this, around 350 ha is owned by private companies for production of around 465 quintals of flower seeds for export to other countries. Apart from floriculture, the state also has 3824 ha area of under various aromatic plants like Mentha, Karnauli and Sonff with production of 2361.39 tons seeds. The state has 49 oil extraction units. The Area/Production of Aromatic Plants and Floriculture in Punjab (2005-06) is presented in Table 2.17.

Table 2.17 Area/production of aromatic plants and floriculture in Punjab (2005-06)

Source: Department of Horticulture, Punjab, 2006

Medicinal plants

The unsustainable harvesting of medicinal plants from the wild, their consequent degradation and high commercial demand has now necessitated their commercial cultivation. The cultivation of medicinal plants by the farmers as an alternative to conventional farming has not only helped in conserving there resources but has also provided productive ways of income and employment generation at village level. At present, Punjab has a meager 795.66 ha area under the cultivation of various medicinal plants like Stevia, Safed Musli (*Chlorophytum arundinaceum*), Amla (*Emblica officinalis*), Kalihari (*Gloriosa superba*), Aloe (*Aloe vera*), Sarpgandha (*Rauvolffa serpentina*) and Ashwanganda (*Withania somnifera*). However, the State Medicinal Plants Board has

recommended cultivation of 32 plants in different parts of Punjab. Ropar (297 ha) and Sangrur (244 ha) districts have more than 65% of total area under medicinal plants in Punjab. The district wise area under medicinal plants is given in Table 2.18.

Table 2.18 District wise area under medicinal plants in Punjab (2005-06)

S.N.	District	Area in ha	Name of crops
1.	Amritsar	23.20	Safed Musli, Amla
2.	Bathinda	5.30	Stevia, Safed Musli, Aloe vera
3.	Fatehgarh Sahib	5.30	Stevia
4.	Ferozepur	6.90	Kalihari, Stevia
5.	Faridkot	2.02	Stevia, Kalihari
6.	Gurdaspur	4.04	Stevia, Safed Musli, Ashwganda
7.	Hoshiarpur	37.65	Stevia, Safed Musli, Kalihari, Sarpgandha
8.	Jalandhar	8.09	Stevia, Safed Musli, Ashwganda
9.	Kapurthala	4.04	Stevia, Safed Musli, Ashwganda
10.	Ludhiana	93.72	Stevia, Safed Musli, Aloe vera, Kalmegh, Amla, Kalihari, Muskdana, Menthol oil.
11.	Mansa	25.90	Stevia, Safed Musli, Sarpgandha
12.	Patiala	38.00	Stevia, Safed Musli, Sarpgandha
13.	Ropar	297.00	Stevia, Safed Musli, Amla, Isbgol, Aloe vera, Kalihari
14.	Sangrur	244.50	Stevia, Safed Musli, Aloe vera, Sarapgandha, Kalihari, Menthol Oil
	Grand Total	**795.66**	

Source: State Medicinal Plants Board, Punjab, 2006

Box 2.8 Cultivation and value addition of Medicinal/Aromatic plants in Shiwalik belt of Punjab

The Punjab State Council of Science and Technology, in collaboration with the Department of Biotechnology, Govt of India, has taken up a project in kandi belt of Punjab to promote cultivation of Amla, a medicinal plant and its value addition. The project had been conceptualised with the objective of increasing the income of farmers in the area. The council has set up a plant to provide post-harvest processing facilities and value addition to bio-resources at Talwara. The council had also tied up with Sunstar Overseas Limited, a Delhi-based company to market 60 tonnes of sweets and other products prepared from amla in India and abroad. Recently, the council had marketed 3,000 kg of sweets and other stuff, including murabba, pickle, ladoo, burfi, candies, jam, chutney, powder, juice and squash prepared from amla in the markets of Chandigarh and Panchkula on an experimental basis.

Crop diversification

To give a boost to the diversification of agriculture in Punjab, a multi-crop multi-year, Contract Farming Scheme was launched in the state in 2002. The twin objectives of this programme are to reduce area under wheat and paddy and prepare farmers to cultivate quality and marketable produce

based on demand supply chain. The Punjab Agro Foods Corporation (PAFC) is the nodal agency to coordinate contract farming. It arranges high-yielding seed varieties for farmers from reputed companies, provides technical supervision, follow-up on agronomic practices and buy back facility for the entire produce with returns comparable to, or better than, those what farmers receive from paddy and wheat. The PAFC had already signed agreements with reputed companies to implement contract farming in the state.

The programme was first initiated in rabi 2002 season covering 8.9 thousand ha with 9100 farmers and by the kharif 2005 season, an area of more than 19 thousand ha involving more than 0.1 million farmers has been covered under the programme (Source: PAFC, 2005). The crop wise details are given below:

- **Moong:** Moong varieties recommended by PAU, which mature in 60 days and provide an opportunity to the farmers to have 3rd crop in a year have been promoted in the state. Moreover, moong being a leguminous crop, it is beneficial for the soil as it helps in nitrogen fixation and contributes to improving the soil fertility. Under contract farming, moong was introduced in kharif 2003 in an area of 976.5 ha in all districts of the state except Gurdaspur, Hoshiarpur and Kapurthala. The area under moong cultivation has increased up to 1054.3 ha during kharif 2004.
- **Hyola (Hybrid rapeseed mustard):** The high yielding variety of hyola with high oil content (40-43%), and less than 2% euresic acid was introduced in rabi 2002 in 3966.8 ha area, which increased to 24291 ha in rabi 2004. The PAFC procured 22230 qt of hoyla worth Rs. 378 thousand from contract farmers during this period. The PAFC is marketing the Hyola oil under the brand name “Five Rivers”.
- **Maize:** The area under the HYVs of maize giving 10-20 qt of yield per acre under the contract farming program has increased from 11,372 ha during kharif 2003 to 12,897.5 ha in 2004 and to 22,267.2 ha during kharif 2005.
- **Malting Barley:** New two row malting barely varieties with high malt content were introduced in Patiala and Sangrur districts in an area of 332 ha in rabi 2002 under the contract faming system in Punjab. The area under the crop has subsequently increased to 2024.3 ha during rabi 2004 covering mainly Mansa, Mukatsar, Ferozpur and Bathinda districts.
- **Sunflower:** The HYV of sunflower having a yield of 8-10 qt/acres has been introduced in the state. The contract farmed area was 3478 ha in rabi 2002, which increased up to 8912.5 ha in rabi 2003 and 12753 ha in rabi 2004 in Hoshiarpur, Kapurthala, Jalandhar, Patiala, Fatehgarh Sabib, Ludhiana, Ropar and Amritsar districts.

Soil fertility status

As reported earlier, the soils of Punjab are generally low in N content, low to medium in P content and medium to high in K content. The available status is given in Figs. 2.17 to 2.19. However, as per recently conducted survey in five districts of the state viz Mukatsar, Patiala, Amritsar, Hoshiarpur and Ludhiana, the soil fertility status is different from the earlier studies (Benbi *et al*., 2006) This could be due to variance in sample size and sampling procedures. While the earlier report was based on samples brought by the farmers to the soil testing laboratories of PAU, the recent survey was based on the analyses of specifically collected geo- referenced samples.

Results indicate that in majority of samples collected from the five districts, organic carbon, P and K fall in medium to high category (as compared to low and medium range reported earlier) except for K in Hoshiarpur districts (where 50% soil samples tested low for K) (Table 2.19).

Table 2.19 Soil Organic Carbon, Phosphorus and Potassium status of geo-referenced soil samples(%) from five districts of Punjab (2004)

	Phosphorus (P)			Potassium(K)			Organic Carbon		
District	Low	Medium	High	Low	Medium	High	Low	Medium	High
Mukatsar	24	44	32	0	16	84	17.5	82.5	0
Patiala	23	29	48	3	36	61	14	66	20
Hoshiarpur	5	17	78	50	44	6	31	61	8
Amritsar	3	20	77	5	51	44	6.8	73.5	19.7
Ludhiana	2	10	88	15	64	21	5	70	25

Source: Benbi *et al.*, 2006

The micronutrient status of soils have been studied by PRSC, Ludhiana in five districts i. e Patiala, Amritsar, Mukatsar, Hoshairpur and Ludhiana (Maps 2.11 to 2.15). The data indicates that there has been an improvement in the micronutrient status of soils over the years, but Zinc (Zn) deficiency is the major constraint to productivity in all districts. Further, the deficiency of Iron (Fe) was found to be more prevalent in Mukatsar district in arid cotton belt followed by Hoshairpur District in North East Punjab. Manganese (Mn) deficiency was found to be prominent in the soils of Ludhiana district followed by Hoshiarpur district. The deficiency of Copper (Cu) was not much prominent in all the districts but it may became a constraint in Hoshiarpur and Mukatsar districts in near future. Micronutrient deficiency was found to be more prevalent in Mukatsar district as 39% and 34% area of the district was found to be deficient in Zn and Fe, respectively. The deficiency of Cu and Mn was observed in 7% to 8% area of the district (Source: Sharma *et al.*, 2004).

Use of fertilizers

As already stated, Punjab is one of the highest users of both, chemical fertilizers and pesticides. The status is given in Figs. 2.20 and 2.21. Punjab accounts for almost 10 % of the total fertilizer consumption in the country in just 2.98 % of the cultivated area and 4.2 % of cropped area of India. It also uses highest amount of fertilizer per hectare (192.5 kg/ ha) followed by Haryana (166.2) as compared to average use of 88.2 kg/ha in India. (Source: Ministry of Chemicals & Fertilizers, Govt. of India, 2006).

Use of pesticides

A comparison of per hectare usage of pesticides with other Indian states indicates that Punjab (923 g/ha) is closely followed by its neighbouring agriculturally advanced state i.e. Haryana (843 g/ ha). Other states like, Andhra Pradesh (548 g/ha), Tamil Nadu (410 g/ha), Karnataka (216 g/ha) and Gujrat(47 g/ha) use much lesser quantities (Agnihotri, 2000). The Indian pesticide industry has also achieved the status of second largest basic pesticide manufacturer in Asia (after Japan). However,

average per hectare pesticide consumption in India (0.5 kg/ha) compared with averages in other Asian countries like Korea (6.60 kg/ha) and Japan (12.0 kg/ha) are quite low. According to the pesticide industry statistics, India spends only $3/ha on pesticides compared to $24/ha spent by Philippines, $255/ha spent by South Korea and $633/ha by Japan (Source: TERI, 2000). The problem, however, is that of mismanagement and non-judicious use resulting in adverse environmental impacts. Pesticides not only contaminate the ecosystem but also bioaccumulate in the food chain and can be traced in plant and animal tissues causing serious health hazards. As per World Health Organization estimates, pesticides lead to one million pesticide poisoning cases and 20,000 deaths every year globally. Results of various studies conducted in Punjab indicate residues of chemical pesticides in human beings, milk, water, vegetables and other food products at levels, which are dangerous for human health. These studies are discussed subsequently.

Availability of water for agriculture

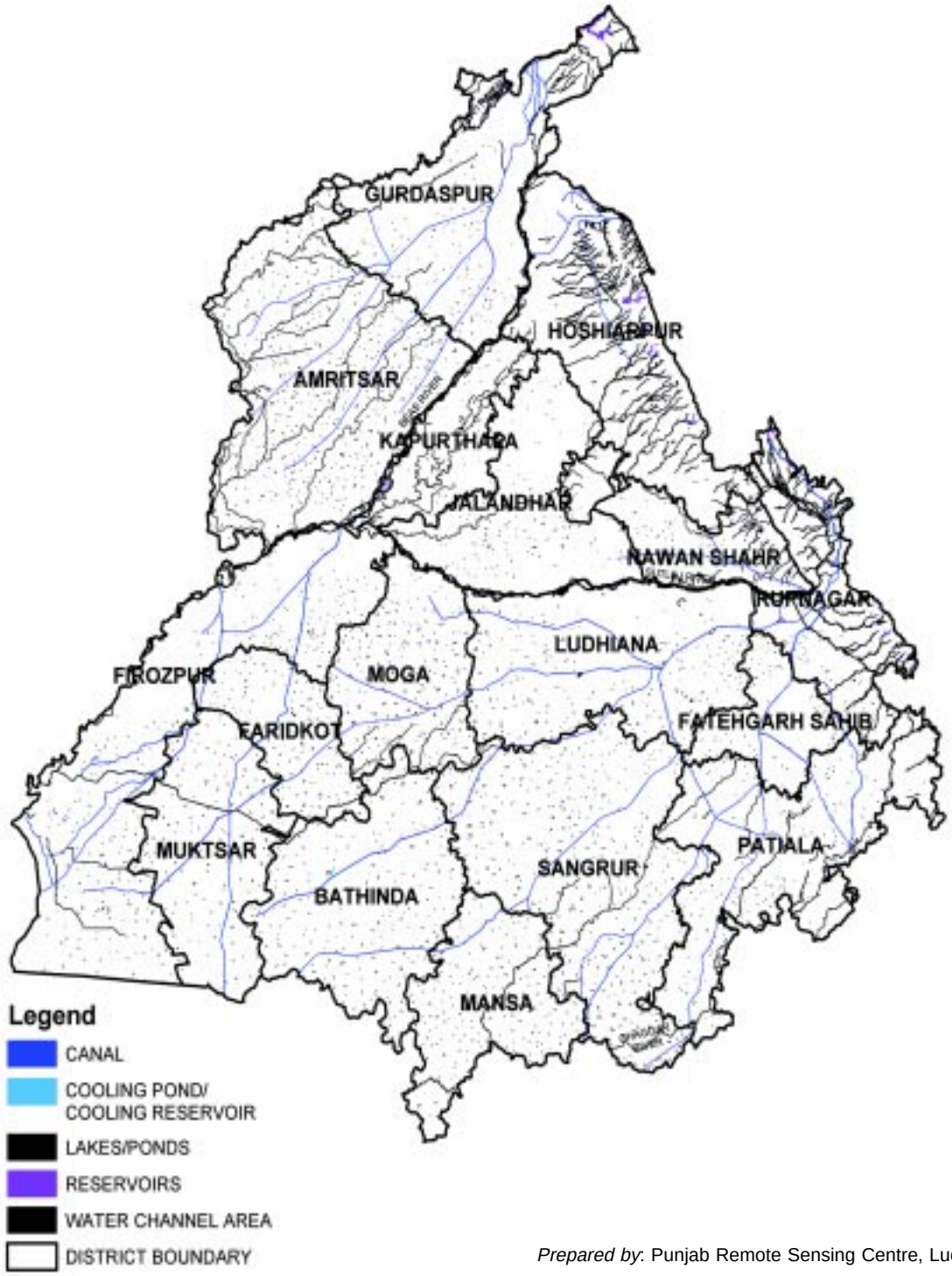
Table 2.20 Area under water bodies in Punjab

Source: PRSC, 2006

Natural water bodies play a pivotal role in maintaining the ecology of an area by providing water for domestic agricultural, animal husbandry and all other uses. As reported earlier the total availaibility of surface and ground water in the state is 3.13 mham. However, the demand for agriculture is 4.38 mham which is being met by over explotation of ground water. The area under various kinds of water bodies in the state is presented in Table 2.20 and Map 2.17. Data indicates that besides water provided by the state's river and canal system, the rural population has been depending upon wet lands and village ponds to meet many of their water requirements. As per information provided by PRSC, the state has 4952 village ponds, which includes 1821 ponds having an area of more than 2.5 ha and 3131 ponds with an area less than 2.25 ha. Around 0.30 % area of the state is under 12 natural and 9 manmade wetlands (out of which three wetlands are Ramsar Sites). These wetlands and ponds have been acting as effective ground water rechargers also. However, off late, a large number of these village ponds are disappearing (Box 2.9).

It has already been discussed earlier that the water table in state has receded at an average rate of 55 cm annually between 1993 and 2003 except in south western parts, where it has been rising. The rise/ fall of water table in Punjab during 2004-2005 is presented in Map 2.18. The issue of steep fall in water table in central districts and its rise in south western districts has been of major concern to the state. Information on rise/ fall of ground water table prior to 2004 has been discussed in SoE 2005 (Tiwana, *et al.*, 2005) in great detail (based on data provided by Department of Irrigation, Department of Agriculture-Hydrology Wing and Central Ground Water Board).

Map 2.17 Water bodies in Punjab



Prepared by: Punjab Remote Sensing Centre, Ludhiana

Box 2.9 Dwindling village ponds

The village ponds commonly known as '*chhapper*' or '*tobas*', which once used to be the centre of thriving rural environment have been disappearing fast throughout the state. Presently most of the village ponds in the state have either silted or are filled up, encroached upon or being used for disposing village sewerage. The sewerage dumped in ponds has been further polluting the groundwater in their surrounding areas. Further, the filling of village ponds have reduced the natural recharging of underground aquifers in the state.

A survey carried out by Kheti Virasat Mission, a Faridkot-based NGO in 2004, in 20 villages of Ropar district of Punjab revealed that only 21 ponds of 2 to 4 acre size exist in these villages, whereas, earlier in just one village three to four of such ponds could be easily found. Out of these 7 ponds had already dried up and 14 had dirty water. According to an estimate, more than 90 percent of the state's ponds have been encroached upon (CSE, 2003).

The village ponds need to be deepened and made bigger as these can play a very important role in conserving the natural ecosystem. Chawla *et al.*, (2001) conducted a study to determine the quality of water stored in village ponds and to develop a strategy for its optimum utilization. Two village ponds were selected randomly in each block of Ludhiana district for detailed investigations. The comparative study of the quality of pond water vis-a-vis, quality standards for irrigation and rearing of fish has revealed that the quality of pond water was not only suitable for irrigation and development of fisheries, but also rich in nutrients, which is an added advantage. The study has revealed that the renovation of village ponds will have a positive affect on environment, rural economy and ground water regime in declining water table areas.

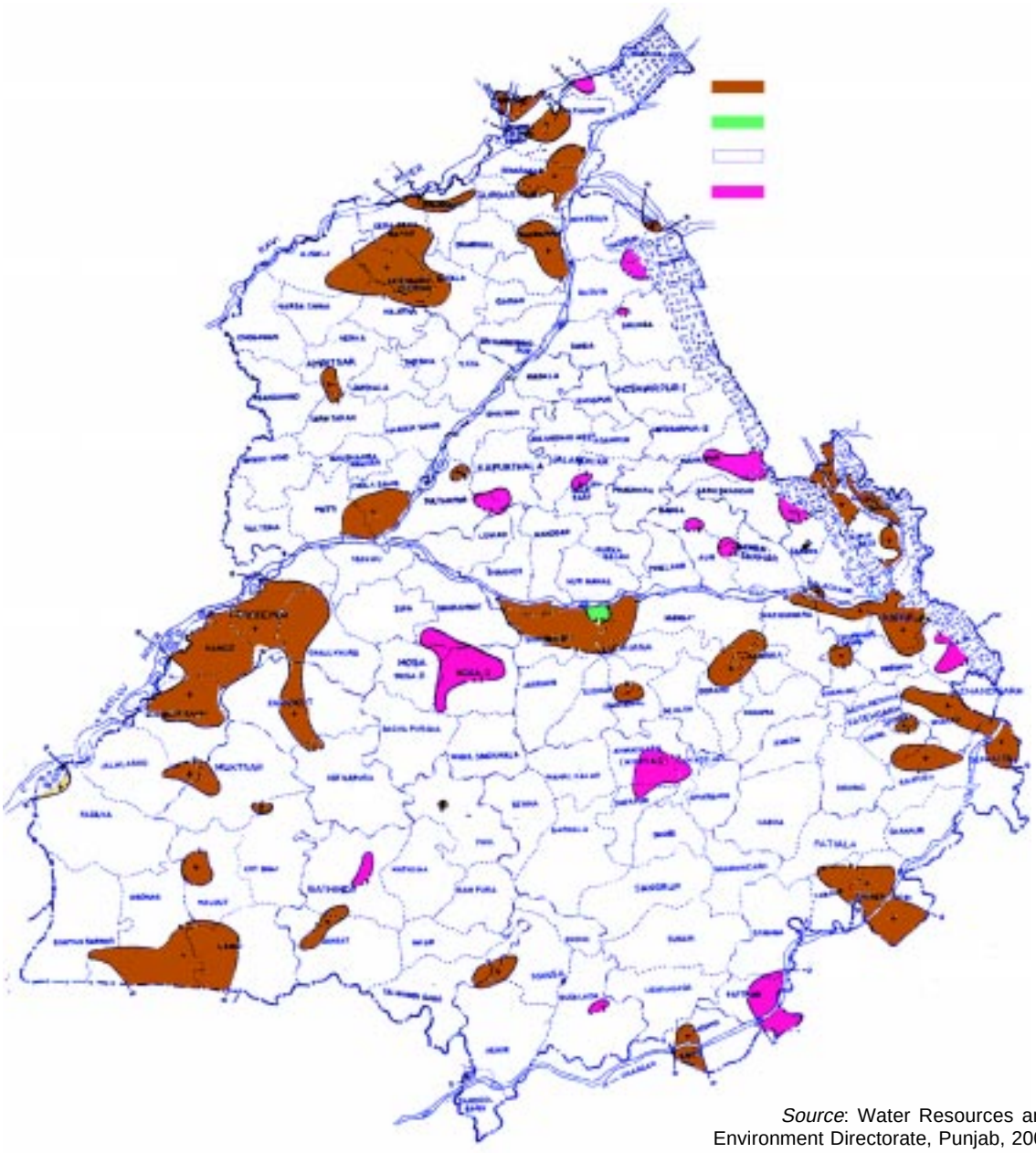
The Government of Punjab had already launched a plan to revive dirty village ponds for fish farming by adopting Duckweed technology. The plant can clean the pond water and bring BOD levels to less than 30 mg/l and in turn can act as feed for fish. The effectiveness of the technique is being monitored by the Punjab State Council for Science and Technology.

Village ponds as effective ground water rechargers

A degraded village pond

Latest data (Map 2.18) indicates that the water table in most parts of state has receded at the rate of 0 to 2 metres during the period June 2004 to June 2005. In some parts of blocks in districts Moga (Moga I, Dharamkot), Sangrur (Malerkotla, Ahmadgarh, Sherpur), Kapurthala (Sultanpur), Jalandhar

Map 2.18 Rise/fall of water table in Punjab from June 2004 to June 2005 (in meters)



Source: Water Resources and Environment Directorate, Punjab, 2006

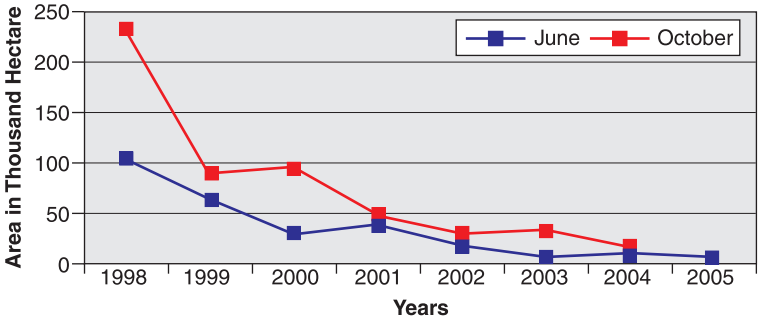
(East), Patiala (Patran), Hoshiarpur (Mahalpur, Bhunga, Hazipur), and Nawanshahr (Banga, Aur), however, the water table has gone down by more than 2 meters during the last one year.

In the south western parts of the state the water table has risen in the range of 0 to 2 meters in Mukatsar (Lambhi, Malout, Kot Bahi), Ferozpur (Guruhar Sahai, Mamdot, Jalalabad), Bathinda (Sangat) and parts of Mansa districts during 2004-05 resulting in water logging and soil salinity. Besdies this, sweet ground water table has also risen by 0-2 m in some blocks of districts Ludhiana (Sidhwan Bet, Samrala, Pakholwal), Patiala (Bhuner, Samaur, Rajpura), Mohali (Derabassi, Kharar), Ropar (Anandpur Sahib, Chamkur Sahib, Nurpur Bedi), Gurdaspur (Kahnuwan, Kalanaur, Dinanagar, Bamyal, Narot Jaimal Singh, Dera Baba Nanak, Fatehgarh Churian) and Amritsar (Ajnala, Chola Sahib, Patti). Most of this is around/near river and/or major canal systems or reservoirs. The water table has risen by more than 2 metres in some parts of Sidhwan Bet block in Ludhiana district (near river Satluj) during 2004-05.

Further, low lying pockets in south western districts of the state have been facing a severe problem of water logging and resultant soil salinity. This can be attributed to excessive canal irrigation, inadequate drainage system and under exploitation of ground water resources due to salinity. Till the eighties and nineties large areas of the state were water logged (out of total geographical area of state, 4.7% was water logged in the year 1998). However, the situation has improved considerably over the years due to expansion and improvement in drainage system in the affected areas. The water logged areas have come down sharply to 0.3% of total area of state in 2004. Further, the water logged (up to 1.5 metres) areas in the post monsoonal season (October) have also decreased by 93.34% from 233.4 th ha in 1998 to 15.5 th ha in the year 2004 (Fig. 2.24). Similarly, for pre monsoonal season (June), it has decreased by 94.61% (from 104.2 th ha in the year 1998 to 5.8 th ha in 2005). Low rainfall during this period has also helped in improving the situation.

The data provided by Directorate of Water Resources and Environment, Department of Irrigation also indicates that in 1998, water logging problem exited in Districts Mukatsar, Ferozpur, Faridkot, Ropar, Mansa and parts of Nawan shehar , Hoshiarpur and Gurdaspur whereas now it is confined to mainly Mukatsar, Ferozpur, Hoshiarpur and parts of Ropar districts.

Fig. 2.24 Water logged area (up to 1.50 mts) in Punjab from June 1998 to June 2005 (in thousand hectares)



Source: Directorate of Water Resource and Environment, Punjab, 2006

Soil erosion status

Water erosion of soil is mainly confined to kandi area (10.5% of total geographic area) of the state. As per Central Water Commission (2003), 9140 sq km area in the state is prone to water erosion. As per results of a study conducted by PAU's Zonal Research Station, large and small catchements of non arable lands (pastures/ current fallow/cultivable waste land) in Shiwalik foothills have been more affected by water erosion as compared to arable land (cultivated areas) (Table 2.21). In rest of the state water erosion is confined to "Dhahas" (ravines) along the rivers, especially along river Beas. This area is less than one lakh hectare as per information provided be Department of Soil and Water Conservation, Punjab. The agricultural lands in rest of the state are irrigated and levelled. Although at times fields do overflow during monsoons, yet the sediment loss from these fields is negligible.

Table 2.21 Runoff and soil loss from non arable and arable land of varying size in the Shiwalik foothills of Punjab

Allowable limit: 12-16 (t/ha/yr)

Source: Director, Zonal Research Station, Ballowal Saunkhri, Nawanshehar, 2000

The wind erosion problem is confined to mainy south western parts of the state. As per 2003 data provided by Central Water Commission,10900 sq km area is prone to wind erosion in Punjab. However, with bringing of more and more area under agriculture and horticulture, sands dunes have been leveled and the problem of wind erosion has reduced.

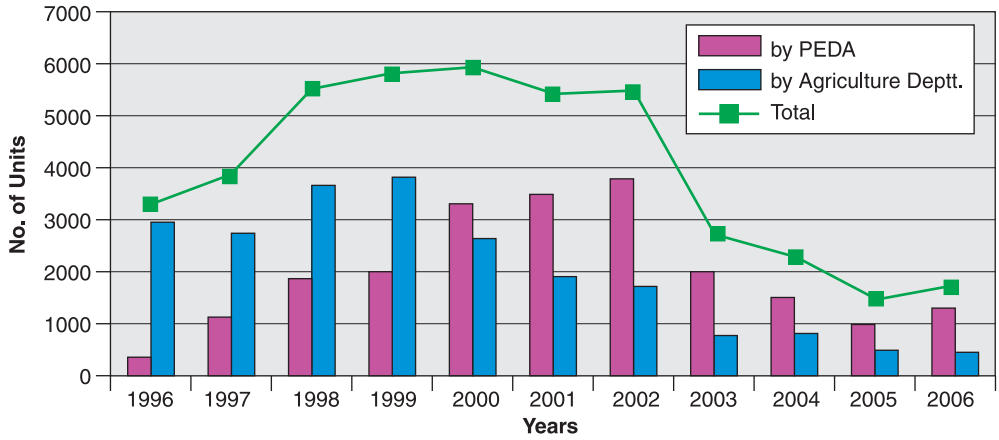
Management of agro waste

The rural agro waste in the state mainly consists of cattle dung, household waste and other crop residues like straw, stalks, husks and shells. As discussed earlier, majority of wheat (48%) and paddy (80%) straw is usually burnt in fields (some wheat straw is used as fodder). The other crop residues are used as household fuels.

In Punjab, livestock waste is the major component of rural agro waste and managed basically in three ways. Traditionally animal waste was collected and dumped outside the village at earmarked places for the whole year in form of heaps, commonly called "roories". This animal dung was composted and later used in the fields as organic manure. However, now other garbage like polythene etc. is also dumped in these heaps thus creating an unpleasant sight and odour (if not covered properly). It also contributes to slush during rainy season as many a times the manure is not transported to the fields due to application of chemical fertilizers. As a consequence organic matter in the soil has decreased substantially over the years. This needs to be reversed in order to improve/increase the soil fertility for sustainable agricultural production. Besides, a large portion of the livestock waste is also used for making dung cakes for use as household fuel. This is a great wastage of organic matter which needs to be utilized or managed in a manner so that both energy and manure can be obtained from livestock waste.

Further, both, central and state government agencies (like Punjab Energy Development Agency - PEDA and Department of Agriculture) are popularizing establishment of community biogas plants and family size individual biogas plants (of 4 m^3 and 6 m^3 size), where animal waste, including organic household waste, is used for the production of methane under anaerobic conditions. The methane gas is used for cooking purposes and the slurry produced after methane extraction is used as farm manure. This technique reduces methane emission in environment also. The Department of Agriculture, Punjab has set up 54337 biogas units upto 2005-06 throughout the state. The Department is also providing subsidy in the range of Rs 1800 to 2300 per unit to the farmers for this purpose. Further, PEDA has also set up 531 community biogas plants (CBP) in the state. It is also providing a subsidy of Rs. 2700/- for small farmers and Rs. 3500/- for schedule caste families on family size biogas plants. The year wise progress is presented in Fig. 2.25. Data indicates that there has been a sharp decline in adoption of this technology by the farmers in the past 3-4 years. This could be due to lack of space for installing biogas plants, easy availability of LPG in rural areas and various problems associated with operation and maintenance of biogas units like low gas production especially during the winter months.

Fig. 2.25 Biogas units (family size) installed in Punjab (1996-2006)



Source: PEDA and Deptt. of Agriculture, Punjab

Another agricultural waste problem is that of stubble remaining in the fields due to combine harvesting of wheat and paddy. In order to ensure early preparation of fields for the next crop open field burning of straw after combine harvesting is a common practice. Punjab produces around 15 million tons of rice straw and 17 million tons of wheat straw annually. The practice of setting the fields on fire after harvesting of crops started with paddy several years ago. Though farm experts have suggested alternative methods for use of rice straw, like insitu incorporation, but the farmers still prefer to burn

Village roories (organic waste dumping sites)

Using organic waste for energy through individual biogas plants

the stubble in the field to enable early sowing of next crop. Lately, the farmers have extended this practice to wheat crop also. Though part of the wheat straw is used as dry fodder for the milch cattle, but the remaining straw is usually burnt for quick disposal. The current end use of rice and wheat straw in Punjab is given in Table 2.22.

Table 2.22 End uses of wheat/paddy crop residues in Punjab

End-Use	(% age of the total produce)	
	Rice	Wheat
Fodder	7	45
Incorporated in soil	1	<1
Burnt	81	48
Rope making	4	–
Miscellaneous	7	7

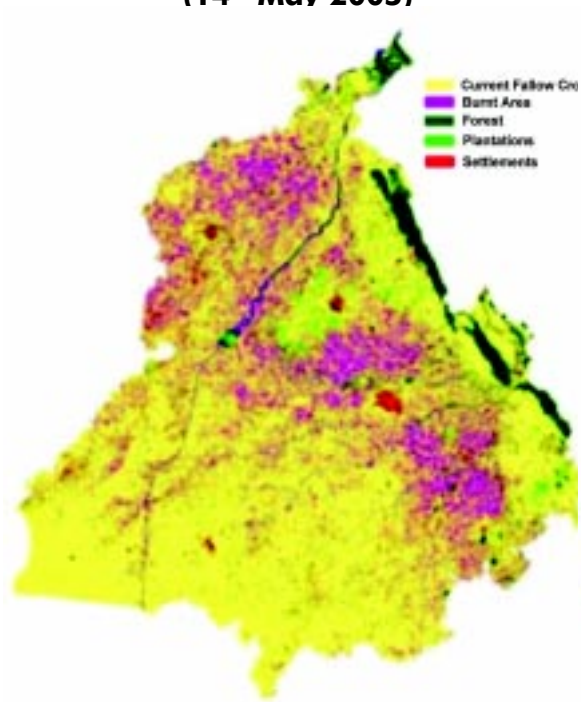
Source: Sidhu, 2002

As per Sidhu (2002), more than 80% of paddy straw and almost 50% wheat straw produced in the state is being burnt in fields every year. Apart form affecting the soil fertility (Box 2.5), burning of agricultural residue is now recognized as an important source of air pollution in rural areas. It leads to emission of large amounts of suspended particulate matter besides gases like CH_4, CO, N_2O, NO_X, SO_2 and hydrocarbons leading to impacts on health of the population (especially respiratory,

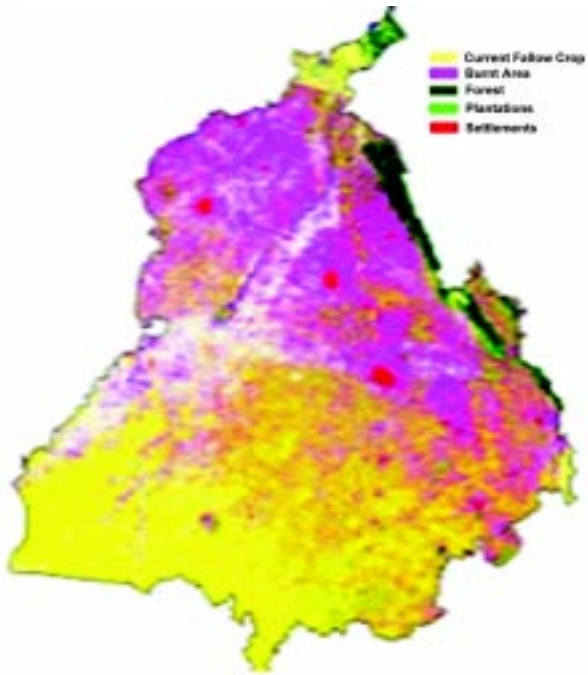
skin and eye diseases) in the region due to trapping of pollutants in the atmosphere due to inversion phenomenon in winters. The smoke is also a major problem for vehicular traffic in the state as it hampers the movement of vehicles on highways and link roads.

The National Remote Sensing Agency (NRSA), Hyderabad (Badrinath *et al.,* 2006) conducted a study to calculate the total emissions produced during straw burning during harvesting season in Punjab. The calculated total emissions suggested that wheat crop residue burning contributes about 113 Gg (Giga Gram: 10 billion gram or 10 million kg) of CO, 8.6 Gg of NO_x, 1.33 Gg of CH_4, 13 Gg PM_{10} (smoke) and 12 Gg of $PM_{2.5}$ during May 2005. The classified remote sensing images for wheat and paddy (Maps 2.19 and 2.20) indicate that Central Punjab is most affected. The extent of paddy crop residue burning during October 2005 has been estimated to be in 12,685 sq km area, which is much higher than the wheat crop residue burning that occurs during May each year. Emissions from paddy fields burning were estimated to be 261 Gg of CO, 19.8 Gg of NOx, 3 Gg of CH_4, 30 Gg of PM_{10} and 28.3 Gg of $PM_{2.5}$ during October 2005.

Map 2.19 Wheat straw burnt area (14th May 2005)



Map 2.20 Paddy straw burnt area (10th October 2005)

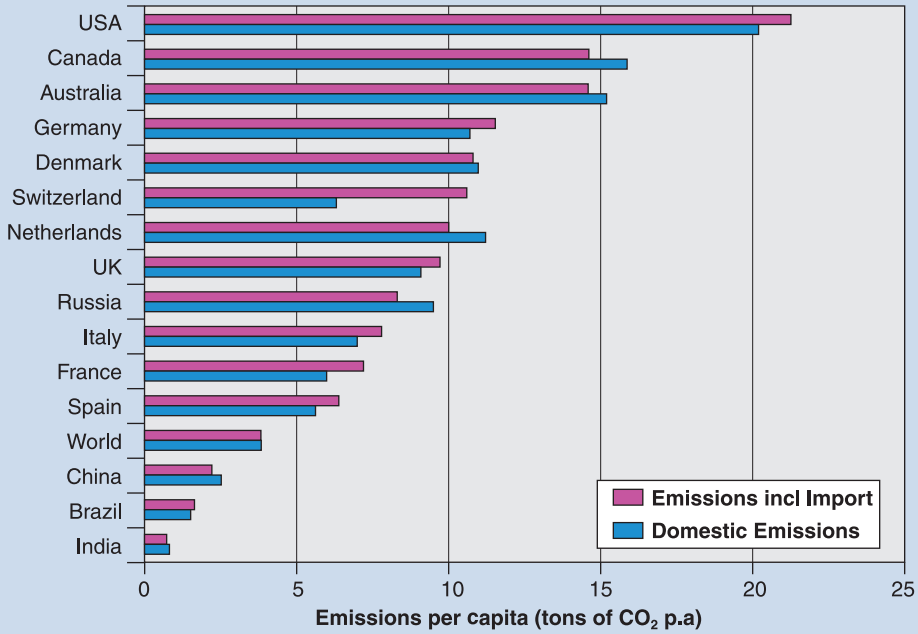


Source: Badrinath *et al.,* 2006 (NRSA, Hyderabad)

Box 2.10 Emissions of Green House Gases (GHG) from India

As per Gupta *et al.* (2004), one ton straw on burning releases 3 kg particulate matter, 60 kg CO, 1460 kg CO_2, 199 kg ash and 2 kg SO_2. These gases and aerosols consist of carbonaceous matter and play an important role in altering the atmospheric chemistry. They can affect regional environment especially CO_2 emissions, which also has linkages with global climate change as it leads to quick depletion of oxygen layer in the natural environment causing green house effect. The worldwide per capita per annum emissions of CO_2 (Fig. 2.26) indicate that contribution of developing countries to green house gases is less as compared to most developed countries.

Fig. 2.26 Worldwide per capita per annum emissions of CO_2



Source: Swiss Alliance of Development Organization, 2006

India's initial national GHGs inventory of anthropogenic emmsions by sources and removels by sinks was prepared for the base year 1994 by National Communication, Ministry of Environment and Forests, Govt. of India according to the stipulated guidelines of United Nations Framework Convention on Climate Change (UNFCCC), 1992 after its ratification by Indian Government in November, 1993. As per the inventory, the aggregate national emissions from anthropogenic activities in India amounted to 7,93,490 Gg of carbon dioxide (CO_2); 18,083 Gg of methane (CH_4) and 178 Gg of nitrous oxide (N_2O). In terms of CO_2 equivalent** (CO_2 eq.), these emissions amounted to 12,28,540 Gg. The per capita CO_2 emissions from India were 1.3 tons of CO_2 in 1994, which was 4% of the US per capita CO_2 emissions in 1994, 8% of Germany, 9% of UK, 10 % of Japan and 23 % of the global average. In India, CO_2 emissions contributed 65% of total GHGs, CH_4 contributed 31% and 4% of emissions were contributed by N_2O.

**Each of the GHGs has a unique average atmospheric lifetime over which it is an effective climate-forcing agent. Global warming potential (GWP) indexed multipliers have been established to calculate a longevity equivalency with carbon dioxide taken as unity. The GWP of methane and nitrous oxide are 21 and 310, respectively (IPCC, WKI, 1996). By applying unique GWP multipliers to the annual emissions of each gas, an annual CO_2 equivalency may be summed that represents the total GWP of all climate-forcing gases considered.

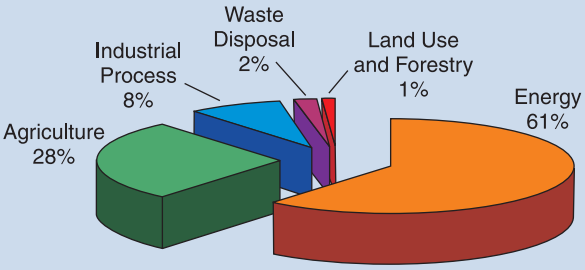
Table 2.23 India's initial national GHG inventories in Gigagram (Gg) of anthropogenic emissions by sources and removals by sinks of all GHGs not controlled by the Montreal Protocol for the base year 1994

GHG source and sink categories (Gg per year)	CO_2 emissions	CO_2 removals	CH_4	N_2O	CO_2-eq. emissions*
Total (Net) National Emissions	817023	23533	18083	178.0	1228540
1. **All Energy**	**679470**		**2896**	**11.4**	**743820**
Fuel Combustion					
Energy and transformation industries	353518			4.9	355037
Industry	149806			2.8	150674
Transport	79880		9	0.7	80286
Commercial/Institutional	20509			0.2	20751
Residential	43794			0.4	43918
All other sectors	31963			0.4	32087
Biomass burnt for energy			1636	2.0	34976
Fugitive Fuel Emission					
Oil and Natural gas system			601		12621
Coal mining			650		13650
2. **Industrial Process**	**99878**		**2**	**9.0**	**102710**
3. **Agriculture**			**14175**	**151.0**	**344485**
Enteric fermentation			8972		188412
Manure management			946	1.0	20176
Rice cultivation			4090		85890
Agriculture crop residue burning			167	4.0	4747
Emissions from soils				146.0	45260
4. **Land Use Change and Forestry***	**37675**	**23533**	**6.5**	**0.04**	**14292**
Changes in forest and other woody biomass stock	14252				(14252)
Forest and grassland conversion	17987				17987
Trace gases from biomass burning			6.5	0.04	150
Uptake from abandonment of managed lands		9281			(9281)
Emissions and removals from soils	19688				19688
5. **Others sources as appropriate to the extent possible**					
5a. **Waste**			**1003**	**7.0**	**23233**
Municipal solid waste disposal			582		12222
Domestic waste water			359		7539
Industrial waste water			62		1302
Human sewage			7		2170
5b. **Emissions from Bunker fuels#**	**3373**				**3373**
Aviation	2880				2880
Navigation	493				493

Not counted in the national totals.
*Converted by using GWP indexed multipliers of 21 and 310 for converting CH_4 and N_2O respectively.

On a sectoral basis (Fig. 2.27), 7,43,820 Gg CO_2-eq. of GHGs were emitted from energy sector including fuel combustion and fuel emission (61%); 3,44,485 Gg of CO_2-eq. emissions came from the agriculture sector (28%); 1,02,710 Gg of CO_2- eq. were contributed by the industrial processes (8%); 23,233 Gg from waste disposal (2%) activities and 14,292 Gg were generated from land use, land-use change and forestry sector (1%). Table 2.23 summarizes the GHG emissions from various sectors by sources and removals by sinks for India for the base year 1994.

Fig. 2.27 Percentage contribution of different sectors to the total GHGs emissions in India (1994)



Source: National Communication, MoEF, Govt. of India (http://www.natcomindia.org/pdfs/chapter2.pdf)

The agriculture sector primarily emitted CH_4 and N_2O. The CO_2 emissions due to the energy use in the agriculture sector are accounted for as a part of all energy emissions. The emission sources accounted for in the agriculture sector are enteric fermentation in livestock (Enteric fermentation occurs when CH_4 is produced in the digestive systems of ruminant animals and passed out), manure management, rice cultivation, agricultural soils and burning of agricultural crop residue. The bulk of the GHG emissions from the agriculture sector were from enteric fermentation (59%), followed by rice paddy cultivation (23%), and the rest were contributed by manure management, burning of agriculture crop residue and application of fertilizers to soils.

Source: National Communication, MoEF, Govt. of India (http://www.natcomindia.org/pdfs/chapter2.pdf).

Labour linked to agriculture

The size of agricultural labour varies from region to region depending on such factors as pressure of population, availability of land for cultivation, cropping pattern, fertility of land and opportunities available for seasonal migration for employment outside agriculture sector. As per the 2001 census data, Punjab has 9.127 million workers, out of which 3.564 million are engaged in agriculture. This includes 2.065 million cultivators and 1.499 million agricultural labourers. Total number of agricultural labourers in Punjab has always been small before its reorganization in 1965. In the post-green revolution situation, farm mechanization and paddy-wheat crop rotation has greatly influenced the labour employment pattern. Abundant labour is employed during the sowing and harvesting seasons. They are relieved after the operations are over. Inter census data from 1971 to 2001 shows that the percentage of total agricultural work force (both cultivators and labourers) to total work force in Punjab has decreased from 62.87% in the year 1971 to 38.95% in the year 2001, whereas, the percentage of agricultural labourers (excluding cultivators) has increased first from 9.65% in 1961 to 23.31% in 1991 and later decreased to 16.32%. As per Punjab Human Development Report, 2004, the state has a very low participation of female agricultural labourers with males constituting 93.78% vs 6.22 % females. A significant proportion of Punjab's agricultural labour force consists of migrant labour from eastern Uttar Pradesh and Bihar.

Migrants labourers

Punjab had earlier been characterized by the predominance of family labour on land, but this was rendered insufficient by the huge demand of Green Revolution. The farmers of the state have become largely dependent on migrant labourers for various farm operations like transplanting, harvesting and threshing of paddy and wheat due to easy availability. Migrant labourers have been coming to Punjab ever since opportunities in agriculture were created by the state's agricultural leap forward. The major factors behind migration were poverty, unemployment and low wage rates in the native areas of migrants. Migration to Punjab began strongly in the early 1970s and reached its pinnacle in the 1990s. The proportion of migrant labourers rose from 7.6% (0.219 million) of the total agricultural labour force in Punjab in 1978-79, to 10% (.386 million) in 1983- 84 and to 11% (0.774 million) in 1995-96. Their number was estimated at 0.327 million during the lean season and 0.656 million during the peak season in 1983-84, but by the year 1995-96 their number during the peak season stood at nearly 0.774 million. The maximum increase of 35.6% was observed during 1983-84 to 1995-96. This can be attributed to both, shift in cropping pattern, scope for increasing cropping pattern intensity and introduction of labour-intensive crops like potato, sugarcane, cotton and large scale adoption of wheat- paddy rotation. The total earnings of the entire migrant agricultural labour force in the state has been estimated at about Rs. 5.34 billion in 1995-96. Two third (Rs. 3.55 billion) of these earnings were remitted by them to their native places and remaining one third (Rs. 1.79 billion) was being spent in Punjab itself (Source: Sidhu *et al.* 1997).

Further, as per HDR, 2004, the districts of Ludhiana, Patiala and Jalandhar have highest concentration of migrant labourers, districts like Amritsar, Faridkot, Firozpur, Sangrur has a medium concentration, whereas Rup Nagar, Hoshiarpur, Gurdaspur and Bathinda districts have low concentration of migrant labourers. In 1998, it was estimated that districts with high concentration had approximately 52 migrant labourers per village, those with moderate concentration had about 30, and villages with low concentration had about 15 labourers per village. However, as per information provided by PSFC, the inflow of migrant labour has decresed since 2005 due to the implementation of National Rural Employment Guarantee Scheme in 200 districts of India (under which employment is provided for 100 days in a year to one member per household for a minimum wage of Rs. 60 per day). The state is facing the shortage of migrant labour during paddy season since then.

Institutional and non institutional credit

Data indicate that farmers in Punjab are heavily under debt. The outstanding institutional loans of farmers in the state had increased from Rs. 18630 million in 1990-01 to Rs. 62060 million in 2000-01, which was more than 25% of Net State Domestic Product (NSDP) from agriculture and livestock. However, these have increased steeply to Rs. 124 billion by end of 2005-06 representing more than 38% of NSDP form agriculture sector (Table: 2.24).

As proved by results of various studies and surveys, besides, institutional sources of credit, the non institutional sources, mainly 'commission agents' also meet around 50% credit needs of the farmers in the state. Thus, it is estimated that total outstanding loans of farmers are around 240 billion, which is more than 50% NSDP from agriculture.

Table 2.24 Total outstanding institutional loans of Punjab farmers (in millions)

Year	Commercial Banks	Primary Agricultural Cooperative Societies	State Agricultural Development Banks	Total	NSDP from Agriculture and livestock	Total Institutional debt as % of NSDP
1970-71	200	520	480	1200	8340	14.4
1980-81	2350	1460	1090	4900	20230	24.2
1990-91	10700	4820	3110	18630	73930	25.2
2000-01	31200	15300	15560	62060	247160	25.1
2001-02	34760	17400	16630	68790	256220	26.2
2002-03	44250	20840	16790	81880	249080	32.9
2003-04	55670	23190	17690	96550	273330	35.3
2004-05	63960*	26650	20120	110730*	294080	37.6
2005-06	72250*	30800*	21060*	124110*	323470*	38.4

*Provisional

Source: PSFC, (Kalkat *et al.*) 2006

Climate change and Carbon credits

The average temperature of the earth has risen by 0.6°C since 1900. The last decade was recorded as the warmest decade globally and 1998 was the warmest year since 1861 (since when temperature had been recorded with adequate global coverage). Because of this warming, snow cover is decreasing, glaciers are receding, rainfall patterns are changing and extreme weather events have become more frequent. This is also affecting crop yield. A decrease in production of wheat has been recorded in the state, where ever sowing is delayed (especially in south western areas due to delayed cotton harvesting) as higher temperature, especially during tillering stage, affects seed setting. The wheat yield has declined in the state from 46.96 qt/ha in 1999-2000 to 42.21 qt/ha in 2004-05 as per data provided by Department of Agriculture.

Under the Cap-and-Trade regime of UNFCC, European Union Allowances (EUAs) have been allocated in first phase in order to control CO_2 emissions from various enterprises through trading of carbon credits. In phase II, the caps are going to be at much lower levels of emissions. Market in carbon trading has developed quite fast. Carbon Credit Markets operate like share markets and stock exchanges in respect of spot purchases and future hedging. The value of global carbon market was more than US$ 10 billion in 2005 and expected to be between US$ 25 to 30 billion in 2006. However, these efforts so far have remained focused primarily on industrial emissions as ever enhancing level of production of industrial good and services is considered to be the major source of environmental degradation through the emission of greenhouse gasses (GHG), especially carbon dioxide, methane and nitrous oxide. Due attention has not been paid to the agriculture sector on this aspect as yet though concerted effort on increasing agricultural production and food security is putting tremendous strain on environmental elements.

Agriculture also enhances climate change with the emission of Greenhouse Gasses (GHG), primarily carbon dioxide, methane and nitrous oxide into the environment. Any biomass whether growing in the field or stored, emits methane, though in very negligible quantities. Any crop growing in standing water, especially paddy, emits considerable amounts of methane, carbon dioxide and nitrous oxide in its root zone due to the anaerobic conditions created by the standing water in fields. The plant has inter-cellular space, which acts like a conduit and these gases are emitted into the atmosphere through leaves. In turn the plant through this intercellular space provides oxygen to the bacteria for their survival. It is estimated that one hectare of rice under standing water conditions emits more than 0.45 tonnes of methane over a growing period of 90 days. In addition, carbon dioxide and nitrous oxide are also produced. Put together, an equivalent of 20 tonnes of carbon dioxide is emitted during this period. One hectare of rice, if replaced with other crops or rice crop that is grown without standing water, has the potential of earning carbon credits worth more than Rs 10,000 in three months of its growing period (Johl, 2006).

Agricultural technologists of Punjab have already developed one such technique (ridge planting) of paddy cultivation under aerobic conditions. PAU has also conducted various experiments and has approved ridge plantation of paddy under heavy soil conditions. It is estimated that Punjab can earn approximately Rs. 200 billion in ten years through these carbon credits if all the rice area can be brought under aerobic conditions (Johl, 2006).

IMPACTS

Agricultural activities have a distinct impact on natural and socio economic environment, as well as, human health. Modern agricultural practices have had an ecological backlash, which is becoming more pronounced as we refuse to change our methods of production. Some of these include:

Overexploitation of land and water resources

In an effort to produce more grain the state has been overexploiting its land and water resources by changing traditional cropping patterns and resorting to high input agriculture (instead of low input, ecologically friendly farming practices) with higher demands of water, nutrients, energy, etc. By lowering cultivation of legumes and switching over from organic to chemical fertilizers, the soil is deprived of natural replenishment of both, micro and macro nutrients leading to lowering of its productive potential. Lack of fallowing period (due to increased cropping intensity) also deprives soil from rejuvenating itself. Further, resorting to high water requiring crops has put undue pressure on the state's surface and ground water resources, the effects of which are increasingly being felt and warrant immediate action for mitigation.

Further, by relying on a narrow spectrum of HYVs, the state has lost its traditional floral and faunal biodiversity, which had been contributing significantly towards food and nutritional security of the masses, as well as, towards natural management of pests. Presently, due to a narrow biological resources base, the state has resorted to high use of chemical pesticides and weedicides, which have not only polluted our air, water and soil (due to residual effect) but have also led to serious health problems. Furthermore, the burning of crop residues in fields itself, to quickly make way for the next

crop, has had a double fold negative impact. It deprives the soil of natural organic matter and nutrients, kills useful micro and macro flora and fauna and at the same time causes significant air pollution.

Most of the impacts have been discussed in detail in the preceding paras. Some other impacts not discussed earlier are as below:

Pesticide residues in biotic and abiotic environment

In the 1960s, Rachel Carson's publication *"Silent Spring"* prompted worldwide interest in the environment and concern about the damage caused by chemical pesticides on human life and on the environment as a whole. Over the years several scientific studies and surveys have been conducted in the state by various researchers, as well as Government and Non Government organizations, on pesticide residues in the environment and food products. Results indicate residues of chemical pesticides in human beings, milk, water, vegetables and other food products at levels, which are dangerous for human health. The results of the various studies conducted in last 30 years on pesticide residues in Punjab are discussed in Box 2.11.

Box 2.11 Major studies on pesticide residues in the environment of Punjab

1. A study on "Residues of DDT and HCH (Hexachlorocyclohexane)/BHC (Benzanehexachloride) in Wheat Flour in Punjab" was conducted during 1974-76 by Joia *et al.*, A total of 140 samples of wheat flour from flour mills and retail shops were collected randomly from different cities: Jalandhar, Patiala, Sangrur, Ludhiana, Faridkot, Amritsar and Chandigarh (20 each from each city). Residues of DDT (dichlorodiphenyltrichloroethane) and HCH were detected in 124 and 116 samples respectively out of 140 samples by using gas-liquid and thin layer chromatography. Both of these insecticides were simultaneously detectable in most of the samples. Twenty seven samples showed DDT level more than 1 µg/g (WHO permissible residue limit of DDT in cereals is 0.1 µg/g). However, in most of the samples, DDT residues were reported in the form of p,p`- DDT and o,p` - DDT. The maximum level of DDT residue of 10 µg/g was detected in one sample collected from Jalandhar. However, the residues of HCH/BHC were found to be higher than DDT. The highest level of HCH/BHC residue of 12 ppm was found in a sample from Chandigarh (WHO permissible residue limit of HCH/BHC in cereals is 0.1 µg/g). The study indicated the possibility of DDT contamination of wheat through sources other than direct admixture with grains. For sources of HCH/BHC residues, the results suggested that the practice of mixing of HCH with wheat grains during storage could be one of the main reasons, but other possible sources of contamination were also not ruled out. The investigators also calculated the daily intake of DDT and HCH/BHC for a man weighing 50 kg to be 120 µg DDT and 300 µg HCH/BHC through the contaminated wheat flour. The intake of DDT through this source alone constituted about 40% of the "Acceptable Daily Intake" (ADI) of 0.005 mg/kg/day of DDT (WHO, 1972). This was much higher than the total dietary intake of DDT in USA (55 µg), UK (34 µg) and Spain (78.4 µg) (No ADI value for BHC/HCH residues is available). Similarly the daily intake of HCH/BHC was found to be higher than in the UK (17 µg). The authors also reported that both these

> The term HCH is used for mixed isomers of (hexachlorocyclohexane: $C_6H_6Cl_6$). The trade brand Lindane contains 99% pure γ-HCH. Other synonymous of this pesticide are Benzene hexachloride (BHC), Agrocide, Gamaxine, etc. with varying composition of α, β and γ isomers.

insecticides are persistent and get stored in the adipose tissues of the human beings. The body burden of these insecticides above certain level may be hazardous to human health. The study urged for serious efforts to check the contamination of wheat with these insecticides.

2. To assess the status and magnitude of Pesticidial contamination in vegetable oils and oil seed cakes in Punjab, a study was conducted by Battu *et al.*, in 1978. Samples of oil/fat rich commodities such as oilseeds and their products were obtained from selected markets of Ludhiana, Mukatsar, Ferozpur, Sangrur and Khanna. These included vegetable oils of mustard, groundnut, coconut, rapeseed, cottonseed, sesame seed and rice bran. Forty three samples of vegetable oils were analyzed. The results indicated the presence of HCH residues (HCH-T) in all the samples which mainly consisted of alpha and gamma isomers, though traces of beta and delta isomers were also detected. Further, 70% of the samples contained DDT residues (DDT-R) which mainly comprised of p,p'-DDT as well as small quantities of p,p' –DDE, o,p'-DDT and p,p'-TDE. Despite the wide occurrence of the DDT and HCH residues in vegetable oils, none of the samples of the most popular brands of hydrogenated vegetable oil (Vanaspati ghee) analyzed showed their presence. This may be due to the effect of processing. Further, analysis of 23 samples of oilseed cake, a by-product of the oil-seed, intended for use as animal feed, revealed much lower level of contamination with DDT and HCH residues than oils.

3. In 1980, a study was undertaken by Kalra and Chawla on "Occurrence of DDT and BHC residues in human milk in India". Seventy Five samples of milk were collected from 75 lactating women within a week after delivery residing in the Punjab state. Results indicated the presence of DDT and BHC residues in all 75 samples of human milk. This publication was the first report on DDT and BHC/ HCH found in human milk in India. The mean level of DDT residue of 0.51 mg/l in human milk in Punjab was more than the level reported from USA, Canada, Europe and Australia, though the highest concentration of DDT of 4.07 mg/l in human milk was reported in Guatemala. BHC/HCH residues in human milk were also reported to be higher than other countries of the world except Japan. DDT present at an average level of 0.5 mg/l in milk indicated an intake of 0.09 mg/kg/day of DDT, which is 18 times the ADI of 0.005 mg/kg/day recommended by WHO.

4. Subsequently, P.K Chattopadhyay of Punjabi Uiversity, Patiala conducted a study on "Insecticide and pesticide pollution of food stuffs and their toxic effect on man" during early nineties (Chattopadhyay, 1998). He reported over 40 pesticides in use in agriculture in various districts of Punjab. Experimental samples were prepared by spraying various vegetables like cabbage, cauliflower, brinjal, etc., with pesticides like quinalphos, malathion, methyl carbaryl, phosphamidon, dimethoate, dichlorovos and phorate and were exposed to various environmental conditions to determine the degradation time of pesticides. It was observed that persistence of the insecticides was dependent on temperature of the atmosphere and time gap between spraying and harvesting. Whereas residues of malathion and quinalphos were observed even after 6 to 7 days when the temperature ranged between 15°C to 22°C, however, phosphamidon, dimethoate and dichlorovos were detected only upto 4 to 5 days, when temperature range was 30.8°C to 42.6°C. The investigator recommended atleast 10 days gap between last application of the pesticide on crop and its harvest. In the blood samples obtained from Patiala region of Punjab, α and β isomers of BHC/HCH within ranges of 1.80 ppb-5.28 ppb and 1.28 ppb-3.12 ppb respectively, were detected. In the blood samples of people involved directly in spraying operations, pesticide residues were found in higher ranges eg. methyl parathion was detected in the range of 17.56-17.94 ppb, quinalphos at a level of 5.30 ppb and malathion at a level of 7.62 ppb.

5. Later, Chahal *et al.*, also investigated the levels of insecticide residue in vegetables in their study, "Monitoring of farmgate vegetables for insecticide residues in Punjab" for an eight year period from 1991 to 1998. In this study, 197 samples of various vegetables like brinjal, cabbage, cauliflower, okra, potato and tomato were collected from farmers fields when these were ready for transportation to the market. Fifty three samples were collected during 1991-93, while 96 and 48 samples were collected during 1994-96 and 1997-98 respectively. Results indicated that 45 out of 65 samples of Brinjal were contaminated with different insecticides and 24 of these contained residues above their maximum residue limits (MRLs). In case of cabbage, 25 samples were found to be contaminated with monocrotophos, methyl parathion, quinalphos, chloropriphos, cypermethrin, fenvalerate, deltametrin and endosulfan. Out if these, 19 samples were found to contain insecticides above their MRL values. Seven out of 17 okra samples analysed were found to be contaminated with methyl parathion, quinalphos, moncrotophos, triazophos, chlorpyriphos and fenvalerate. However, none of the samples were found to exceed their respective MRLs. Three out five samples of potato were found containing residues of dichlorvos above its MRLs of 0.5mg/kg. Residues of phosphamidon in one and quinalphos in two samples of tomato, out of 25 samples were found to exceed their respective MRLs. All the samples were also analysed for the presence of DDT and HCH/BHC residues; however, the residues of both these insecticides were found to be below the detection limit of 0.001mg/kg during 1996-98, thereby showing a decline in the residues of these insecticides, which may be attributed to their ban in agriculture. The study revealed that 70 percent of vegetables were contaminated with different insecticides and about 27 percent of the samples contained residues above their respective MRLs. The authors also confirmed the fact that farmers were not adhering to recommendations of Punjab Agriculture University. They recommended periodic monitoring of vegetables to ensure that timely preventive measures are adopted.

6. In the year 2002, Balwinder Singh, in his study "Pesticides contamination of the Environment in Punjab", compared pesticide residues in food products during 1976-1996 with 1996-2001 in Punjab. The results are summarized below in Table 2.25 and Table 2.26. Data indicates that whereas between1976 to 1996 the major pesticides used in agriculture were DDT and BHC/HCH (and hence

Table 2.25 Insecticide residues in different food and feed commodities in Punjab during 1976-1996

Commodities	Samples			
	Number Analysed	Insecticides detected	Contaminated (%)	Above tolerance limits (%)
Cereals	1088	DDT	87.4	15.8
		HCH/BHC	67.6	1.9
Fruits and Vegetables	183	DDT	38.3	Nil
		HCH/BHC	43.7	Nil
Milk	1110	DDT	97.7	41.0
		HCH/BHC	100.4	40.0
Butter	283	DDT	100.0	71.0
		HCH/BHC	100.0	Nil
Infant formula	54	DDT	100.0	8.5
		HCH/BHC	86.01	Nil
Animal Feed	228	DDT	100.0	35.0
		HCH/BHC	100.0	32.0

Source: Singh, 2002

Table 2.26 Insecticide residues in different food and feed commodities in Punjab during 1996-2001

Commodities	Samples			
	Number Analysed	Insecticides detected	Contaminated (%)	Above tolerance limits (%)
Rice	99	HCH/BHC	97.0	9.0
Fruits	27	Phosphamidon Quinalphos	85.0	11.0
Vegetables	147	Endosulfan, Quinalphos Chlorpyrifos, M. Parathion, Monocrotophos	71.0	18.0
Milk	92	DDT Lindane/HCH	2.2 53.2	Nil 53.3
Butter	16	DDT Lindane/HCH	75.0 31.3	Nil Nil
Animal Feed	31	DDT HCH/BHC Malathion	22.5 77.5 38.5	10.0 Nil Nil

Source: Singh, 2002

studied most by agricultural scientists), the trend shifted to other organic pesticides thereafter, especially due to ban on use of DDT in agriculture. However, HCH/BHC was still used on cereals (with 97% rice samples indicating contamination). Further, the per cent contaminated samples of fruits and vegetables with other persistent organic chemicals have also increased between 1996 to 2001 (85 and 71 percent respectively during 1996 to 2001 against 38.3 and 43. 7 percent respectively during 1976 to 1996) indicating their higher use in perishable, ready to market food products. The percent samples of these products with residues of pesticides above tolerance limits has also increased, which is a cause of concern. However, the contamination of milk and butter with DDT has distinctly reduced.

7. As reported by Tiwana *et al.*, in 2005, the Punjab Pollution Control Board has also initiated studies on estimation of pesticide in river water since 2002. The results of the studies confirmed the presence of pesticide residues in water and sediments of river Sutlej, Beas and Ghagger. Data indicates that the residues of pesticides were highest in river Sutlej. This could be primarily due to run off. Further, though DDT is banned in agriculture, however, it is still being used in public health programs and is found in river water. Since, this water is used for agriculture and human and cattle use in the state, it could cause adverse health impacts.

It is evident from the results of studies discussed above that as Punjab recovers from the ecstasy of the green revolution, it is now battling with residual effects of extensively used chemical pesticides in various components of the environment and food products. For the general population, diet has become a major exposure route for most known toxic contaminants. With the ban on highly persistent organochlorine pesticides in agriculture, there has been a decline in their residues in food. However, the incidence of contamination by less persistent but more toxic organophosphates and carbamate pesticides are on the rise in the state.

Impact of pesticides on human health

Most chemical pesticides are known to pose serious health affects on humans and cattle. They can affect the gastroentritic, hepatic, renal and nervous systems when ingested, besides affecting skin, eyes and respiratory system while handling. Many pesticides are also known to have carcinogenic affects. However, very few epidemiological studies have been carried out in the state in this regard. One of the few important studies carried out includes a study by Post Graduate Institute of Medical Education and Research (PGMIER), Chandigarh sponsored by Punjab Pollution Control Board (PPCB) in the cotton belt of Malwa region of the state (Kumar, 2005). The study titled 'An epidemiological study of cancer cases reported from villages of Talwandi Sabo block, District Bhatinda, Punjab', compares cancer incidence in Talwandi Sabo (the study area) with that in Chamkaur Sahib block (selected as the control area) of Rupnagar district, Punjab. Since more than half of the pesticides manufactured in the country are estimated to be used on cotton crop, the study tried to find out if cotton cultivation, which is much more pesticide dependant than rice and wheat, could be linked to cancer. A total population of 39,732 families comprising 183,243 people were surveyed in 129 villages of both the blocks. The number of age adjusted confirmed cancer cases in Talwandi Sabo, block were 103 per lakh compared to 71 per lakh at Chamkaur Sahib. Further, cancer deaths per lakh per year were 52 in Talwandi Sabo block verses 30 in Chamkaur Sahib. Several factors like age; sex; sources of drinking water; polluted water; usage, storage and spraying of pesticides; chewing of tobacco, vegetarian and non vegetarian food consumption; use of spices; alcohol and smoking; and jaundice incidence were taken into account. Water (tap and ground) and vegetable samples were analyzed between March to May 2004 from the study and control areas. Heptachlor levels, both in tap and ground water in Talwandi Sabo were reported to be higher then the permissible limit of 0.00003 mg/l. However, this pesticide was not found in Chamkaur Sahib. Similarly, malathion in tap water was higher than the permissible limit (0.0005 mg/l) in Talwandi Sabo, where as its level was within the permissible limit in Chamkaur Sahib. Several vegetable samples were also analyzed for pesticide residues. These included potato, bottle gourd, cabbage, round gourd and bitter gourd from various villages of Talwandi Sabo block and potato, bottle gourd, cauliflower, brinjal and capsicum in Chamkaur Sahib block. The levels of heptachlor endoepoxide, β- endosulfan, γ- HCH/BHC, ethion and chloropyrifos (0.027 µg/g), were more in vegetables grown in Talwandi Sabo as compared with vegetable samples from Chamkaur Sahib. Chloropyrifos and ethion pesticide levels were found to be above the permissible limits (0.01 µg/g and 1.0 µg/g) in fruit samples from Talwandi Sabo. Heptachor, aldrin and endosulfan were detected in blood samples taken from cancer patients from Talwandi Sabo and Chamkaur Sahib. Based on the above data, the report observed that, though it is difficult to pinpoint a single cause for cancer, a multi-pronged strategy to provide safe water supply and discouraging indiscriminate pesticide use needs to be adopted.

Subsequently, the Department of Entomology and Soil Sciences of PAU conducted another study (Battu, *et al*., 2005) to check the status of pesticide residues in villages Jajjal and Giana in Talwandi Sabo, District Bathinda in May 2005. In total, 15 samples containing samples of soil, water and vegetable (okra) were collected (8 from Jajjal and 7 from Giana). As per the results of the study, residues of all the insecticides (organochlorine, synthetic pyrethroid and organophospahate) in all the samples (except one) were below the detection limits of 0.01 ppm for water and 0.1ppb for soil.

However, residues of ethion in the only sample of okra taken from village Jajjal was found to be 1.42 µg/g, which is above the MRL of 1 µg/g fixed for vegetables under Prevention of Food Adulteration Act, 1954. The study also ruled out possibility of presence of Arsenic and Chromium in water, soil or crops due to use of pesticides for crop protection as none of the commonly used modern synthetic organic pesticide of all groups contain Arsenic, Chromium, Lead and Mercury.

Another study conducted by the Centre for Science and Environment (CSE), New Delhi by Mathure *et al*., in 2005 on "Analysis of pesticide residues in blood samples from villages of Punjab" has found very high levels of pesticide residues in human blood samples which were taken from five Punjab villages (Mahi, Nangal, Jajjal and Balloh villages in Bhatinda district and Dher village in Ropar district). The study tested 20 randomly obtained blood samples which showed 15 to 605 times higher residues of certain persistent organochlorine pesticides as compared to samples of people in the United States. Six to 12 types of pesticide residues were found. The average levels of monocrotophos in the blood samples (0.095 µg/g) were found to be four times higher than the short-term exposure limit for humans set by the World Health Organisation and the Food and Agriculture Organisation. The CSE study calls for urgent action to regulate pesticide use and suggests for large scale biomonitoring.

The awareness level of farmers with respect to harmful effects of pesticide usage is discussed in Box 2.12.

Box 2.12 Awareness level of farmers regarding pesticide pollution

Sharma *et al.*, in 2005 conducted a study in Jalandhar and Moga districts of Punjab in order to find out the "Awareness level of the farmers regarding the implications caused due to excessive use of pesticides". Results indicate that 28% of the respondents were not aware about instructions written on pesticide containers and more than 50% did not follow these instructions. Further, 64.5% respondents were not aware about recommended dose of inputs although they were aware about environmental pollution being created due to overuse of pesticides. Furthermore, 48.5% respondents were unaware of the need to keep pesticides in original containers and 54% were careless about their safe storage. Majority of the farmers (75.5%) did not dispose off empty containers; rather they reused them in household activities, whereas only 24.5% were aware about disposing the containers properly. Though persistence of some pesticides was known to a majority of farmers (67%), only 36% respondents were aware about the hazardous effects of their excessive use on soil nutrients and bio control agents. About 54% of farmers were also unaware of the ill effects and respiratory and skin diseases and allergies caused by pesticides in human beings.

Accumulation of heavy metals in vegetables and soils

In certain areas waste water is being used for irrigation to dispose of urban sewage water. This water, when used after proper treatment and disinfection, contains nutrients and can serve as an alternative water source. However, the sewage waste water of big cities is highly contaminated with untreated industrial effluents and contains heavy metals, organic compounds and a wide spectrum of

pathogens. Long term use of this water (especially untreated or partially treated) for irrigation results in the accumulation of heavy metals in soils which leads to their higher content in crops grown on these soils causing health hazards to the consumers.

A study was undertaken by Guru Nanak Dev University (Singh *et al.*,1990) on the effects of sewage irrigation from Ganda Nallah (Hakimwala drain) and Tung Dhab Drain on the soil and crops in Amritsar during 1986 to1990. It was observed that copper and zinc accumulated in the soil with prolonged sewage irrigation. The contents of these two heavy metals was found upto 270 µg/g and 412.8 µg/g, respectively, which were very high for cultivated lands. In some vegetable crops the content of Cu, Zn and Pb was found above prescribed limits. In general, higher metal content was reported in vegetables and fodder crops than cereal crops like wheat and paddy. Further, it was observed that sewage water irrigation did not affect the content of iron and manganese in soils, but increased the availability of these metals for uptake by plants due to lowering of soil pH. The study recommended that sewage water could be used for irrigating cereal crops only along Ganda Nallah up to 5 kms from point of referernce (Khem Karan road bridge), but vegetables and fodder crops should be grown beyond 5 kms. For Tung Dhab Drain, all crops should be grown beyond 10 kms from referncence point (Ram Tirath road bridge).

Results of a study conducted by Khurana *et al*. (2003), in districts Ludhiana, Jalandhar, Amritsar and Sangrur showed elevated levels of DTPA (Diethylene triamine penta-acetic acid) extractable heavy metals in sewage irrigated soils as compared to tubwell irrigated soils (Table 2.27). The heavy metal content was highest in the more industrialized city of Ludhiana and least in the soils of less industrialized city of Sangrur. The mean concentration of DTPA – Lead, Nickel Cadmium, Zinc, Manganese and

Table 2.27 Concentration of DTPA extractable heavy metals (mg/kg) in sewage water (SW) and ground water (GW) irrigated soils in four cities of Punjab

Heavy metal	Ludhiana		Jalandhar		Amritsar		Sangrur	
	SW	GW	SW	GW	SW	GW	SW	GW
Lead	4.21	1.00	3.57	1.37	5.06	0.98	2.76	1.32
Nickel	3.58	0.78	0.47	0.20	0.65	0.26	0.40	0.20
Zinc	11.90	5.60	3.65	1.25	12.8	3.78	2.10	1.45
Manganese	25.40	5.60	7.99	4.92	9.44	6.99	8.34	5.37
Iron	40.20	12.80	12.86	6.12	14.7	13.66	10.88	6.27
Cadmium	0.30	0.05	0.14	0.08	0.19	0.02	0.12	0.02
Copper	–	–	5.13	1.01	14.2	0.56	1.88	0.94

Source: Khurana *et al.*, 2003

Using waste water for irrigation

Iron in surface soils (0-15 cm) of Ludhiana irrigated mainly with sewage water was 4.21, 3.58, 0.30, 11.9, 25.4 and 49.2 mg/kg respectively. In comparison to this sewage water irrigated soils of Sangrur contained 2.76, 0.40, 0.12, 2.10, 8.34 and 10.38 mg/kg of Lead, Nickel, Cadmium, Zinc, Manganese and Iron, respectively.

Table 2.28 Influence of cropping system on selenium content in seleniferous soils of Punjab

Source: Dhillion *et al.*, 1997

Further, in approximately 1000 ha areas of Hoshiarpur and Jalandhar districts of Punjab, selenium content has registered a four fold increase due to following of rice-wheat cropping pattern as compared to when maize-wheat cropping pattren was practiced (Dhillion *et al.*, 1997). The influence of cropping system on selenium content in seleniferous soils of Punjab is shown in Table 2.28. The source of selenium is these soils appears to be ground water and the selenium rich material transported through floodwater from Shiwalik hills.

The health affects of heavy metals are presented in Box. 2.13.

As per a study conducted by Punjab Pollution Control Board (Ram *et al.*, 2005) to identify the ill effects of wastewater irrigation on soil and vegetables in and around Chandigarh city and Mohali town, the concentration of heavy metals such as Cadmium, Lead, Zinc and Chromium have been found beyond the permissible limits in root vegetable crops collected from the fields irrigated with

Box 2.13 Health affects of heavy metal pollution on humans and plants

At high concentrations, all the heavy metals are toxic to human beings, animals and plants. Major sources of some of these metals and their health affects on humans and plants are discussed below:

Lead (Pb)

- **Humans/Mammals:** The upper limit of blood-lead level before it is considered to reach harmful proportions is 35µg Pb/100 ml of blood for adults and 30 µg Pb/100 ml in children and pregnant women (ATSDR, 1994). Lead can affect almost every organ and system in human body. The most sensitive is the central nervous system, particularly in children and can affect their IQ. It can also lead to anaemia and deposition of Pb in bones. Lead also damages kidneys and the reproductive system.

- **Plants:** Lead has a toxic effect on plant growth. Application initially results in enhanced growth, but from a concentration of 5 ppm onwards, this is counteracted by severe growth retardation, discoloration and morphological abnormalities (Anonymous, 1976). There is an adverse influence on photosynthesis, respiration and other metabolic processes.

Nickel (Ni)

- **Humans/Mammals:** Short-term overexposure to nickel is not known to cause any health problems, but long-term exposure can cause decreased body weight, heart and liver damage, and skin irritation. The LDLo (lethal dose low) of Nickel for rats is 12 mg/kg (Ullmann, 1991 as cited in CES, 2001), but its affect on other mammals needs to be studied. Nickel can accumulate in aquatic life, but its magnification in food chain is not confirmed.

Zinc (Zn)

- **Humans/Mammals:** The inhalation of zinc-oxide causes metal-fume fever with symptoms, like, fever, pain, fatigue, shivering, sweating, etc.

- **Plants:** Excessive use of zinc on plants causes necrosis, chlorosis and inhibited growth.

Chromium (Cr)

- **Humans/Mammals:** The WHO and BIS safe limit for Total Chromium is 0.05 mg/l in drinking water. Ingesting chromium beyond this concentration can cause stomach upsets and ulcers, convulsions, kidney and liver damage, and even death. Chromium (VI) and certain chromium compounds are classified as substances known to be carcinogenic for human and animals.

- **Plants:** The toxic effect of chromium on plants has mainly been described on the basis of batch tests. Studies on oats (*Avena sativa*) indicate that the roots remain small and the leaves narrow and exhibit reddish brown discoloration and small necrotic blotches (Source: CES, IISc, 2001).

Copper (Cu)

- **Humans/Mammals:** The lethal concentration of Copper for humans is 700-2100 mg/g of dry liver tissue (Sorbe, 1986 as cited in CES, 2001). Copper is highly toxic and very dangerous to infants and to people with certain metabolic disorders. Short term exposure can lead to gastrointestinal distress.

- **Plants:** Damage to roots, by attacking the cell membrane and destroying the normal membrane structure; inhibited root growth and formation of numerous short, brownish secondary roots. Aquatic plants absorb three times more Cu than plants on dry land (Source: CES, 2001).

Iron (Fe)

- The presence of high concentration of iron in drinking water may increase the hazard of pathogenic organisms, since most of these organisms need iron to grow.

water from various waste water channels and drains like Chandigarh choe, Patiala ki Rao, Lakhanpur drain and Mohali drain (Table 2.29). Pathogens were also found in all root vegetables like turnip, onion, potato, turmeric and radish.

Table 2.29 Analysis of results of vegetable samples (root and others) taken from agricultural fields irrigated with waste water of Drains/Choes

Heavy Metal	Value of parameter in root vegetable sample (mg/kg)	Value of parameter in other than root vegetable sample (mg/kg)	Permissible Limits in vegetables (mg/kg)
Arsenic	Not Detected	Not Detected	0.43
Cadmium	0-0.7	0.47-1.2	0.20
Copper	3.1-10.8	13.4-26.6	73.3
Nickel	0-41.8	1.4 -5.1	67.9
Lead	Not Detected	1.22 -5.7	0.30
Zinc	44.1-161.1	24.7 - 42.0	99.40
Chromium	0-40.5	4.7-11.7	2.30
Iron	86.5-427.4	95.1-197.3	425.5
Mercury	Not Detected	Not Detected	0.02

Source: Ram *et al.,* 2005

Resistance in pests and emergence of new pests

The pest situation has changed drastically with the onset of green revolution in Punjab. The changing status of insects and pests in agriculture in the state is given in Table 2.30. Large scale use of pesticides to control pests has also resulted in the development of pesticide resistance in various insects and pests.

Table 2.30 Changing status of insect pests in Punjab agriculture

Crop	Traditional agriculture	Modern agriculture
Cotton	Jassid, Pink bollworm	Whitefly, American bollworm
Rice	Stem borer, Hispa, Rice bug	Stem borer, Whitebacked plant hopper, Rice leaf-folder
Wheat	Termite, Ghujhia weevil	Aphids, Armyworm, Shoot fly, Pink stem borer
Sugarcane	Gurdaspur borer, Root borer, Shoot borer	Stalk borer, Pyrilla, Black bug

Source: Dhaliwal *et al.,* 2002

Vandana Shiva in 1989 had reported that DDT induced pest increase could be from thirty six fold to over twelve hundred fold (Shiva, 1989). The insect pests which were considered insignificant in Punjab before the green revolution became major pests later on, which could be due to destruction of natural enemies of pests. She also reported 40 new insect pests and 12 new diseases in rice monoculture

since the ushering of the green revolution in Punjab. The rice leaf folder (*Cnaphalocrocis medinalis*) was first recorded as minor infestation in 1964. However, later on it appeared in the all the rice growing areas of the state as a major pest and caused heavy losses in 1983.

Lately, American bollworm (*Helicoverpa armigera*) of cotton has developed resistance to all the major groups of conventional pesticides (Dhaliwal *et al.*, 2000). The insecticide resistance and insecticide induced resurgence of insects and pests is presented in Table 2.31.

Predators have proved useful in suppressing the population of insect pests in cotton, sugarcane and rice. Among the predators in the cotton ecosystem, *Chrysoperla carnea* (Stephens) has been commercially exploited for the management of cotton pests in combination with insecticides. However, the indiscrminate use of pestcides has also led to the destruction of non target flora & fauna thus

Table 2.31 Insecticide resistance and insecticide-induced resurgence of insect pests

Insect pests	Insecticide	Resistance factor	Reference
A. Insecticide resistance			
Bermisia tabaci	Oxy-demeton methyl	High	Singh *et al.*, (1998)
	Dimethoate	High	
	Phosphamidon	High	
	Cypermethrin	High	
	Chlorpyrifos	High	
	Monocrotopohos	Moderate	
	Quinalphos	Moderate	
	Deltamethrin	Moderate	
Helicoverpa armigera	Cypermethrin	High	Mehrotra and Phokela (1992); Kapoor *et al.*, (2000)
	Chlorpyrifos	Low	Kapoor *et al.*, (2000)
Plutella xylostella	All groups of insecticides	High	Chalwa and Kalra (1976) Joia and Udeaan (1998)
B. Insecticide-induced resurgence			
Bemisia tabaci	Cypermethrin	High	Dhawan *et al.*, (2000)
	Fenvalerate		
	Deltamethrin		
	Acephate		
	Monocrotophos		
	Chlopyriphos		
Amrasca biguttula	Quinalphos	High	Dhawan *et al.*, (2000)

Source: As reported by Dhaliwal *et al.*, 2002

Box 2.14 Health affects and environment pollution from dairy farming

Dairy cattle constitute more 90% of total livestock population in Punjab. A study was conducted jointly by Punjab University, Chandigarh and International Institute of Sustainable Development, Canada in Ropar and Patiala districts in 2004 to examine the relationship between livestock (particularly dairy production in rural and urban areas) and its differential impacts on the environment. Dairy farming has been found to have far reaching impacts on ecosystem services as per results of the study.

Impacts on human health: Dairy farming negatively impacts the health of dairy farmers, family members, farm workers and people living in the neighborhood due to breeding of houseflies, mosquitoes and other harmful insects in and around animal sheds. Disposal of cow dung and other waste in the open or along water bodies or pits adjacent to animal sheds result in spreading of gastrointestinal and other diseases like cholera, malaria, dengue, etc.

Excessive use of medication: Commercial dairy farmers often use injections, antibiotics and other medicines excessively without realizing their negative impacts on the health of animals, human beings and others in the ecosystem. The indiscriminate use of Oxytocin injection by dairy farmers, which is used as a muscle relaxant for stimulating lactation, has emerged as the central concern of environmentalists and policy makers. Residuals of the injection accumulate in the bodies of milking cows and increase the chances of abortion. Chemicals from the injections enter the milk of the animals and adversely affect human health, including early puberty in girls, hormonal disturbance and induction of female characters in boys, increasing the likelihood of abortion among women, etc. In addition, the excessive use of Diclofenac in animals has resulted in accumulation of residues of the drug in the carcasses of dead animals, which according to scientists, resulted in the decline of the vultures population.

Adulterated feed: It has been reported that the readymade feed purchased from the market is adulterated with limestone, urea and salt mixed with cardboard, straw, crushed stone, etc. More than 50% of the feed samples tested by the Punjab Dairy Development Department found limestone powder and urea above permissible levels. Excessive use of these components causes fat dissolution in cattle, which results in increased milk yield for a short while and makes farmers believe that the feed is very effective. But in the long run, animals are often rendered infertile and there is a decrease in the lactation period apart from reducing the life span. Reports suggest that milk coming from commercial dairies contains residues of urea, pesticides, sodium bicarbonate, formalin, ammonia, hydrogen peroxide, starch, water and salts, fertilizers, and non edible cream.

Improper disposal of chemicals and medicines: Research indicates that used pesticides, medicines, and injection containers are disposed indiscriminately and in some cases, are used for domestic purposes for storage of food, which can lead to a number of health problems.

Water pollution: The regular flow of animal waste and chemical residues causes contamination of village ponds and deteriorates the ground water quality.

Animal health and hygiene: Barring a few farmhouses, usually animal sheds are very congested and extremely unsanitary. This results in the spread of infectious diseases, suffocation and a build-up of animal odour and moisture that results in irritation of lungs, pneumonia and, in some cases, death of animals.

Excessive use of chemicals: Commercial dairy farmers rely upon fodder grown on their own land and often use chemicals fertilizers and pesticides to increase green fodder production. Most farmers agree that the consumption of fertilizers per acre has increased over time to get higher yield. During the study, more than half the respondents opined that chemicals (fertilizers and pesticides) affect the quality of milk, besides affecting health of the cattle and the workers. It was reported that animals, particularly buffaloes, fed on sprayed fodder suffer fevers, delayed conception, miscarriage and abortions. Excessive use of chemical ertilizers, pesticides, excessive cutting of wild grass, etc. also causes soil degradation.

The study strongly recommends that livestock policy and dairy farming policy in particular, must address environmental issues for making dairy farming a sustainable and viable alternative to crop husbandry in the state. The study also recommends that training programmes should be conducted to educate dairy farmers about the environmental dimensions of dairy farming.

Source: Ghuman *et al.,* 2005

Unhygenic dairy farming practices adversely affecting cattle health and environment

adversely affecting biodiversity and ecosystem stability. The population of natural predators in cotton agro ecosystem has declined by 68.4% during the last two decades (Table 2.32) Commercial availability, coupled with extensive use of insecticides has limited the utilization of predators for cotton pest management.

Table 2.32 Changes in population of different predators in cotton agro ecosystem under Punjab conditions in different years

Parasitoids	Population/ 5 plants (mean ± S.D)		
	1975	1985	1995
Predatory bugs	1.07 ± 0.68	0.81 ± 0.74 (24.29)	0.22 ± 0.42 (79.43)
Chrysoperla sp.	1.19 ± 1.08	0.96 ± 0.98 (19.32)	0.56 ± 0.64 (52.94)
Coccinellids	1.04 ± 0.96	0.81 ± 0.74 (22.11)	0.33 ± 0.48 (68.26)
Spiders	1.78 ± 1.58	1.41 ± 0.89 (20.78)	0.52 ± 0.58 (70.78)
Misc.	0.41 ± 0.64	0.37 ± 0.56 (9.75)	0.26 ± 0.53 (36.58)
Total	**5.46 ± 2.80**	**4.41 ± 1.93 (19.23)**	**1.07 ± 1.03 (68.36)**

Figs. in parenthesis are reduction in population over base year 1975 *Source*: Dhawan, 1999

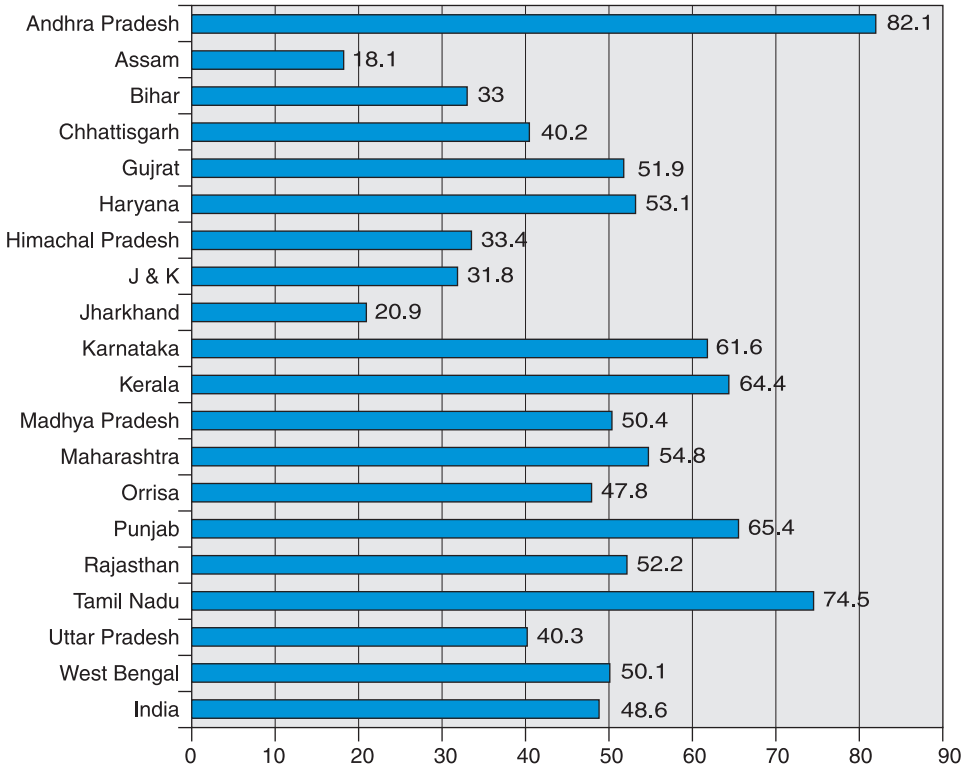
Farmers debt and suicides

A majority of Punjab farmers are "*born in debt, live in debt and die in debt*" wrote Sir Malcolm Darling in his most influential book "*Punjab Peasantry in Prosperity and Debt*" (Darling,1928). The findings are as true today as they were a century ago. Agriculture in the state has witnessed slowdown in its growth. The most significant fact is the decline in per capita income in agriculture sector from Rs. 12,375 in 2001 to 11,587 in 2004 (Kalkat *et al*., PSFC, 2006). Because of declining

trend in farmers income in the state, a large number of marginal and small farmers have been pushed into the vicious cycle of debt. The small farmers have been borrowing mostly from non institutional sources to fulfill their social obligations and bridge the gap between income and expenditure. As per March 2006 estimates of PSFC, the Punjab farmers are heavily indebted to the tune of more than 50% of the Net State Domestic Product (NSDP) from agriculture. The total indebtedness is around Rs. 24000 crores (50% each to Institutional and Non Institutional sources).

As per results of a recent survey conducted on "Indebtedness of Farmer Households" by National Sample Survey Organization (NSSO) starting in 2003 every farmer household in India, on an average, owes Rs. 12,585, with Punjab farmers topping the list having an average indebtedness of Rs. 41,576. The survey revealed that out of the 89.35 million rural households engaged in farming in India, nearly 43.42 million or 48.6% are in debt. The survey defines indebtedness as having a liability in cash or kind with a value more than Rs 300 at the time of transaction. The degree of indebtedness is fairly high in the relatively better off states of Punjab and Tamil Nadu. The state of Andhra Pradesh tops the list with 82% of all farmer households in debt, followed by Tamil Nadu with 74.5% and Punjab with 65.4% (Fig 2.28). As per survey, every 38 out of 100 Punjab farmers are ready to quit farming

Fig. 2.28 State wise percentage of farmers indebted in India



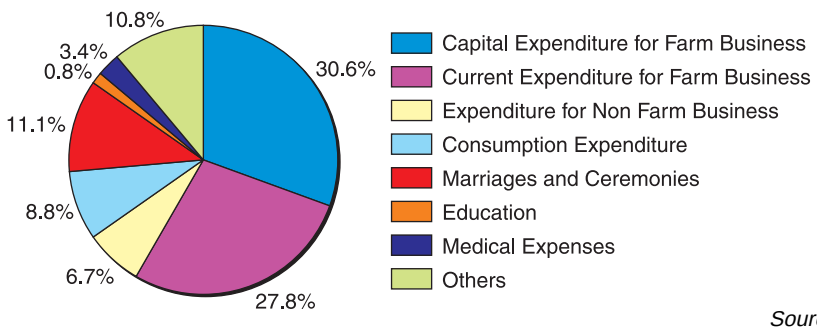
Source: NSSO, 2005

immediately, given a chance of alternative employment. At the bottom end of the scale is Meghalaya where only 4% of farmer households are in debt, while in Arunachal Pradesh the figure is 6%. Uttaranchal has 7% indebtedness.

The survey report further indicates that the average outstanding loan per farmer household is the highest in Punjab (Rs 41,576), followed by Kerala (Rs 33,907), Haryana (Rs 26,007), Andhra Pradesh (Rs 23,965) and Tamil Nadu (Rs 23,963). Another notable feature in case of Punjab is that farmer households belonging to Scheduled Tribes (ST) were highly over burdened with outstanding loans amounting to Rs. 1,18,495 (only state in the country with loans > Rs 0.1 million for ST farmers). This was followed by general category farmers (Rs. 66,147), OBCs (Rs. 21,862) and Scheduled Caste households (Rs. 10,399).

The report has also highlighted the fact that more than half of indebted farmer households took loans for capital or current expenditure on farm businesses. At the all-India level, out of every 1000 rupees taken as loan, 584 rupees had been borrowed for these two purposes taken together. Marriages and ceremonies are the next major cause of indebtedness, accounting for about 11% of outstanding loans. The all India farmers debt by purpose of loan is given in Fig 2.29.

Fig. 2.29 All India farmers debt by purpose of loan



Source: NSSO, 2005

Loans for farming included borrowing for capital investment purposes like tractors, tubwells, farm chemical inputs, seeds and also other social needs. The prices of agricultural inputs such as seeds, fertilizers, pesticides, diesel and labour, etc. are soaring on one hand and farm yield and income are declining on the other, on account of low MSP of food grains, receding water table, soil erosion, etc. The rise in prices of important agricultural inputs in the state in last four years is presented in Table 2.33. The cost of cultivation of rice has increased by 5% (44% to 49%)

Table 2.33 Rise in prices of important agricultural inputs in Punjab

As on 31st march, 2006

Source: Deptt of Agriculture, Punjab

during 2000-01 to 2005-06 period as compared to 1995-96 to 2000-01 period (Table 2.34), while for wheat the cost of cultivation has increased by 8% (58% to 66%) during the crossponding intervals. Thus, the gross income of farmers has reduced by 33% for rice resulting in 70% decline in gross margins. Further, for wheat gross income has declined exactly by 100% during 1995-2001 to 2001- 2006, resulting in 101% decline in gross margin.

Table 2.34 Percentage increase in cost and income for rice and wheat in Punjab

Rice

Source: PSFC (Kalkat *et al.*), 2006

Further, the depletion of underground water table has forced farmers to borrow more as they need to deepen tubwells every fifth year. Moreover, the traditional centrifugal water lifting technology is becoming redundant and being replaced by the costlier submersible technology in the state. As per information provided by PSFC, the number of tubwells with submersible pumps in 2005 has gone upto 0.3 million in the state (a submersible pump installation costs more than Rs 80,000 as compared to expenditure of Rs. 30,000 incurred on installation of a centrifugal pump). It has been estimated that by 2010, a whopping amount of Rs. 40 billion would be spent by farmers on replacing centrifugal pumps with submersible pumps in state if ground water table does not improve. Thus farmers are compelled to borrow, while their repaying capacity is suffering and debt burden is accumulating.

The initial success of green revolution and raising of per capita income of farmers has also affected the socio-economic fabric of the state. It has led to high expenditure life styles, dependence on external farm labour and little esteem for farming as a profession, especially amongst the youth. Now, with decrease in farm income and crushed by heavy load of debt, helpless farmers are committing suicides to escape from the vicious circle of indebtedness. This has now become a countrywide phenomenon. The cases of suicides by farmers have been reported from several states including Andhra Pradesh, Maharastra (especially Vidharba), Punjab, Karnataka, Rajasthan, Orissa and Tripura. This phenomenon is a unique product of psycho-socio-economic conditions prevailing in the countryside though the internal factors(individual of family specific) have their own role in instigating the process.

As per report on "Suicides in rural Punjab, 2006" (Kumar *et al.*, 2006) prepared by PSFC and Institute for Development and Communication (IDC), the general suicide rate in Punjab was 0.57% in 1988 and rose to 0.95 % in 1993 and to 2.04% in 2001. It came down to 1.38 % in 2005. Further, the report analyses suicides among cultivators and non cultivators in the state since 1988 (Table 2.35).

Data reveal that the rate of suicides by cultivator farmers was higher than the non cultivator farmers between 1988 and 1997. There was a sharp increase in cultivator farmers suicides between 1995-1997. However, rate of suicides by cultivators declined sharply from 1997 onwards upto 2005 and suicide rate by non cultivators was higher than the cultivator farmers during all the years between 1998-2005. The average suicide rate of cultivators was 3.17 and 0.48 between 1991-1997 and 1998-

2005, respectively. The percentage share of cultivator farmers suicides to the total number of suicides between 1996-2005 is only 3.5% against the general perception that the suicide rate is on the increase among the cultivators.. The data further highlighted that Sangrur and Bathinda districts during 1991-1997 and Fatehgarh Sahib, Mansa, Faridkot and Bathinda districts during 1998-2005, were highly prone to cultivator's suicides. The report also highlights that the actual figures could be much higher because some of the suicide cases might have not been registered/recorded.

Table 2.35 Number of suicides and suicide rate for cultivators, non cultivators and total population of Punjab (1996-2005)

	1988	1991	1994	1997	2000	2001	2002	2003	2004	2005
Cultivator Farmers										
No. of Suicides	32.00	24.00	57.00	84.00	12.00	12.00	5.00	10.00	13.00	3.00
Suicide rate	1.81	1.28	3.05	4.49	0.63	0.63	0.24	0.48	0.63	1.15
Non-Cultivators										
No. of Suicides	63.00	104.00	163.00	334.00	397.00	401.00	371.00	350.00	446.00	333.00
Suicide rate	0.42	0.57	0.89	1.82	2.16	2.18	1.66	1.57	2.00	1.49
Total Population										
No. of Suicides	95.00	128.00	220.00	418.00	409.00	413.00	376.00	360.00	459.00	336.00
Suicide rate	0.57	0.76	1.08	2.06	2.02	2.04	1.54	1.48	1.88	1.38

As per Punjab Police statistics for various years
Suicide Rate: Suicides per lakh of population of the respective categories

Source: Kumar *et al.*, 2006

As per results of a field survey conducted by IDC , a majority of farmers including suicide vitctim's households reported that either the yield of the three important crops (wheat, paddy and cotton) have remained stagnant or have been declining. The perception of households on the crop yield of three crops during 2001-2006 is presented in Table 2.36. Among the suicide viticms, majority of the respondents reported that all yields of all three crops had declined during last five years. The general households also reported that the yield of major crops remainded stagnant or declined during last five years. The declining or stagnant yield level of principal crops is of major concern to the farming community.

Table 2.36 Perception of households on the crop yield of principal crops during 2001-2006

	Wheat			Paddy			Cotton		
Category	**Growing**	**Declining**	**Stagnant**	**Growing**	**Declining**	**Stagnant**	**Growing**	**Declining**	**Stagnant**
General Household	11.33	29.83	33.33	10.17	19.17	26.33	7.17	18.17	13.50
Suicide victims household	1.50	51.00	5.00	1.50	27.00	30.00	0.50	50.00	2.50

Source: IDC, 2006

The report states that indebtedness is a condition produced by the prevailing state of agricultural distress. Though indebtedness, family disputes, alcohol abuse, drug abuse, mental tension and stress were stated to be suspected causes of suicide, on a deeper probe it was discovered that indebtedness played a role together with crop failure, poverty and family disputes to induce suicide among the victims (Kumar *et al.,* 2006).

RESPONSES

Legal and Policy response

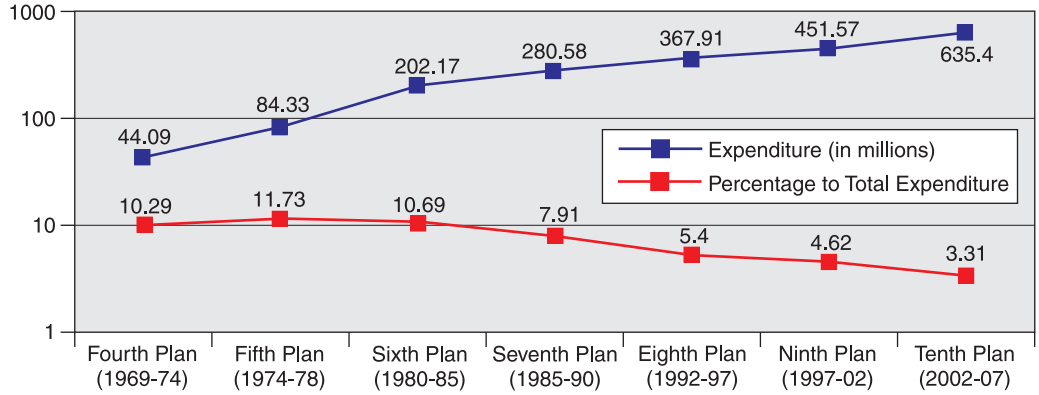
As discussed earlier, many National and State level policies, Acts and laws (which focus not only on the various methods of agricultural production, farm inputs and their trade and marketing related aspects but also directly or indirectly govern the use of various natural resources especially water and land in agricultural activities) are implemented in the state. A list is provided at the beginning of the chapter. The state is following the National Agriculture Policy, 2000, for agricultural development. The new policy focuses on:

- Over the next two decades, it aims to attain:
  - A growth rate in excess of 4 percent per annum in the agriculture sector;
  - Growth that is based on efficient use of resources and conserves our soil, water and bio-diversity;
  - Growth with equity, i.e., growth which is widespread across regions and farmers;
  - Growth that is demand driven and caters to domestic markets and maximises benefits from exports of agricultural products in the face of the challenges arising from economic liberalization and globalisation;
  - Growth that is sustainable technologically, environmentally and economically.
- The policy seeks to promote technically sound, economically viable, environmentally non degrading, and socially acceptable use of country's natural resources-land, water and genetic endowment, to promote sustainable development of agriculture.
- The use of bio-technology will be promoted for evolving plants which consume less water, are drought resistant, pest resistant, contain more nutrition, give higher yields and are environmentally safe. Conservation of bio-resources through their ex-situ preservation in Gene Banks, as also in-situ conservation in their natural habitats through bio-diversity parks, etc., will receive a high priority to prevent depletion of bio-diversity.
- Balanced and conjunctive use of bio-mass, organic and inorganic fertilizers and controlled use of agro chemicals through integrated nutrients and pest management (INM and IPM) will be promoted.
- The regionalization of agricultural research based on identified agro-climatic zones will be accorded high priority. Application of frontier sciences like bio-technology, remote sensing technologies, pre and post-harvest technologies, energy saving technologies, technology for environmental protection through national research system as well as proprietary research will be encouraged.
- The research and extension linkages will be strengthened to improve quality and effectiveness of research and extension system.

Administrative responses

Agriculture being the back bone of Punjab's economy, the State Government has been focusing on this sector, as well as sectors affecting agriculture (like irrigation & flood control and energy) in all its plans. The total funds allocated to these sectors have increased over the years although the percentage plan expenditure has slightly decreased (Figs. 2.30, 2.31 and 2.32). These include several new schemes, which focus on natural resource conservation like Zero tillage, biofertilizers, biopesticides, integrated pest management and diversification of agriculture.

Fig. 2.30 Expenditures in the agriculture and allied services sector of Punjab in various plan periods (1969-2007)



*2002-2007: Provisional

Source: Computed from Statistical Abstract of Punjab, 2005

Fig. 2.31 Expenditures in the irrigation and flood control sector of Punjab in various plan periods (1985-2007)

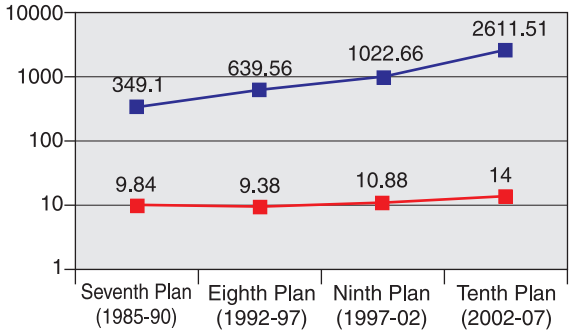
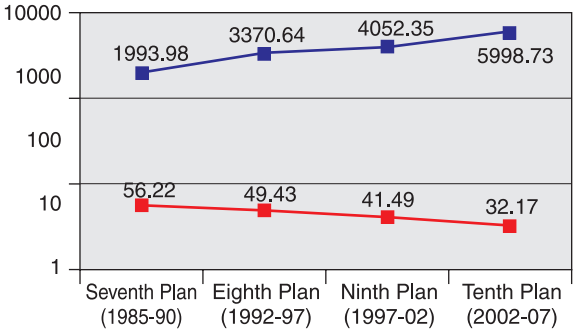


Fig. 2.32 Expenditures in the energy sector of Punjab in various plan periods (1985-2007)



Expenditure (in millions) Percentage to Total Expenditure

*2002-2007: Provisional

Source: Computed from Statistical Abstract of Punjab, 2005

The agriculture department is one of the major department of the state government. It is directly under the administrative control of Financial Commissioner (Development) with Director Agriculture as the technical head. He is assisted by 11 Joint Directors, 46 Deputy Directors/Chief Agriculture Officers and has a sanctioned staff strength of about 1500 personnel, out of which the actual staff strength is approximately 50%. The department has officers in each district headed by Chief Agriculture Officers. At district level, all the programmes are implemented under the supervision of Chief Agriculture Officer with the assistance of Agriculture Development Officers (ADO).

The activities of the department are complemented with Boards and Corporations like Punjab Agro Industrial Corporation, Punjab Agro Food Corporation, Punjab State Seeds Corporation, MARKFED, PUNSUP, PUNSEED and Punjab Land Development Board. Programmes of the other Departments of State Government like Irrigation and Power, Livestock and Fisheries, Soil and Water Conservation also complement the activities of Department of Agriculture.

In recognition of the importance of agriculture in the state, the state government set up the Punjab Agricultural University in 1962 at Ludhiana. The university has played a pivotal role in promoting green revolution and also conducted excellent, pioneering and internationally acclaimed research along with providing extension education. The university has 15 Krishi Vigyan Kendras (KVKs) in various districts of state. The University covers an area of 1510 acres on its main campus and 4615 acres at the regional research stations. The Punjab Agricultural University has 4 constituent colleges (College of Agriculture, College of Agricultural Engineering, College of Home Science and College of Basic Sciences and Humanities) and 28 different departments under these constituent colleges.

In addition, recently the state government initiated new programs to promote sustainable agriculture and has set up the following institutions in recognition of addition infrastructural needs:

Punjab State Farmers Commission (PSFC)

The Government of Punjab constituted PSFC in July, 2005 to examine and review the status of agriculture and allied sectors in the state and suggest measures for economically viable and ecologically sustainable agricultural development. The commission has currently undertaken the task of bringing down the area under rice cultivation by implementing crop diversification and promoting cultivation of moong, soyabean, hybrid maize and banana. This includes arrangement for growing soyabean and hybrid maize on 404.8 ha and 0.101 million ha, respectively during kharif 2006. Banana plantation has also been taken up on 20.2 ha during 2006. The commission is also undertaking studies on various social and economic issues related to agriculture and farmers in state. It has already prepared an indepth report on farmers indebtedness and phenomenon of suicides by the farmers in the state. Further, to regulate the transplantation of paddy in the state to ensure judicious and rational use of water (to check the rapidly declining water table), PSFC had also prepared a draft of the Punjab Preservation of Sub Soil Water Bill, 2006. As per the bill, no farmer should be allowed to sow nursery of paddy before 10th May and transplant paddy in the state before June 10th, dates fixed by the Department of Agriculture in consultation with the Punjab Agricultural University, Ludhiana. The technology of low cost net house cultivation of pesticide free vegetables has been successfully demonstrated by the commission. Upto December, 2006 more than 50 such net houses have been

Promotion of pesticide free cultivation of vegetables in net houses

established in the state. The cultivation of vegetables through this method gives about 50% more income to the farmers. The technology will be introduced on a bigger scale in the next 2/3 years. The produce will be purchased through collection centres under the scheme of a terminal market to be set up at Chandigarh and also through a net work or rural hubs being set up in the state.

Agriculture Councils

Conscious of the fact that the wheat and paddy monoculture is having a harmful effect on the ecology and economy of the state, the government had been focusing on diversification towards alternate remunerative and less water intensive crops since the last few years. As a part of its diversification programme in agriculture, the Punjab Government has set up four Special Purpose Vehicles (SPVs) to promote citrus and fruit juices, value- added horticulture, viticulture and organic farming. These are:

- Council for Citrus and Agri. Juicing
- Council for Value added Horticulture
- Organic Farming Council of Punjab
- Viticulture Council of Punjab

These councils were set up in January 2006 under Financial Commissioner (Development). The main objective of the councils is to focus on shifting Punjab from primary agricultural and low value produce to high value processed products. The Government's aims is that one-third of the State's farm sector should diversify to citrus and high value horticulture, viticulture and organic farming in the next ten years.

State Medicinal Plants Board

Punjab State Medicinal Plants Board (SMPB) was set up in Chandigarh in the year 2005 under a resolution of Union Ministry of Health and Family Welfare, Government of India, for co-ordination of all matters relating to medicinal plants including drawing up policies and strategies for conservation, proper harvesting, cost-effective cultivation, research and development, processing and marketing of raw materials in order to protect, sustain and develop this sector. SMPB is creating awareness for the promotion of cultivation of medicinal plants in Punjab. SMPB has recommended cultivation of 32 medicinal plants in the state.

Punjab Biodiversity Board (PBB)

Punjab Biodiversity Board was notified in the state in December, 2004 under section 22 of the Biological Diversity Act, 2002, to conserve biodiversity, including agricultural biodiversity, to ensure sustainable use of its components and fair and equitable sharing of the benefits arising out of the use of the biological resources. Under the Act, no corporate body or association can commercially utilize the state's biodiversity (except species notified as normally traded commodities) without approval of State Biodiversity Board. Further, no foreigner without the approval of the National Biodiversity Authority (NBA), can obtain any biological sample or knowledge associated for research or for commercial utilisation or for bio-survey and bio-utilisation. These include wild relatives of crop species also. The board has already notified committees to identify biological heritage sites outside Protected Area Network (PAN) and for identifying commercially important flora and fauna in the state. The board proposes to promote in-situ and ex-situ conservation of traditional agricultural varieties and domesticated faunal biodiversity besides undertaking economic evaluation of medicinal plants in Punjab.

Veterinary and Animal Sciences University

The state government has recently set up Guru Angad Dev Veterinary and Animal Science University at Ludhiana to focus on veterinary education, research, development and extension activities.

Agricultural diversification, infrastructure, research and development fund

The Punjab Government has also set up Agricultural diversification, infrastructure, research and development fund (ADIRF) of Rs 10 million in the year 2005-06 to give boost to agriculture sector in state. The ADIRF would be used for the diversification of crops, improved post harvest technologies, value addition through processing, supply chain management, improving yields through genetic modifications and biotechnology.

Centre of agriculture excellence by Bharti Group

A model R&D Farm "Field Fresh Agri Centre of Excellence" has been set up in 2005 at Ladhowal, District Ludhiana jointly by Bharti Enterprises, Rothschild and Punjab Agricultural University with the initial investment outlay of $50 million on 300 acres of land to promote the development of agriculture in Punjab. The farm includes 42 acres of state-of-the-art protected cultivation including, poly-houses, glass and green houses, micro irrigation and net houses. The Centre also has an extensive area under nursery trials and 20 different fruit crops, under cropping cycle with 200 varieties, are being currently tried.

Field Fresh Agri Centre of Excellence is one of the largest integrated research and development facility of its kind in the country focusing on crop and varietal trials, progressive farming techniques, identification and adoption of appropriate technologies for round-the-year production of fruits and vegetables, besides creation of infrastructure for value addition through processing of fruits and vegetables. The centre will showcase advanced technologies and agricultural best practices and serve as the hub to impart knowledge and training to agricultural community of the state. The focus will be on early adoption of best practices across the fields to enhance agricultural productivity in an

environmentally sustainable manner. A pack house and cold storage facility will soon be ready at the Centre to maintain the quality of the fresh produce. The centre not only aims to provide best quality fresh produce to the world but is also working towards protecting the land under cultivation and improving the quality of lives of the workers and their communities.

Task force to tackle rice straw burning problem

The Department of Science, Technology & Environment and Non Conventional Sources of Energy, Government of Punjab has constituted a task force in September, 2006 for formulation of policy to mitigate the problem due to the severity of burning of agricultural waste in the open fields after harvesting and its consequent effects in soil, ambient air and health affects on living organism. The task force has suggested promotion of agronomic practices and technological measures for better utilization of agricultural waste. These include use of happy seeder, developed by PAU in collaboration with Australian Centre for International Agriculture Research (ACIAR) and use of paddy straw for power generation.

Setting up of Biotechnology Cluster

Department of Biotechnology (DBT), Government of India has decided to set up biotechnology cluster comprising National Agri-Food Biotechnology Institute, Bioprocessing Unit, Biotechnology Park and National Institute of Nanotechnology in the Knowledge City, Sector 81, Mohali.

1. **National Agri-Food Biotechnology institute (NABI):** The institute will focus on agriculture and agro-processing for value addition using biotechnological innovations. It will be an institute dedicated to translation and would increase the competitiveness of agri-food industrial sector through innovation and R&D support. The institute will also be involved in training world class human resource in food science and technology and nutritional science.
2. **Bio Processing Unit:** The Bioprocessing Unit is being set up by Department of Biotechnology, Governtment of India to serve as an incubator for start-up companies. It will facilitate the scale-up and process optimization of new technologies developed by NABI or acquired through licensing from other sources within India and abroad.
3. **Establishment of a Biotechnology Park in Punjab:** Department of Biotechnology, Government of India had decided to develop the Biotechnology Park in Punjab comprising innovation business centre, utilities, facilities and service centre to promote biotech industry in Punjab. DBT has appointed M/s Ernst and Young as consultants for feasibility study and preparation of business plan for development of the park in the state. Government of Punjab has agreed to provide land for the park in Knowledge City proposed to be set up in SAS Nagar, Mohali.
4. **Punjab Biotechnology Incubator:** Punjab Biotechnology Incubator comprising a testing and certification facility for agri produce and products has been set up. It is a joint project of DBT, Government of India and State Government. This facility has presently been made operational in hired premises in Mohali and will eventually be shifted to Bioprocessing Unit in Knowledge City in future.

5. **National Institute of Nanotechnology:** Department of Science and Technology (DST), Government of India has planned to set up National Institute of Nanotechnology in the Knowledge City at Mohali. The institute would be set up as a part of Indian Institute of Science Education and Research to be established by Ministry of Human Resource Development, Government of India. DST has submitted the proposal for the institute to the Planning Commission.

Technological response

The various technological responses for conservation of environment as affected by agricultural activities include:

Agriculture Diversification

Crop diversification refers to a shift from one particular cropping system to a varied and multicropping system to stabilize farm income (particularly on small farm holdings) and protect our natural resources. There is an urgent need in Punjab to diversify into new areas like vegetables and fruits, oil seeds, pulses and allied fields such as dairy farming, poultry, piggery, etc. As already discussed, the Government of Punjab had launched a multi crop multi year contract farming scheme to give boost to crop diversification in 2002. The programme is being implemented by Punjab Agro Foods Corporation (PAFC). So far more than 0.186 million ha acres is covered under crops other than wheat and paddy like hoyla, winter maize, sunflower, drum wheat, moong etc. involving 0.1 million farmers under this program (Source: Punjab Agro Foods Corporation, 2005).

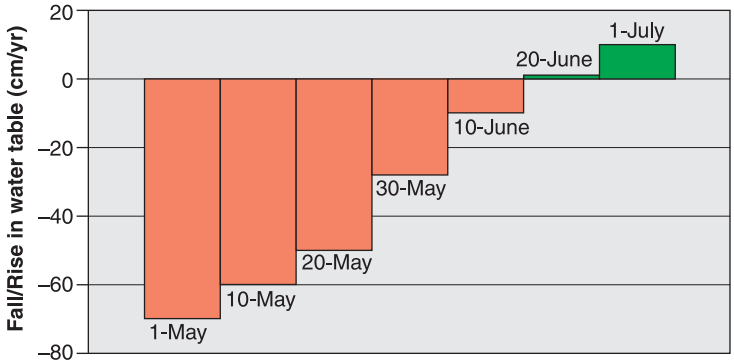
Conservation of water in agriculture

Various interventions include

- **Promoting timely transplantation of paddy:** This is one of the most effective strategy to control the falling water table in the state. In the recent past it has been observed that farmers have started early transplantation of paddy due to which the scarce canal water is required to be supplemented by withdrawals of ground water to meet the additional irrigation demands. Experiments conducted by Punjab Agricultural University indicated that if paddy is planted by 10th May, the ground water level recedes by 60 cms every year and if it is planted by 10th June the depletion is not more than 10 cms (as monsoons usually arrive by this time). Further, the chances of depletion of ground water further recede if the paddy is planted by June 20 as shown in Fig. 2.33. The Evapo-transpiration requirement of paddy declines with the delay in the date of transplanting. Thus PAU has advised the farmers to defer transplanting of paddy till June 15 from kharif 2006. This technology is widely promoted by PAU, Department of Agriculture, Krishi Vigyan Kendras (KVKs) and the Farmers Advisory Service Scheme (FASS) by organizing various extension activities. Farmers have also been educated during Kisan Melas, in addition to special radio and TV Talks. This also saves farmers from inconvenience during procurement as early sowing leads to early arrivals of paddy in the market, whereas government procurement start only in the first week of October.

- **Promotion of Zero Tillage:** The department of Agriculture, Government of Punjab is promoting "Zero Tillage Technique" since 2001-02, in areas of state where wheat is sown after harvesting

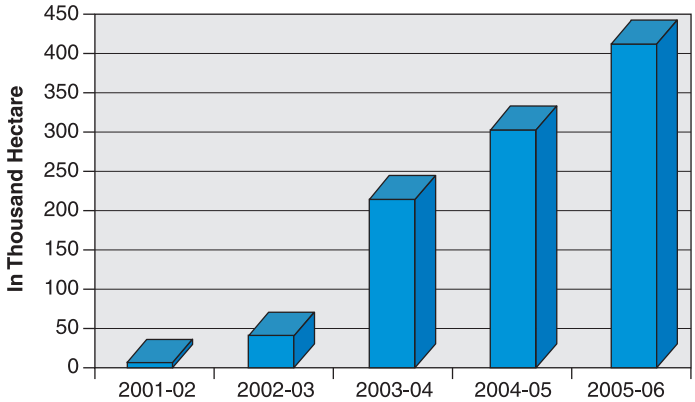
Fig. 2.33 Fall/Rise of water table with date of transplantation of paddy



Source: Deptt. of Soil Science, PAU, 2006

of rice. Zero till system refers to planting crops with minimum of soil disturbance. The wheat seeds are placed directly into narrow slits of 3-4 cm width and 4-7 cm depth made with drill fitted with chisel, "inverted T" or double disc openers without land preparation. The other novel approach with much promise is the use of "Happy Seeder", which combines stubble mulching and seed drilling functions into one machine. The emphasis is on conserving moisture and residue management. Apart from benefits like proper mulching of paddy residue instead of burning, timely sowing, reducing run off and soil erosion, lesser deep percolation and improving soil health by incorporating plant nutrients, the zero tillage increases farmer's profit by Rs. 2200-3000/- per ha by saving 80% of diesel as wheat is sown in one pass only. Moreover in zero till planted wheat, about 1000 m^3 per ha of irrigation water is saved due to planting in residual moisture from the previous rice crop and application of a light first irrigation. About 30-50% of water is saved in first irrigation. The area under zero tillage in Punjab has increased from 6.83 th ha in 2001-02 to 412.692 th ha in 2005-06 (Fig. 2.34). As per information provided by Punjab Agricultural University, zero tillage sowing of wheat on 412 th ha in state during rabi

Fig. 2.34 Area under zero tillage in Punjab



Source: Deptt. of Agriculture, 2006

2005-06 has reduced the consumption of diesel by 20.6-24.7 million liters and also reduced the emission of CO_2 to the tune of 53.6-64.2 million kg in the environment on the basis of conversion factor of 2.6 kg of CO_2 per litre of diesel burnt.

- **Adoption of ridge planting method of paddy:** A novel resource conservation technology of planting paddy on ridges is becoming popular amongst the farmers in the state especially in villages on the outskirts of Ludhiana. This method of cultivating rice saves 40% water as no puddling is required. The innovation has been developed by JDM Research Foundation and recognized by Agriculture Technocrats Action Committee of Punjab (AGTC). The paddy seedlings are transplanted on to ridges spaced 24 inches apart with furrows that are filled with water. While the crop is irrigated daily for the first week after transplantation, subsequent irrigation is done at weekly intervals with special attention during tillering and grain setting stages. Since less water is used than the flooded rice fields, about 30% less fertilizer is applied in the ridge-furrow system of paddy cultivation. In June 2006, Markfed announced contract farming of 20,000 hectares of basmati in 12 districts of Punjab through ridge planting method. Recently, PAU has also recommended growing paddy on ridges mainly on heavy soils.
- **Artificial recharge of ground water:** The Central Ground Water Board (CGWB) (North zone) has undertaken various schemes jointly with state departments like Irrigation, Soil Conservation and Agricullture, etc for artificial recharge of aquifers to arrest the falling water table in the state (Box 2.15). The board has also been carrying out exploratory drilling for identification of aquifer systems, demarcation of potential aquifer zones and evaluation of aquifer characteristics, etc. The Board has drilled 142 exploratory wells, 154 observation wells, 22 slim holes and 75 piezometers in various parts of Punjab, till March 2004.
- **Promotion of micro irrigation techniques:** Modern irrigation methods like drip and sprinkler have been recognized as the most efficient methods of irrigation, which save water and at the same time enhance the quality and quantity of farm produce, particularly fruits and vegetables. A centrally sponsored scheme on micro irrigation was started in the state in the year 1992-93 with a focus on horticulture crops under the National Horticulture Mission. The scheme is being promoted and implemented by Department of Soil and Water Conservation, Government of Punjab. Under the scheme an assistance in the form of subsidy of 50% of

Zero tillage technology

Ridge planting of paddy

Box 2.15 Artificial recharge of aquifers in Punjab

Sr. No.	Scheme Details
1.	Artificial Recharge to Ground Water in district Jalandhar and district Kapurthala (1998-99) – in two areas i.e. Channian, Jalandhar District and Kalasinghia, Kapurthala district.
2.	Scheme for Artificial Recharge to Ground Water in Golden Temple, Amritsar, Punjab (1998-99).
3.	Pilot scheme for roof top rainfall harvesting to recharge the ground water in Amritsar town (khati Bhawan), Amritsar (1998-99).
4.	Artificial Recharge to Ground Water from Dhuri Link drain in Sangrur District, Punjab (1999-2000).
5.	Artificial Recharge to Ground Water from Dhuri drain in Sangrur District, Punjab (1999-2000).
6.	Pilot project for Artificial Recharge from Choe No.1 of Bhakra Main line canal, near village Dhanetha, Samana block, Distt. Patiala, Punjab (1999-2000).
7.	Pilot Project for Artificial Recharge to Ground Water from village pond in village Issru in Khanna Block, Distt. Ludhiana, Punjab (1999-2000).
8.	Pilot Project for Artificial Recharge to Ground Water from BIST-Doab canal system in Nurmahal area, Distt. Jalandhar (1999-2000).
10.	Pilot study for artificial recharge scheme to ground water from Sirhind Choe, Patiala district (2000-2001).
11.	Pilot study for artificial recharge to ground water from Bassian Drain, Moga (2000-2001).
12.	Pilot study for artificial recharge to ground water by utilizing surplus water of existing water harvesting structures (low dams), village Chotti Bari Naggal, Majri Block, Tehsil Kharar, District Ropar (2000-2001).
13.	Artificial recharge to ground water from existing and new rainwater harvesting structures, village Parol Naggal, Block Majra, Block Majri, tehsil Kharar, district Ropar (2000-2001).
14.	Scheme for artificial recharge to ground water by harvesting rainfall in low dam, village Majra, block Majri, tehsil Kharar, district Ropar (2000-2001).
15.	Scheme for artificial recharge to ground water by harvesting rainwater in low dam , village Bardar, Tehsil and district Ropar (2001-2002).
16.	Scheme for artificial recharge to ground water by harvesting rainwater in low dam, village Siswan, Block Majri, Tehsil Kharar, District Ropar (2001-2002).
17.	Pilot study for artificial recharge to ground water from Patiala Nadi, district Patiala (2001-2002).
18.	Scheme for artificial recharge to ground water from Khanna distributory in Bhattian Canal colony, Block Khanna, district Ludhiana (2001-2002).
19.	Pilot study for artificial recharge to ground water from Miranpur choe, district Patiala (2001-2002).

Source: CGWB, 2006 (www.cgwbchd.nic.in)

cost of drip and sprinkler system is provided to the farmers. (Out of which 40% assistance is being borne by the Central Government and 10% by the State Government). The scheme is applicable to small farmers having land less than 5 hectares and growing mainly horticultural crops including vegetables, medicinal and aromatic plants. A total area of 4500 ha (3800 ha under drip and 700 ha under sprinkler) has already been covered under the micro irrigation techniques in Punjab (upto March, 2006). The districtwise and cropwise wise area covered under micro irrigation is given in Table 2.37. As per the department, micro irrigation increases the productivity by 30-100% with 50% to 70% saving of water in various crops.

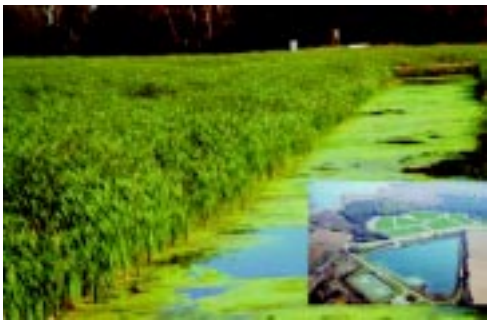
- **Revival of village ponds through duckweed and constructed wetland technologies:** The duckweed based rural waste water treatment system in conjunction with pisciculture and constructed wetland technology are being promoted and implemented by PSCST in the state for the restoration of clean village ponds. Duckweed is a small free floating aquatic plant often seen growing in thick mats on waters of natural ponds. Besides offering effective waste water treatment, the duckweed technology has the potential

Table 2.37 Area covered under drip/ sprinkler irrigation in Punjab

(Districtwise and cropwise as on March 2006)

Source: Deptt. of Soil and Water Conservation, Govt. of Punjab, 2007

Duckweed Technology



Constructed wetland technology

of providing economic returns by providing employment opportunities in rural areas. The technology has been promoted by PSCST in 19 villages of Punjab (Table 2.38).

Table 2.38 Locations adopted under duckweed technology in various districts of Punjab

Source: PSCST

A constructed wetland project has also been taken up by PSCST in collaboration with M/s CH2M Hill, Canada to promote an alternative low cost technology for sustainable water treatment using reed beds as plant biofilters. *Typha* and *Phragmites* are commonly used species. The project has been demonstrated in villages Peepal Majra (District Ropar) and Shekhupur (District Patiala), which were facing the problems of degrading water quality due to influx of sullage and storm water in village ponds.

- **Watershed management:** The following watershed development projects are being implemented in the state for providing irrigation facilities to farmers, checking erosion and improving vegetation cover:

1. An integrated watershed project was initiated by Central Soil and Water Conservation Research and Training Institute, Chandigarh at village Rel Majra of Tehsil Balachur, District Nawanshahar. The watershed area spread over 627 ha drains into river Sutlej through six seasonal streams/choes (seasonal streams). The entire region was facing degradation due to over exploitation of hill vegetation by humans and animals, leading to denudation of forests and expanding net work of choes which were continually getting deeper and wider with large scale movement of silt along with runoff causing water erosion. This project helped the collection and sustainable use of rainwater by construction of a check dam. A 13.5 m high homogenous earthfill dam was constructed in 1992 to store 13.7 ha m runoff of water from this area. An underground pipeline 2.9 km long, was laid for providing water with gravity flow for irrigation and other purposes. Since the implementation of the project there has been a constant rise in cultivated area during the kharif and rabi crops. Area under rabi crops (mainly wheat) has increased from 1.54 ha to 22.07 ha during 1992 to 1999 and area under kharif crops (mainly sorghum, bajra and maize) from 3.55 ha to 24.70 ha during the same interval. Availability of more fodder from the cropped and the catchment areas, has led to increase in number of bullocks and milch cattle also (Samra *et al.*, 2002).

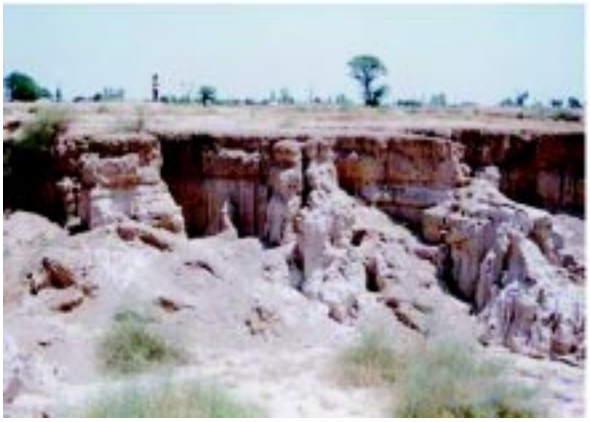
2. Another watershed project has been implemented in foothills of Shivaliks at village Sahoran in Dasuya block of Hoshiarpur District by Department of Soil and Water Conservation under National Watershed Development Project for Rainfed Areas for Integrated Development. The total geographical area of the watershed is 3743 ha and it overs the area falling in villages of Sahoran Kandi, Siprian and Jagiyal. Loose boulder structures, with or without vegetative support, check dams and spurs were constructed in drainage lines for reducing soil erosion and controlling runoff. Ninety five dugout ponds with a capacity of 36 ha m were also constructed for harvesting rain water. Agro forestry has also been given priority under the project by planting 18600 plants of Amla, Date, Subabool, Kikar, Sarin etc. The yields of major crops i.e. wheat, maize and fodder increased by 30% as compared to the pre-project yield. Milk and horticulture production has also increased by 25% and 30% respectively. The ground water table of watershed has come up by approximately 2.5 m after implementation of project, thereby increasing value and fertility of land.

3. The Department of Soil and Water conversation has indentified 106 sub-watershed projects in the Kandi area, which forms about 10% of the total geographical area of the state. The main objective of these watersheds is conservation, development and sustainable management of natural resources and enhancement of agricultural productivity in the watershed area.

- **Water logging and flood control measures:** The Department of Irrigation, Punjab has been making effects to control water logging in the state over the years by expansion of drainage network. This includes construction of main drains and link drains of approximate of 570.5 km length in the affected areas. The department has also constructed 305 km long flood protection embarkment (Dhussies) in district Amritsar and Gurdsapur and 415 km long embarkment in District Ferozpur. As per the department this will help to reclaim 2000 sq km area. A vertical drainage system has also been proposed which includes initially 500 shallow tubwells (280 already installed) along sides of the Sirhind feeder to arrest the seepage in south western part of the state. In critically water logged areas of Mukatsar and Mansa districts, lift drainage schemes are also being constructed by the department. A subsurface drainage scheme has also been taken up in Mukatsar district (Ratta Khera and Jamuana blocks), which involves laying underground collection and lateral pipe lines to recharge about 15 sq km area. The department is also regulating the flow of water in rivers and canals to provide irrigation facilities in various parts of the state. The draft of State Water Policy has also been prepared by the department for promoting sustainable water use.
- **Wetland management:** Wetlands are natural source of ground water recharge. PSCST is conducting a wetland conservation and management program in the state. This includes survey of wetlands area and management of water hyacinth, regular flow of water, afforestion, fencing and construction of ponds and mounds. These activities are sponsored by Ministry of Environment and Forests, Govt. of India. Wetland evaluation programs are also being conducted with wetland International - South Asia. Awareness projects are also being carried out under UNDP Small Grants Program.

Before

After



Before

After

Ravinous land treatment

Land and soil conservation measures

The Department of Soil Conservation, Punjab is taking various land reclamation and soil conservation measures throughout the state to prevent soil erosion due to flash floods in hilly areas. More than 52 thousand hectares of land has been reclaimed from gullies up to the year 2006. Maximum reclamation has taken place in the districts of Hoshiarpur followed by Ropar and Gurdaspur, where land in each district has been brought under cultivation during the past five years. The department had reclaimed more than 0.1 million hectares area in the state by land leveling and waste land development works. The maximum land leveling, wasteland development work and ravine reclamation have been carried out in Ferozpur, Faridkot and Amritsar districts. Sand dunes are also being reclaimed gradually to reach the good soil in the southern areas of the state for brining it under cultivation. The district wise progress of land and soil conservation measures carried out by the department upto March, 2006 is presented in Table 2.39.

Laser leveler is the latest land management technique through which vast tracts of land can be leveled with high precision. As per information provided by the department, precision leveling of agricultural fields helps in conservation of irrigation water by increasing water application efficency, top soil management, land saving, uniformity of crop maturity, reduced weeds and increased yield. The department has already purchased three laser levelers which are being used for demonstrative purposes.

Prevention of pollution from farm chemicals

- **Ban on chemical pesticides:** Based on scientific studies and feed back from national and international agencies several general chemical pesticides and insecticides were banned in the state for use in agriculture. A list of such banned and restricted pesticides is given in Tables 2.40, 2.41 and 2.42.

Table 2.39 District-wise progress of land and soil reclamation works in Punjab upto 2005-06 (Hectare)

Source: Department of Soil and Water Conservation, Punjab, 2007

Table 2.40 List of pesticides banned (year wise) for use in agriculture in India

S. N.	Name of pesticide	S. N.	Name of pesticide
1.	Dibromochloropropane (DBCP) (1997)	15.	Calcium cyanide (1995)
2.	Endrin (1997)	16.	Copper acetoarsenite(1995)
3.	Pentachloronitrobenzene (PCNB) (1998)	17.	Ethyl mercury chloride (1995)
4.	Pentachlorophenol (PCP) (1998)	18.	Menazon (1995)
5.	Toxaphene (1998)	19.	Sodium methane arsonate (1995)
6.	Ethyl parathion (1997)	20.	BHC/HCH (1997)
7.	Chlordane (1997)	21.	Phenyl mercury acetate (PMA)
8.	Heptachlor (1996)	22.	Nichotine sulphate (1997)
9.	Aldrin (1996)	23.	DDT(1989)
10.	Paraquat-di-methyl sulphate (1997)	24.	Chlorobenzilate (2003)
11.	Nitrofen (1997)	25.	Nicotine sulphate (1997)
12.	Tetradifen (1997)	26.	Phenyl mercury acetate
13.	Aldicarb	27.	TCA (Trichloro acetic acid)(2003)
14.	Dieldrin (1990)	28.	Maleic Hydrazide (2003)

Source: Punjab Agricultural University, Ludhiana, 2006 and Central Insecticide Board, Govt. of India

Table 2.41 List of pesticides restricted for use in agriculture in India

S. N.	Name	Status
1.	Aluminium phosphide	It is to be sold only to Government undertakings/organizations and to be used under strict supervision of Government expert or Pest Control Operators
2.	Carbaryl	Not to be sprayed at flowering stage of crops
3.	DDT	Restricted for use in public health only
4.	Methyl bromide	Restriction of its sale and use is similar to that of Aluminium phosphide
5.	Sodium cyanide	Use of sodium cyanide shall be restricted for fumigation of cotton bales by Plant Protection Adviser to the Govt. of India
6.	Lindane(HCH/BHC)	Use of Lindane formulations generating smoke for indoor use is prohibited in India. It can be used for the control of insect pests of field crops
7.	Methyl parathion	—
8.	MEMC (methoxyethyl mercuric chloride)	Use is permitted only on those crops where honey bees are not acting as pollinators

Source: Punjab Agricultural University, Ludhiana, 2006

Table 2.42 Pesticide formulations banned for use in agriculture w.r.f. 26th March, 2002

Sr. No.	Name of formulations	Sr. No.	Name of formulations
1.	Carbofuran 50% SP	2.	Methomyl 24% L
3.	Methomyl 12/5% L	4.	Phosphamidan 85% L

Source: Punjab Agricultural University, Ludhiana, 2006 and Central Insecticide Board, Govt. of India

- **Promotion of organic farming:** The practice of organic farming is gaining gradual momentum with growing demand of organic food due to increasing awareness of health and environment issues in agriculture. Organic farming in the state is promoted by Organic Farming Council of Punjab. The council has set up a model farm over 202.4 ha of land at Ropar for production, demonstration and training of organic farming and commercial vermicomposting production. More than 900 farmers with approximately 2631.5 ha of land in verious district (Table 2.43) have

Table 2.43 Area under organic farming in Punjab

Districts	Area in ha
Ferozpur, Mukatsar, Bathinda, Faridkot, Sangrur, Mansa	1214.5
Ropar, Nawanshehar, Mohali	283.4
Ludhiana, Moga, Patiala	485.8
Amritsar, Tarntaran, Hoshiarpur, Jalandhar, Kapurthala	404.8
Fatehgarh Sahib	101.2
Birla Farm, Ropar	141.7
Total Area	**2631.5**

Source: Organic Farming Council of Punjab, 2007

already been registered with the council. More farmers are expected to join the programme in the near future. The main crops under this programme are wheat, basmati rice, pulses, fodder, Amla, Hyola, Kinnows, oilseeds and vegetables, etc. Organic farming results in value addition without processing of crops as it commands premium price in the market. A brand of name 'Bio-organic' has been registered to market organic/chemical free produce.

- **Promotion of Vermicomposting:** Vermicomposting denotes the use of earthworms for efficient biodegradation of organic solid waste into organic manures. It is an environment friendly technology. Application of vermicompost improves soil health by supplying nutrients such as NPK, micronutrients and plant growth harmones. Besides efficient waste management, it provides excellent employment opportunities to small farmers through sale of worms and compost. The Punjab State Council for Science and Technology is promoting vermicompostiong for management of organic wastes of diverse categories including farm and livestock waste, household vegetable waste, garden waste and vegetable market waste. About 1595 units have been set up in the state by PSCST and respective district administrations (Table 2.44). Punjab farmers are opting for vermicomposting technology in order to bring their crops under organic farming. The Department of Agriculture, Punjab has also promoted the setting up of vermicomposting units in 140 villages (one village in each block) in the state in 2004-05.

Table 2.44 Status of vermicomposting units in Punjab

Districts	No. of Blocks	No. of Units to be set up in each Block	No of units set up
Gurdaspur	16	35	Nil
Amritsar	16	35	Nil
Kapurthala	5	35	225*
Jalandhar	10	35	3*
Nawanshehar	5	35	218*
Hoshiarpur	10	35	3*
Roopnagar	7	35	40
Ludhiana	12	35	190
Firozpur	11	35	3*
Faridkot	2	35	27*
Mukatsar	4	35	6*
Moga	5	35	34*
Bathinda	8	35	70+130*
Mansa	5	35	9*
Sangrur	13	35	30+483*
Patiala	9	35	30
Fatehgarh Sahib	5	35	94
Total	**143**	**35**	**1595**

*Districts have set up vermiculture units on their own

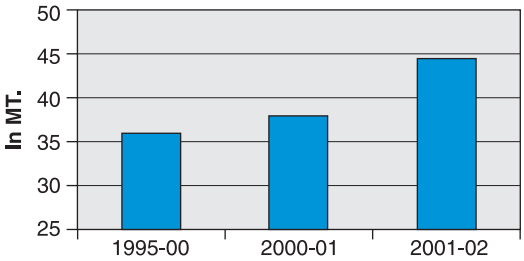
Source: PSCST, 2006

- **Promotion of biofertilizers:** Biofertilizers, like vermicomposting, are also eco friendly, low cost and maintain soil health. The commonly used biofertlizers are *Rhizobium*, *Azotobactor* and blue green algae. The first two occur naturally in soil and the latter generally grows on the surface of stagnant waters. Their efficient strains are being isolated, commercially grown, dried and made available in the market. The Department of Agriculture is making efforts to encourage the use of biofertilizers in the state for promoting organic farming. The department has already provided subsidy of Rs. 30

million for extensive use of biofertilizers. Recently organic fertilizers and biofertilizers have been included in Fertilizer Control Order (FCO), 1985 for providing quality products to farmers. The consumption of biofertilizers in the state is shown in Fig. 2.35.

The PAU has also generated information related to the efficient management and use of FYM (Farm yard manure), pressmud, green manure and poultry manures and their application is being extensively promoted among farmers since many years.

Fig. 2.35 Consumption of biofertilizers in Punjab (in metric tons)



Source: Shiva, V., 2003

- **Introduction of Biopesticides:** Biopesticides are derived from natural material such as animals, plants and certain minerals. These are safer than traditional chemical pesticides. The total biopesticides consumption in the state was 23 tons in 2004-05 and approximately 14 tons upto July 2005 as per data provided by Department of Agriculture, Punjab. The main biopesticides used in the state are *Bacillus thuringiensis* (Bt), *Trochoderma viride*, *Nuclear polyhydrosis Virus* (NPV) and Neem based pesticides containg *Azadirachtin*.

  The most widely used biopesticides in Punjab are subspecies and strains of *Bacillus thuringiensis* (Bt). With the introduction of Bt cotton in Punjab, the area under cotton has increased from 449 thousand hectares in 2002-03 to 560 thousand hectares in 2005-06 and production of cotton has almost doubled from 1.08 million bales (170 Kg each) to 2.2 million bales during the corresponding years (Source: Department of Agriculture, Government of Punjab, 2006). As many as six varieties of Bt Cotton approved by the Genetic Engineering Approval Committee (GEAC) namely RCH 134 Bt, RCH 317 Bt, Ankur 651 Bt, Ankur 2534 Bt, MRC 6301 Bt and MRC 6304 Bt have been extensively sown in the state for the last two years especially in Malwa belt known as "Punjab's cotton country". As per Department of Agriculture, Government of India statistics, the area under Bt cotton in Punjab has increased by 10 times from 20, 000 ha during 2003-04 to nearly 2 lakh ha during 2004-05, which is nearly almost 30% of total area under cotton in the state (CSE, 2007). The technology has given farmers in Punjab a new lease of life mainly because of better harvests and substantial savings on pesticides. The economic benefit of bt cotton is mainly because of its superior American Bollworm (*Helicoverpa armigera*) control. As per experts, it results in cost saving of 50% on insecticides and labour. However, reservations have been expressed by various quarters against the technology in view of conflicting reports on the affect on environment and human health. Several unscrupulous elements are also playing in the market offering cheaper seeds with poor resistivity and return. The technology, therefore, needs to be carefully monitored and propagated.

- **Promotion and implementation of Integrated Pest Management (IPM):** IPM employs available alternate pest control methods and techniques to keep pest population low, such as, mechanical and biological control with greater emphasis on use of crop rotation, bio-pesticides and pesticides of plant-origin like Neem formulations. The use of chemical pesticide is advised

as a last resort only when pest population crosses economic threshold level. PAU has developed and is promoting IPM technology for cotton and paddy crops in order to minimize the use of pesticides and bring down the cost of cultivation. It has lead to reduction of 50% sprays on cotton. During kharif 2006 season, the technique was implemented by PAU in about 380 villages of the state. Similarly, Agriculture Department has also undertaken IPM programmes extensively with the help of private groups in nearly 190 villages in the cotton belt of the state during 2005. The farmers are being made aware and trained for not going in for blind spraying of chemical pesticides. They are being educated for need based spraying to eliminate pests of cotton like aphids, jassid and white fly. The farmers are being suggested non chemical agronomic practices like manipulation of sowing dates, clean cultivation, use of botanical pesticides, bio agents and judicious use of irrigation and fertilizers for control and management of insect pests through various extension activities. Similarly, various cultural and agronomic practices like crop rotation, early sowing of crops, closer spacing, higher seed rates and placement of fertilizers are promoted among farmers for suppressing and controlling weeds. Further, to regulate the timing of N application in rice and minimizing environmental pollution, PAU has recently introduced the use of relatively inexpensive Leaf Colour Chart (LCC) amongst farmers of the state. The university has carried out large scale demonstrations to disseminate the use of LCC chart.

Cotton – A cash crop of Punjab

Management of agricultural waste

Agricultural waste includes paddy and wheat straw, cotton sticks, bagasse and animal waste. At present large volumes of wastes are being burnt in the field or as fuel. Several initiatives for its proper management have been taken up. These include:

- **Utilization of straw and husk:** As already discussed in the previous section, burning of rice/ wheat straw causes problems of air and soil. Hence, various district administrations in the state have imposed a ban on burning of rice straw in the fields after its harvesting (Box 2.16 for Ludhiana). As a result various departments and institutions are promoting alternative uses of straw instead of burning.

- **Use as fodder:** Almost 40% of wheat straw produced in the state is used as dry fodder for animals. Rice straw, however, is not suitable in view of high silica content. A pilot project was however, taken up by PSCST at PAU under which trials on natural fermentation of paddy straw for use as protein enriched livestock feed were conducted. The cattle fed with this feed

Box 2.16 Notice related to ban on burning of rice straw

ਹੁਕਮ ਜ਼ਿਲਾ ਮੈਜਿਸਟਰੈਟ, ਲੁਧਿਆਣਾ
(ਐਮ.ਏ ਸਾਖਾ)

ਆਮ ਦੇਖਣ ਵਿਚ ਆਇਆ ਹੈ ਕਿ ਝੋਨੇ ਦੀ ਕਟਾਈ ਤੇ ਬਾਅਦ ਬੱਚਦੀ ਰਹਿੰਦਖੂਦ ਨੂੰ ਸਬੰਧਤ ਮਾਲਕਾ ਵਲੋ ਅਕਸਰ ਅੱਗ ਲਗਾ ਦਿਤੀ ਜਾਂਦੀ ਹੈ । ਇਸ ਨਾਲ ਹਵਾ ਦੇ ਵਿੱਚ ਬਹੁਤ ਪ੍ਰਦੂਸ਼ਣ ਫੈਲਦਾ ਹੈ ਤੇ ਸਾਹ ਦੀ ਬਿਮਾਰੀਆਂ ਹੋ ਜਾਂਦੀਆਂ ਹਨ । ਧੂਏ ਕਾਰਨ ਆਵਾਜਾਈ ਵਿੱਚ ਵੀ ਵਿਘਨ ਪੈਂਦਾ ਹੈ ਤੇ ਲੋਕਾਂ ਦੀ ਜਾਨ/ਮਾਲ ਨੂੰ ਖਤਰਾ ਪੈਂਦਾ ਹੈ ।

ਇਸ ਲਈ ਫੌਜਦਾਰੀ ਦੀ ਸੰਖਤਾ 1973 ਦੀ ਧਾਰਾ 144 ਅਧੀਨ ਹੋਏ ਅਧਿਕਾਰਾਂ ਦੀ ਵਰਤੋਂ ਕਰਦੇ ਹੋਏ ਮੈਂ, ਅਨੁਰਾਗ ਅਗਰਵਾਲ, ਆਈ.ਏ.ਐਸ. ਜ਼ਿਲਾ ਮੈਜਿਸਟਰੈਟ, ਲੁਧਿਆਣਾ, ਜੀਰੀ/ਝੋਨੇ ਦੀ ਰਹਿੰਦਖੂਦ ਨੂੰ ਅੱਗ ਲਗਾਉਣ ਤੇ ਜ਼ਿਲਾ ਲੁਧਿਆਣਾ ਵਿੱਚ ਮੁਕਮੰਲ ਪਾਬੰਦੀ ਲਗਾਉਂਦਾ ਹਾਂ ।

ਇਹ ਹੁਕਮ ਮੌਜੂਦਾ ਸਥਿਤੀ ਨੂੰ ਮੁੱਖ ਰੱਖਕੇ ਇਕ ਤਰਫਾ ਪਾਸ ਕੀਤਾ ਜਾਂਦਾ ਹੈ ਇਹ ਹੁਕਮ ਮਿਤੀ 08.10.2002 ਤੋਂ ਮਿਤੀ 06.12.2002 ਤਕ ਲਾਗੂ ਰਹੇਗਾ ।

ਇਹ ਹੁਕਮ ਢੋਲ ਵਜਾਕੇ ਤੇ ਲੋਕ ਸਪਰੰਕ ਵਿਭਾਗ ਦੀ ਪਰਚਾਰ ਗੱਡੀ/ਅਕਾਸ਼ਵਾਣੀ/ਦੂਰਦਰਸ਼ਨ ਕੇਂਦਰ/ ਅਖਬਾਰਾ ਵਿੱਚ ਖਤਰਾ ਰਾਹੀਂ ਪਰਚਾਰ ਕਰਵਾਕੇ ਅਤੇ ਪੁਲਿਸ ਸਟੇਸ਼ਨ/ਨਗਰ ਪਾਲਕਾਵਾ/ਉਪ ਮੰਡਲ ਮੈਜਿਸਟਰੈਟਾ/ ਤਹਿਸੀਲਦਾਰਾਂ ਅਤੇ ਸਦਰ ਮੁਕਾਮਾ ਦੇ ਨੋਟਿਸ ਬੋਰਡਾ ਤੇ ਇਸ ਦੀਆ ਕਾਪੀਆਂ ਸਪਰਾ ਕੇ ਲਾਗੂ ਕੀਤਾ ਜਾਵੇਗਾ ।

ਇਹ ਹੁਕਮ ਮੇਰੇ ਹਸਤਾਖਰ ਅਤੇ ਅਦਾਲਤੀ ਮੋਹਰ ਹੇਠ ਮਿਤੀ 8.10.02 ਨੂੰ ਜਾਰੀ ਕੀਤਾ ਗਿਆ ।

ਸਹੀ/
(ਅਨੁਰਾਗ ਅਗਰਵਾਲ)
ਜ਼ਿਲਾ ਮੈਜਿਸਟਰੈਟ, ਲੁਧਿਆਣਾ

ਪਿੰਨ ਐਕਟ ਨੰਬਰ 9849-9948/ਐਮ. ਏ. ਮਿਤੀ 8.10.02

ਉਤਾਰਾ ਹੇਠ ਲਿਖੇ ਅਧਿਕਾਰੀਆਂ ਨੂੰ ਸੂਚਨਾ ਤੇ ਲੋੜੀਂਦੀ ਕਾਰਵਾਈ ਹਿੱਤ ਘਲਿਆ ਜਾਂਦਾ ਹੈ ।

1. ਮੁੱਖ ਸਕੱਤਰ, ਪੰਜਾਬ ਸਰਕਾਰ, ਚੰਡੀਗੜ੍ਹ,
2. ਗ੃ਹਿ ਸਕੱਤਰ, ਪੰਜਾਬ ਸਰਕਾਰ, ਚੰਡੀਗੜ੍ਹ,
3. ਡਾਇਰੈਕਟਰ ਜਨਰਲ ਆਫ ਪੁਲਿਸ, ਪੰਜਾਬ ਚੰਡੀਗੜ੍ਹ

showed improvement in health and milk production. The technology was demonstrated in district Gurdaspur, Ludhiana, Hoshiarpur and Bathinda. The department of Animal Husbandry, Punjab has propogated the technology in the state.

- **Straw/biomass based thermal power plants:** PSEB had set up 10 MW biomass based power plant at village Jalkheri, Fatehgarh Sahib in the year 1992 with rice straw as fuel. The plant is operational since of 2001, after the PSEB entered into a lease cum power purchase agreement with Jalkheri Power Private Limited (JPPL). The original system installed by BHEL i.e. firing the boiler with rice straw in baled form, used to create innumerable problems like ash melting, slagging, super heater choking, clinkerisation, drop in boiler temperature due to moisture in the bales, etc. Hence, the fuel was changed from rice straw to rice husk, wood chips, cotton

waste, etc. in mixed form or rice husk alone to achieve the desired parameters. The total requirement of biomass is estimated to be 82,500 MT/annum at 100% capacity utilisation for optimum plant activity. Crop residues are bought from the farmers at Rs. 35/quintal (which would otherwise have remained unutilized or burnt in the field). The farmers are being made aware of this offer through newspapers and other awareness activities (Box 2.17). Apart from the generation of electricity for supply to state grid to meet the ever-increasing demand for energy in the state, the plant also reduces the Green House Gases (GHGs) emissions. As per Cleaner Development Mechanism (CDM) estimates, the plant would supply energy equivalent of approximately 417.9 million kWh to the grid in a period of 10 years (2002-2012), thereby resulting in total CO_2 emission reduction of 0.3 million tons (Source: www.cdm.unfccc.int).

Box 2.17 Farmer's awareness advertisement

A similar biomass based power project of 7.5 MW was initiated by Malwa Power Pvt. Ltd. at village Gulabewalla in district Mukatsar in 2002. The project was commissioned in May 2005 and is operating satisfactorily. The plant is selling electricity to PSEB through power purchase agreement. The plant is using crop residues available in the area like cotton stalks, mustard stalks, lops and tops of Eucalyptus, Poplar and *Prosopis juliflora* and some quantity of agro waste such as rice husk and saw dust. The total requirement of biomass is estimated to be 65,043 MT/ annum at 90% capacity utilization and 72,270 MT/annum at 100% capacity utilization. As per Cleaner Development Mechanism (CDM) estimates, this plant would supply energy equivalent of approximately 465.10 million kWh to the grid in a period of 10 years (2005-2015) and would result in reduction of 0.43 million tons total of CO_2 emission. (Source: www.cdm.unfccc.int).

Both these power plants are obtaining Carbon Credits under CDM.

Further, in August, 2006, PSEB has signed two agreements with M/s Punjab Biomass Power Limited for setting up 12 MW rice straw based power plants at village Baghaura near Rajpura and Village Sawai Singh near Patiala. The company intends to collect rice straw from command area of 25 sq km around each village and would use 1 lakh MT/annum rice straw for generation of 12 MW of electricity. The company has entered into an agreement with farmers on barter system and farmers will be provided electricity in lieu of supplying rice straw. The plants are expected to start operations in 2009. Land at Baghaura village has already been purchased.

- **Paddy Straw as bedding material for cattle:** The farmers of the state have been advised to use paddy straw as bedding material for cross bred cows during winters as per results of a study conducted by the Department of Livestock Production and Management, College of Veterinary Sciences, Punjab Agricultural University. It has been found that the use of paddy straw bedding during winter helped in improving the quality and quantity of milk as it contributed to animals' comfort, udder health and leg health. Paddy straw bedding helped the animals keep themselves warm and maintain reasonable rates of heat loss from the body. It also provides clean, hygienic, dry, comfortable and non-slippery environment, which prevents the chances of injury and lameness. Healthy legs and hooves ensure enhancement of milk production and reproductive efficiency of animals. The paddy straw used for bedding could be subsequently used in biogas plants. The use of paddy straw was also found to result in increased net profit of Rs. 188 to Rs. 971 per animal per month from the sale of additional amount of milk produced by cows provided with bedding. The PAU has been demonstrating this technology to farmers through training courses, radio/TV talks and by distributing leaflets.
- **Use of straw in Mushroom cultivation, Paper making and Pulp board manufacturing:** Paddy straw can be used for the cultivation of *Agaricus bisporus*, *Volveriella volvacea* and *Pleurotus* spp. One kg of paddy straw yields 300 gms, 120-150 gms and 600 gms of these mushrooms respectively. At present, about 20,000 MT of straw is being used for cultivation of mushrooms in the state. Paddy straw can also be used in conjunction with wheat straw in 40: 60 ratio for paper production. The sludge can be subjected to biomethanization for energy production. The technology is already operational in some paper mills, which are meeting 60% of their energy requirement through this method. Rice straw is also used as an ideal raw material for paper and pulp board manufacturing. As per information provided by PAU, more than 50% pulp board mills are using paddy straw as their raw material.
- **Use of dairy waste:** Dairy waste in the state is either composted or used as fuel in the form of cow dung cakes. It is also being used in the operation of individual and community biogas plants promoted by department of agriculture and PEDA, the details of which have already been discussed. A high rate biomethanation plant has also been set up at Ludhiana by PEDA (Box 2.18).

Box 2.18 High rate biomethanation power project from dairy waste at Haibowal, Ludhiana

Punjab Energy Development Agency (PEDA) has set up a high rate biomethanation power plant in the vicinity of Haibowal dairy complex, Ludhiana for scientific disposal and recovery of energy from animal dung along with reducing the GHG emissions especially methane (CH_4). The plant has been designed to utilize 235 tons of cattle dung daily for recovering about 18,000 KWhs of electrical energy. The project is also producing almost 47 tons of valuable nutrient rich bio manure per day. As per agreement, land measuring 2.42 acres has been provided to PEDA by MC, Ludhiana on lease basis @ Rs. 1/- sqm for a period of 25 years. Biogas Induced Mixing Arrangement Digester Technology (BIMA) was used in this project. The project has been commissioned in Novebmber, 2004 and synchronized with PSEB grid. The project has generated 47.14 lacs units of energy till April. 2006 and 3990 tons of organic manure has been generated and sold.

Source: PEDA, 2006

- **Use of straw for making biogas:** The PSFC has been coordinating a project for processing of farm residue into biogas based on the technology developed by Sardar Patel Renewable Energy Research Institute (SPRERI). A power plant of 1 MW is propose to be set up at Ladhowal on pilot basis on land provided by PAU. The new technology will generate 300 cubic metre of biogas from one tonne of paddy straw.
- **Use of other agriculture waste:** Other agricultural waste like bagasse, cotton sticks, etc are used as fuel.

Promotion of alternate sources of energy in agricultural activities

Besides energy from biomass and biowaste, alternate sources of energy are being promoted by the state government in the farm sector. This includes implementation of solar powered pumpsets scheme. PEDA has been implementing this scheme with the use of solar photovoltaic devices in the state since 2000-01 with the primary aim of saving electricity and reducing the consumption of fossil fuels like diesel. These pumping systems are ideal for small farmers to meet their irrigation requirements especially those who do not have electric connection and use diesel operated pumps. Moreover, these pumping systems are totally pollution free, easy to install and require very little maintenance. Under this Central and State Government supported scheme, farmers are being provided with 2 HP solar water pumping systems at subsidized cost of Rs 35,000 against the actual cost of Rs. 4.56 lac (0.45 million) per pump. The pump is sufficient to irrigate 4 to 5 acres of land with a total discharge of 1.40 lac (0.14 million) litres of water per day. As per information provided by PEDA, the use of 500 pumpsets results in savings of around 0.6 million litres/annum of diesel costing Rs. 1.8 million (i.e. savings of around 2500 litres of diesel on 5 hours running every day for 240 days). Similarly, the use of 500 pumpsets results in a saving of around 6000 units of electricity per day i.e for one year approximately 6000 MW hrs (240 days) of electric energy is saved which amounts to Rs. 4.3 million @ Rs. 3 per kwh. PEDA has so far set up 1850 tubwells throughout Punjab (Table 2.45). The farmers are being educated through various extension activities for the adoption of this new scheme of the state government.

Table 2.45 Solar pumps installed in various districts of Punjab

The scheme was discontinued in 2003-04 and 2004-05

Source: PEDA, 2006

Solar powered tubewell

Other initiatives: These include

- **Promotion of horticulture under National Horticulture Mission (NHM):** The Government of India has launched National Horticulture Mission (NHM) for holistic development of horticulture with an aim to double the horticulture production by the year 2011-12. Crop diversification and income generation to farmers are other main components of NHM. The Department of Horticulture, Punjab is implementing and promoting all NHM programmes in the state through existing extension staff and with the help of media. New processing units for fruits and vegetables are being installed at Abohar and Hoshiarpur to process citrus, guava, pear, tomato and other vegetables. The department is adopting cluster approach for promoting cultivation of some key fruits (Table 2.46).

Table 2.46 Fruits cluster in Punjab under NHM

Source: Department of Horticulture, Punjab, 2007

- The department has already released Rs. 2.24 million to 11 NHM districts and concerned departments like Punjab Agro Industrial Corporation, Punjab Mandi Board, PAU and Post Harvesting Technology Centre. Ludhiana for implementation of NHM programmes. Apart from setting up 5 new nurseries in the state under the scheme an area of 2480 ha and 3350 ha has been covered and rejuvenated, respectively (Source: www.nhm.nic.in).

The horticulture department is also taking various steps to bring diversification by bringing more and more area under horticulture and floriculture. Every year the department brings about 4000 ha additional area under various horticultural crops. The farmers are being encouraged to

cultivate these crops by organizing seminars at village level to provide technical guidance related to horticulture plantations.

- **Revival of cotton through village adoption scheme:** Cotton Industry Consortium has undertaken village adoption project for bringing about overall improvement in method of cotton cultivation. The consortium has adopted 25 villages of Bathinda district in 2005 and average yield in the villages has increased to 873 kg per hectare as against the average of 587 kg per hectare for entire state by practicing renewed technological package prepared for cotton by PAU. The department of Agriculture, Punjab in collaboration with a private Trust, had similarly adopted 56 villages in 2005 and the number has been increased to 112 villages during 2006. These adoption programme are proving to be a boon to the farmers for the revival of cotton crop in the state.

- **Citrus plantation:** As already discussed, Citrus Council has been set up for promotion of citrus cultivation in state. During 2006, the council had brought about 500 acres under citrus plantation and the target for 2007 is 5000 acres. The citrus plants have been imported form Florida, USA and varieties are recommended based on soil and water tests carried out by the council. The council has set up nurseries at Jallowal and Lesriwal villages in Jalandhar district on an area of 30 acres. The nurseries have the capacity of producing 10 lakh plants annually with a planting out capacity of around 36,000 acres.

- **Cultivation of *Jatropha*:** Cultivation of *Jatropha* as the best source for biodiesel holds promise as fuel alternatives for diesel. Large scale research trials are being undertaken by PAU and Department of Forests, Punjab with a view to produce good quality and high yielding *Jatropha* for cultivation in about 1 lakh acres of sub mountainous area of the state. Similarly, the surplus maize grains produced in state can also be used for production of ethanol. The Governnet of India has already recommended blending of 5% of ethanol in petroleum.

Development initiatives for animal husbandry

The state Animal Husbandry Department has taken various measures for developing and uplifting the livestock sector. Some of these are given below:

– The department has banned the use of anti-inflammatory drug Diclofenac for cattle w.e.f. April, 2005 to save the fast dwindling population of vultures (Box 2.19).

– Punjab has become the first state in India to introduce Herd Registration Act, 2006, for animal recording system based on lines of developed countries. Under the Act, Herd Registration Authority will be set to regulate registration of all animals in a scientific manner to generate data base of livestock population, their health status, vaccination, artificial insemination, milk production and pedigree record. The Act will also help to control the stray animal population.

– A world class Embryo Transfer Technology Lab costing Rs. 50 million would be soon set up by the department at Patiala for producing high genetic bulls for semen banks and elite cows.

Box 2.19 Ban on the use of diclofenac drug

ਡਾਇਰੈਕਟੋਰੇਟ, ਪਸੂ ਪਾਲਣ ਵਿਭਾਗ, ਪੰਜਾਬ
(ਵਿਕਾਸ ਸ਼ਾਖਾ-1)

ਸੇਵਾ ਵਿਖੇ,

ਸਮੂਹ ਡਿਪਟੀ ਡਾਇਰੈਕਟਰ/ਅਧੀਨ ਦਫਤਰ,
ਪਸੂ ਪਾਲਣ, ਪੰਜਾਬ ।

ਮੀਮੋ ਨੰ: 10037-37
ਚੰਡੀਗੜ੍ਹ, ਮਿਤੀ 29/4/05

ਵਿਸ਼ਾ :- ਬੈਨ ਆਨ ਵੈਟਰਨਰੀ ਯੂਜ਼ ਆਫ ਡਾਇਕਲੋਫੀਨੈਕ ਇਨ ਲਾਇਵਸਟਾਕ ।

ਹਵਾਲਾ:- ਪੰਜਾਬ ਸਟੇਟ ਵਾਇਲਡ ਲਾਇਫ ਬੋਰਡ ਦੀ ਮੀਟਿੰਗ ਮਿਤੀ 27-4-05

ਉਪਰੋਕਤ ਵਿਸ਼ੇ ਦੇ ਸਬੰਧ ਵਿੱਚ ਆਪ ਨੂੰ ਪਹਿਲ ਦੀ ਸੂਚਿਤ ਕੀਤਾ ਗਿਆ ਹੈ ਕਿ ਡਾਇਕਲੋਫੀਨੈਕ ਦਵਾਈ ਦੀ ਪਸੂਆਂ ਵਿੱਚ ਕੀਤੀ ਜਾਣ ਵਾਲੀ ਵਰਤੋਂ ਗਿਰਝਾਂ ਵਾਸਤੇ ਬਹੁਤ ਮਾਰੂ ਸਾਬਿਤ ਹੋ ਰਹੀ ਹੈ । ਇਥੇ ਇਹ ਕਿ (250 ਮਰੇ ਜਾਨਵਰਾਂ ਦੇ ਕਾਰਕੇਸਾਂ ਵਿੱਚੋਂ ਜੇਕਰ ਇੱਕ ਵਿੱਚ ਹੀ ਡਾਇਕਲੋਫੀਨੈਕ ਦੀ ਮਾਤਰਾ ਹੋਵੇ ਅਤੇ ਉਸ ਮਾਸ ਨੂੰ ਖਾਣ ਨਾਲ ਹੀ ਹੀ ਗਿਰਝਾਂ ਦੀ ਭਾਰੀ ਮਾਤਰਾ ਵਿੱਚ ਮੌਤ ਹو ਜਾਂਦੀ ਹੈ) ਇਸਦਾ ਕਾਰਨ ਡਾਇਕਲੋਫੀਨੈਕ ਹੈ ਜੋ ਗਿਰਝਾਂ ਵਿੱਚ Viscereal Gout and Renal Failure ਦਾ ਕਾਰਨ ਬਣਦਾ ਹੈ ।

ਤੁਸੀ ਸਾਰੇ ਭਲੀ ਭਾਂਤ ਜਾਣਦੇ ਹੋ ਕਿ ਗਿਰਝਾਂ natural scavengers ਹਨ (ਕੁਦਰਤੀ ਸਫਾਈ ਕਰਨ ਵਾਲੇ ਪਕੀ ਹਨ) ਜੋ ਮਰੇ ਜਾਨਵਰਾਂ ਦਾ ਮਾਸ ਖਾਂਦੀਆਂ ਹਨ । ਪ੍ਰੰਤੂ ਪਸੂਆਂ ਵਿੱਚ ਡਾਇਕਲੋਫੀਨੈਕ ਦੀ ਵਰਤੋਂ ਇਨਾਂ ਦੀ ਮੌਤ ਦਾ ਕਾਰਨ ਬਣ ਗਿਆ ਹੈ । ਹਾਲਾਤ ਇਥੇ ਤੱਕ ਪਹੁੰਚ ਚੁਕੇ ਹਨ ਕਿ ਇਹ ਗਿਰਝਾਂ ਖਤਮ ਹੋਣ ਦੇ ਕਗਾਰ ਤੱਕ ਪਹੁੰਚ ਗਈਆਂ ਹਨ ।

ਮਿਤੀ 27-4-05 ਨੂੰ ਮਾਨਯੋਗ ਮੁੱਖ ਮੰਤਰੀ ਜੀ ਦੀ ਪ੍ਰਧਾਨਗੀ ਹੇਠ ਸਟੇਟ ਵਾਇਲਡਲਾਇਫ ਬੋਰਡ ਦੀ ਬਹੁਤ ਹੀ ਮਹੱਤਵਪੂਰਣ ਮੀਟਿੰਗ ਵਿੱਚ ਇਹ ਫੈਸਲਾ ਲਿਆ ਗਿਆ ਹੈ ਕਿ ਪਸੂਆਂ ਵਿੱਚ ਡਾਇਕਲੋਫੀਨੈਕ ਦੀ ਵਰਤੋਂ ਪੂਰਣ ਤੌਰ ਤੇ ਤੁਰੰਤ ਬੰਦ ਕੀਤੀ ਜਾਵੇ ਜਿਸ ਨਾਲ ਅਸੀ ਆਪਣੇ ਵਾਤਾਵਰਣ ਦਾ ਸਤੁੰਲਨ ਰੱਖ ਸਕੀਏ ਅਤੇ ਕੁਦਰਤ ਵੱਲੋਂ ਭੇਜੇ ਗਏ ਸਫਾਈ ਕਰਨ ਵਾਲੇ ਜੀਆਂ (ਗਿਰਝਾਂ) ਦੀ ਜਾਨ ਬਚਾ ਸਕੀਏ ।

ਇਸ ਲਈ ਸਾਰੇ ਵੈਟਨੇਰੀਅਨਜ਼ ਨੂੰ ਹਦਾਇਤ ਕੀਤੀ ਜਾਵੇ ਕਿ ਡਾਇਕਲੋਫੀਨੈਕ ਦੀ ਵਰਤੋਂ ਤੁਰੰਤ ਬੰਦ ਕੀਤੀ ਜਾਵੇ । ਕਿਸੀ ਵੀ ਕਰਮਚਾਰੀ ਵੱਲੋਂ ਹਦਾਇਤਾਂ ਦੀ ਪਾਲਣਾ ਨਾ ਕਰਨ ਦੀ ਸੂਰਤ ਵਿੱਚ ਉਸ ਵਿਰੁਧ ਅਨੁਸਾਸ਼ਨੀ ਕਾਰਵਾਈ ਕੀਤੀ ਜਾਵੇਗੀ ।

ਡਾਇਰੈਕਟਰ, ਪਸੂ ਪਾਲਣ ਵਿਭਾਗ,
ਪੰਜਾਬ, ਚੰਡੀਗੜ੍ਹ

ਪਿਠਅੰਕਣ ਨੰ: 10037
ਚੰਡੀਗੜ੍ਹ, ਮਿਤੀ

ਇਸਦਾ ਇੱਕ ਉਤਾਰਾ ਸਕੱਤਰ, ਪੰਜਾਬ ਸਰਕਾਰ, ਪਸੂ ਪਾਲਣ, ਮੱਛੀ ਪਾਲਣ ਅਤੇ ਡੇਅਰੀ ਵਿਕਾਸ ਵਿਭਾਗ ਜੀ ਨੂੰ ਸੂਚਨਾ ਹਿੱਤ ਘੱਲਿਆ ਜਾਂਦਾ ਹੈ ਜੀ ।

ਡਾਇਰੈਕਟਰ, ਪਸੂ ਪਾਲਣ ਵਿਭਾਗ,
ਪੰਜਾਬ, ਚੰਡੀਗੜ੍ਹ

– The department has recently launched a programme for identification of elite buffaloes with milk yields ranging from 12 -22 kgs and providing cash incentives to dairy farmers ranging from Rs.1000- 10,000 depending upon milk yield.

– The poultry farmers have been given incentives in the state by abolition of sales tax on poultry chicks and dressed chicken.

– The department has launched a Turkey rearing scheme in the year 2003-04 for bringing diversification within the poultry sector.

– Regional Disease Diagnostic Labortary has been established in Jalandhar to cater to seven states of north India for investigation of diseases.

– Veterinary Vaccine Institute at Ludhiana produces various vaccines for prophalectic measures against contagious diseases of animals.

Value addition through Agro processing Industries

Even though the state has enormous potential for agro processing industries, however, it has not been fully exploited till date. At present, agro-processing industry is mainly limited to traditional processing of agricultural raw materials, such as atta chakkies, oil mills, cotton ginning, rice shelling, etc. There are a few high-tech agro/food industries adding value to primary agricultural products. Some of these include:

– Glaxo Smithkline Plant at Nabha, district Patiala, for dairy and health care products

– Nestle Plant at Moga for dairy products

– Nijjer Agro foods at Jandiala, district Amritsar, for tomato, chilli, fruits and milk products

– Pepsi Agro Foods Plant at Zahura, district Hoshiarpur, for tomato products

– Dumex Plant at Jagraon, District Ludhiana, for dairy and cereal products (under construction)

Punjab Agro Industrial Corporation (PAIC) has been promoting agro based industries in various parts of the state. It has already implemented 39 successful agro processing projects and currently 9 projects are being implemented throughout the state. The corporation will also implement 7 new projects shortly related to wheat, rice, corn, poultry, malt and brewery processing (Source: PAIC, website).

As already discussed, PSCST has also successfully undertaken a project for post-harvest processing facilities and value addition of medicinal/aromatic plants at Talwara in District Hoshiarpur.

Initiatives for awareness and training

The extension education department of PAU has made significant contribution over the years in extending education, awareness and training with respect to latest technologies in the field of agriculture in the state. The institution is ably assisted by KVKs for demonstration of technologies. The Kisan Mela organized by the department each year offers a very good platform for information dissemination

and sharing and is highly valued by the farmers. The District Chief Agriculture Officers and their support staff also organize need based awareness and training programmes for farmers at field level from time to time. Such trainings are also organised by Department of Horticulture, Animal Husbandry, and Fisheries, etc. Other initiatives include:

– A Kisan call Centre for Punjab has been set up at Chandigarh (w.e.f. January, 2004) by Department of Agriculture and Cooperation, Government of India with a toll free telephone facility (Number 1551) to provide free information to farmers all across the state with respect to agriculture and allied areas including meteorology, in local language.

– A regular punjabi programme titled "Mera Pind Mere Khet" is being telecast by Doordarshan Kendra, Jalandhar for spreading awareness amongst farmers related to various aspects of agricultural activities including conservation and sustainable use of natural resources in agro ecosystem.

– Various NGOs working in the field of agriculture and environment have been promoting activities like, the cultivation of pesticide free organic farming and traditional varieties, efficient use of village ponds and wetlands for ground water recharge, use of organic manures, etc amongst the farming community by organizing seminars, meetings, special lectures, conducting field visits, camps, etc. and by distributing awareness materials in regional language.

– Mass awareness about conservation of natural resources is being promoted by PSCST through its various environmental awareness, science popularization and biotechnology awareness programmes, as well as through the Environment Information Centre's bilingual website (www.punenvis.nic.in).

RECOMMENDATIONS

The present reports recommends that:

- The State Agriculture Policy needs to be formulated. The policy should attempt to identify the most suitable cropping systems in different agro climatic zones of the state depending upon existing soil, climate and water quality and quantity. District/block wise crop adjustment programs need to be prepared taking into account crop diversification and cropping intensity.
- Sustainable low-input agriculture needs to be promoted by promoting diversification from the existing input intensive wheat-rice cropping pattern to alternate crops. The ecologic vs economic cost benefit analysis of switching over to crops like maize, pulses, etc. needs to be evaluated to ascertain long term sustainability of the production system vs income of farmers.
- The State Agriculture Policy also needs to take into account the water balance of crops especially with respect to products which meet basic nutritional requirements of our own society vs products which are exported for economic benefits (like, rice and sugarcane).
- Legumes, oilseeds and horticultural crops along with agroforestry systems need to be promoted.
- In order to ensure better remuneration to farmers switching over to such crops, post harvesting and value addition facilities need to be promoted in the state.

- Further, facilities like appropriate support price, procurement systems, assured markets, crop insurance schemes and institutional loans on easy terms need to be extended to farmers adopting crop diversification programs. The Punjab Agriculture Produce Markets Rules need to address this issue.
- Storage facilities at community level need to be established to cut down on transportation and marketing costs.
- As per Thakker (2007) our average national water use efficiency in 25-35% in canal irrigated areas and a little higher in groundwater irrigated areas. As per second term revision of 10th five year plan, a 10% increase in irrigation efficiency can add 14 million ha additional area under irrigation. Hence, attempts should be made to improve water use efficiency in agriculture. PSFC has also recently proposed the Punjab Preservation of Sub Soil Water Bill, which aims at saving 30% water to help arrest declining water table. The recommendations of the bill especially with respect to transplanting date of paddy, needs to be implemented (No farmer to be allowed to sow nursery of paddy before 10th May and transplant the same before 10th June).
- The gap between irrigation potential created and actual irrigation achieved needs to be bridged. This is possible by arresting siltation in canals and reservoirs and by remodeling, reconditioning, repair, maintenance and upgradation of existing canal system to provide assured water supply upto the tail end.
- Land Information System (LIS) is a planning and development tool that acts as a link between Cadastral Information System (CIS: Cadastral information system is a compilation of land records information into a continuous map of a jurisdiction) and Geographical Information System (GIS). The development of an efficient LIS requires accurate up-to-date and standardized cadastral maps in digital environment, geodetic control framework for linking CIS to GIS and high resolution satellite data to generate/update thematic maps and for geo-referencing of cadastral maps. Thus, there is a need to update the cadastral maps in the state and develop an accurate LIS which can serve as a useful monitoring tool in future.
- The state is in the process of industrialization and urbanization. Hence, the State Land Use Policy needs to be finalized in conjunction with the State Agriculture Policy. Prime agricultural lands need to be identified and no diversion of such lands be allowed.
- Revival and renovation of village ponds needs to be taken up in a big way as these ponds act a effective ground water rechargers.
- Artificial recharge of ground water through roof top rain water harvesting should be made mandatory in the state.
- The policy of providing free electricity for agriculture needs to be reviewed as it leads to excessive irrigation and withdrawal of ground water.
- On the lines of horticulture crops under National Horticulture Mission, Government should also provide financial assistance in the form of subsidies and interest-free loans to the farmers for installing micro irrigation systems, like drip irrigation for non horticulture crops like, sugarcane.

- The state also needs to promote modification in cultivation methods especially rice (e.g. increasing spacing between plants, transplanting younger seedlings, reduced flooding, ridge planting, etc.) which have already been endorsed by Union Agriculture Ministry.
- In order to reduce the dependence on chemical fertilizers, organic farming needs to be promoted in a big way. For this, composting, vermicomposting, mulching, etc needs to be promoted. Also dedicated markets for organic food need to be developed.
- The use of organic farmyard waste for production of biogas and subsequent use of digested sludge as organic fertilizers in the fields also needs to be promoted in a big way as the state has high cattle population and this technology offers duel benefits of providing gas for energy (both, for power generation and household fuel), besides providing organic fertilizer.
- In order to reduce use of pesticides in agriculture, IPM and biopesticides may be promoted.
- More residue testing laboratories equipped with modern and sophisticated equipments should be established in the state for detection and quantification of pesticides and heavy metal residues in various components of the environment and food products, on lines of Punjab Biotechnology Incubator.
- Alternative uses of agricultural wastes and biomass need to be promoted. Existing technologies also need to be assessed.
- The burning of paddy and wheat straw in the fields has been banned in the state. Recommendations of the Task Force set up by the government for suggesting alternative uses of straw need to be implemented. These include using straw (especially paddy straw) for power generation, as feed and bedding of animals, as mulch, etc.
- The ownership of expensive agricultural machinery by individual farmers should be discouraged as far as possible. These facilities should be provided by village cooperatives or private entrepreneurs on custom hiring basis.
- By promoting diversification of agriculture (especially reducing area under rice cultivation), organic farming, biogasification of farm yard waste, etc, the state should also avail of Carbon Credits Facility provided by UNFCC. This would help generate additional resources for the farmers and state government.
- The state needs to protect its agricultural and domesticated animal biodiversity. Area where traditional crop varieties are being grown need to be assessed. Further, traditional varieties need to be re-introduced in the farming system. A gene/seed bank needs to be set up, preferably at PAU, to preserve such varieties.
- Intensive research and development activities need to be taken up to achieve major breakthroughs for increasing crop and livestock production to meet global challenges.
- Emphasis be given on use for biotechnological tools in agriculture.
- Environmental cells be set up in key departments related to agriculture to assess long term environmental impacts of activities and programs.
- Since data gaps are a major constraint in policy formulation and planning, statistical wing of key departments be strengthened.
- Last, but not the least epidemiological studies related to agricultural activities need to be taken up.

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3

Municipal Solid Waste

3

Municipal Solid Waste

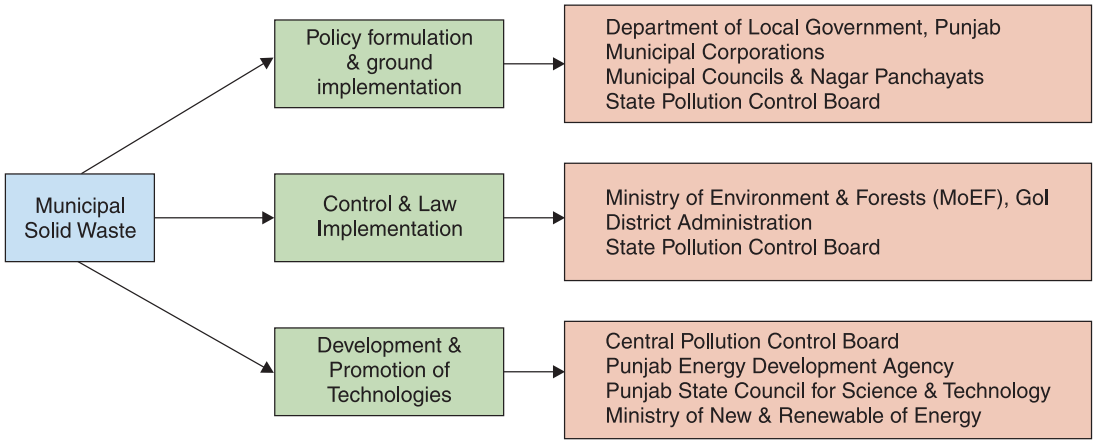
According to World Health Organization, waste is defined as any substance or object arising from human or animal activities that has to be discarded as 'unwanted' (Economopoulos, 1993). Solid waste is also described as "matter in the wrong place," implying that a material becomes waste only when a specific owner ceases to have a use for it. Thus, Municipal Solid Waste is 'the material for which the primary generator or user abandoning the material within the municipal area requires no compensation upon abandonment' (Palnitkar, 2000). A large volume of solid waste is generated in both urban and rural areas and there has been a significant increase in waste generation. Municipal Solid Waste includes commercial and residential wastes generated in municipal or notified areas in either solid or semi-solid form excluding industrial hazardous waste, but including treated bio–medical wastes (Ministry of Environment and Forests, 2000).

Box 3.1 Sources and types of Municipal Solid Waste (MSW)

S.N.	Source	Description	Type of MSW
1.	Residential	Single and multi family dwelling	Household waste, kitchen, house cleaning, old papers, packing, bottles, crockery wares, furnishing materials, garden trimmings, etc.
2.	Commercial and Construction	Business premises, shops, offices, markets, departmental stores, schools, colleges, large hotels and restaurants, markets selling vegetables, fruits, meat, fish, etc., community halls, religious places.	Old papers, packing, bottles, crockery wares, animal waste, furnishing materials, food waste, street waste, vegetable waste, digging of roads by various utilities comprising earth, brickbats, stones, wooden logs, etc.
3.	Industrial	small/medium scale industry office and canteen	Office waste, food waste, packaging material etc.

Source: RITES, 1998

INSTITUTIONAL FRAMEWORK



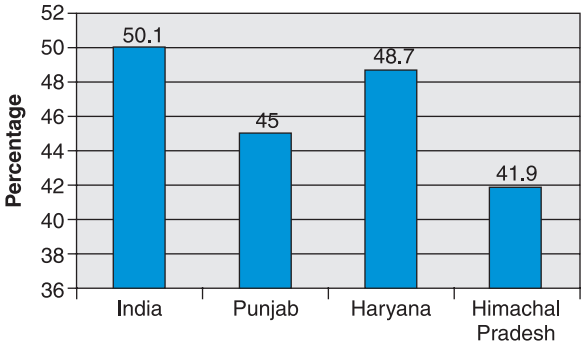
DRIVING FORCES

Major factors contributing towards generation of municipal solid wastes are growth of population, urbanization, construction and commercial activities, increase in slaughter houses besides shift towards western lifestyles.

Growth of population

In most developing countries, like India, population increases in a geometrical ratio where as subsistence facilities increase in arithmetic ratio resulting in a wide gap between demand and supply of such facilities. As discussed in Chapter 1, the population of the state is about 2.4% of the national population. It is ranked 15th in terms of population growth (1981–2001) (Statistical Abstract of Punjab, 2005). The increase in population in Punjab has been 45 % in the past two decades, as compared to national population growth of 50.1% during the said period (Fig. 3.1). Ludhiana district has, however, witnessed maximum increase of 66.7 percent population from 1981-2001 (Table 3.1).

Fig. 3.1 Comparison of increase in population of Punjab and neighboring states with national population growth (1981-2001)



Source: Statistical Abstract of Punjab, 2005

On the other hand population density of the state is 49.3% higher than the national average. The state occupies 10th rank in the country in terms of population density with 484 persons per sq km while national average is 324 persons per sq km.

Table 3.1 District wise population increase in Punjab since 1981 (in number)

Districts	1981	1991	2001	Percentage increase 1981–2001	Density per sq km (2001)
Gurdaspur	15,13,435	17,57,281	21,04,011	39.0	590
Amritsar	21,88,490	25,05,034	30,96,077	41.4	608
Kapurthala	5,45,249	6,46,647	7,54,521	38.3	462
Jalandhar	17,34,574	16,49,909	19,62,700	13.1	746
Nawanshehar[2]	–	5,31,253	5,87,468	10.5	464
Hoshiarpur	12,43,807	12,98,712	14,80,736	19.0	440
Roopnagar	7,16,662	8,99,587	11,16,108	55.7	543
Ludhiana	18,18,912	24,28,382	30,32,831	66.7	805
Firozpur	13,07,804	14,48,903	17,46,107	33.5	329
Faridkot	14,36,228	4,55,005	5,50,892	26.2	375
Mukatsar[2]	–	6,54,434	7,77,493	18.8	297
Moga[2]	–	7,77,922	8,94,854	15.0	404
Bathinda	13,04,606	9,85,301	11,83,295	20.0	350
Mansa[1]	–	5,74,662	6,88,758	19.85	317
Sangrur	14,10,250	16,85,449	20,00,173	41.8	399
Patiala	15,68,898	15,28,569	18,44,934	17.5	509
Fatehgarh Sahib[1]	–	4,54,919	5,38,041	18.2	456
Total Population	**1,67,88,915**	**2,02,81,969**	**2,43,58,999**	**45.0**	**484**

[1]New district formed in 1992; [2]New district formed in 1996

Source: Statistical Abstract of Punjab, 2005

Urbanization

Rural to urban migration

Punjab is the seventh most urbanized state in the country with urbanization level of 33.95%. This is higher than the national average of 27.8%. The rate of urban growth (37.8%) was three times than rural growth (12.6%) during the past decade (Table 3.2). More than half of the state's urban population (58.39%) lives in class I cities (Classification of Municipal bodies is shown in Box 3.2). Every sixth urbanite lives in Ludhiana whereas every ninth is in Amritsar (Punjab Infotech, 2006). The reason behind rural to urban migration is the income differential which

Box 3.2 Classification of Municipal bodies

(List of Class 1, II and III cities is attached as Annexure 3.1)

Source: State Urban Development Authority, 2006

Table 3.2 Rural and urban population of Punjab

Districts	Population (1991)		Population (2001)	
	Urban	Rural	Urban	Rural
Gurdaspur	3,86,412	13,70,320	5,35,223	15,68,788
Amritsar	8,53,831	16,50,729	12,23,275	18,72,802
Kapurthala	1,66,605	4,80,042	2,46,527	5,07,994
Jalandhar	7,28,802	12,97,985	9,31,983	10,30,717
Nawanshehar	–	–	81,066	5,06,402
Hoshiarpur	2,22,138	12,32,890	2,92,074	11,88,662
Roopnagar	2,32,317	6,83,286	3,62,407	7,53,701
Ludhiana	12,42,781	12,28,813	16,93,653	13,39,178
Firozpur	3,84,400	12,23,417	4,50,725	12,95,382
Faridkot	4,39,839	12,91,037	1,93,571	3,57,321
Mukatsar	–	–	1,98,564	5,78,929
Moga	–	–	1,78,640	7,16,214
Bathinda	3,51,133	12,08,830	3,51,754	8,31,541
Mansa	–	–	1,42,429	5,46,329
Sangrur	4,17,994	12,92,126	5,84,819	14,15,354
Patiala	5,66,973	13,29,269	6,44,710	12,00,224
Fatehgarh Sahib	–	–	1,51,091	3,86,950
Total Population	**59,93,225**	**1,42,88,744**	**82,62,511**	**1,60,96,488**

Source: Statistical Abstract of Punjab, 2003 & 2005

motivates people to move from low–income areas to relatively high–income areas. In the rural areas (especially in nearby states), sluggish agricultural growth and limited development of the rural non–farm sector raises the incidence of rural poverty, unemployment and underemployment. Moreover, as most of the high productivity activities are located in urban areas, many ruralites migrate to urban areas, not only from within Punjab, but also from the nearby states in search of jobs. This flux, tremendously adds to the municipal solid waste generation in urban areas.

Growth of slums

According to Census of India 2001, 15 percent of total urban population lives in slums. The persons living below poverty line in these urban areas constitute 23.6 percent (NSSO, 2000). In Punjab, average slum population is 13.97 percent in 28 major cities and towns. The percentage of notified and non-notified slums (Fig. 3.2) in the state is 33.1 (vs. national percentage of 50.6) and 66.9 (vs. national percentage of 49.4) (NSSO, 2002).

Further, Ludhiana has the highest number of slum dwellers (3.14 lacs) in the state followed by Amritsar (3.07 lacs) (Punjab Infotech, 2006). Most of these slum dwellers are from Bihar, Uttar Pradesh, Madhya Pradesh, Arunachal Pradesh and Rajasthan. Slum dwellers living near dumping sites are mostly rag pickers who, though help in scavenging the environment, but also cause nuisance

and interfere in scientific management of waste. Further, most slum dwellers are forced to send remittances to their native places thus themselves living in squatter and disease.

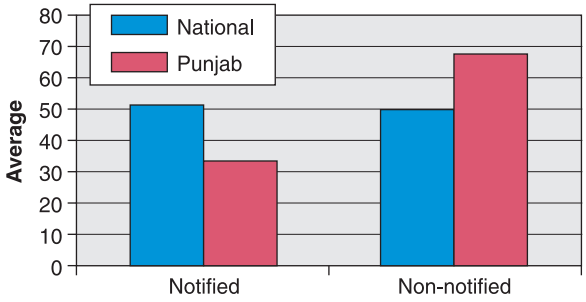
Shift to western life style

Western life–style with emphasis on "consume and discard" culture has brought in its wake the acute problem of solid waste disposal across the globe. Life has been made easier and more convenient with disposable goods, but, increased consumerism is also leading to generation of an increasing amount of waste. The daily per capita generation of municipal solid waste in India ranges from 100 g for small towns to 500 g for large towns (Joshi & Eashwar, 2001) and it is considered to be directly related to economic wellbeing. Punjab is ranked sixth amongst major states in terms of per capita income (Statistical Abstract of Punjab, 2005) and waste generation is on the higher side. A study was carried out in 59 cities (35 metro cities and 24 state capitals) by Central Pollution Control Board (CPCB) with the assistance of NEERI in 2004-05 (CPCB, 2006). The study revealed that waste generation rate varies from 170 to 620 gm/capita/day (Annexure 3.2). As evident from Fig. 3.3, the per capita waste generation of Ludhiana is higher than the average waste generation rate from other cities.

Construction and commercial waste

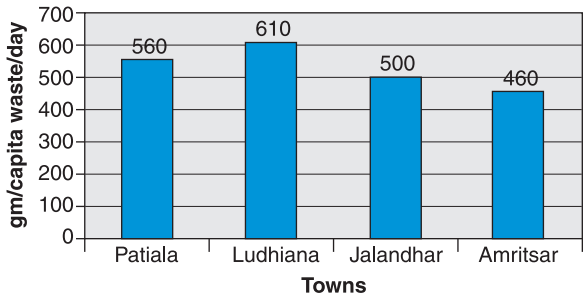
There has been a rapid increase in construction activities in the state over the years such as, construction of mega housing projects, malls, and multiplexes. This results in generation of large volume of demolition waste due to construction of new facilities in place of existing structures. Day-to-day commercial activities such as shops, commercial establishments (Fig. 3.4), apni mandis are also on the rise, which add to solid waste

Fig. 3.2 The percentage of notified and non–notified slums in the state



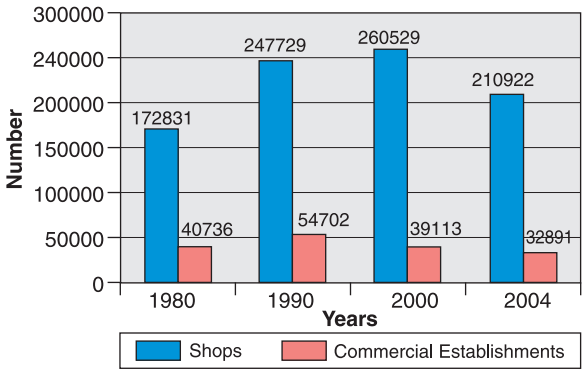
Source: NSSO, 2002

Fig. 3.3 Per capita/day generation of Municipal Solid Waste (MSW) in major cities of Punjab



Source: PPCB, 2006

Fig. 3.4 Number of shops and commercial establishments in Punjab



*Commercial establishment includes theatres/cinema halls

Source: Statistical Abstract of Punjab, 2005

generation. (Data is based on numbers registered. Post 1992, mandatory registration has been discontinued, so, though number of commercial establishments continue to rise, this is not reflected in the data). A study conducted by Punjab Energy Development Agency (PEDA) at Amritsar, Jalandhar and Ludhiana indicate that approximately 689 tons/day, 830 tons/day and 1187 tons/day of fruits and vegetables are procured in the mandis out of which against the expected norms of 5% biodegradable waste, only 0.5-0.6% of waste is being generated. As per information provided by Punjab Mandi Board a total of 6784 tons/day vegetables and fruits are procured by various mandis of Punjab (Table 3.3). Hence, as per expected norms approximately 339 tons/day of mandi waste is generated in the state. There is also increase in restaurants and road side dhabhas which dispose their wastes on to the roadside that degrades the environment. However, data on quantum of wastes from these sources is not available.

Increase of slaughter houses

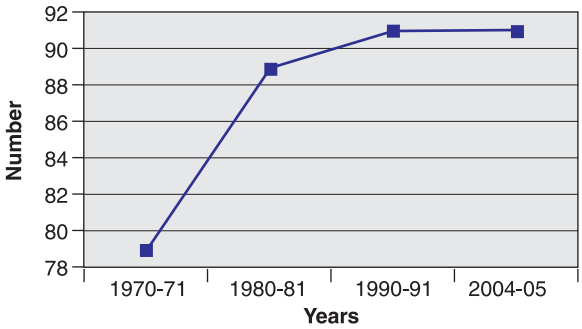
A slaughter house means 'place where 10 or more than 10 animals are slaughtered per day'and is duly licensed or recognised under a Central, State or Provincial Act or any rules or regulations made there under (Prevention of Cruelty to Animals (Slaughter House) Rules, 2001). With increase in overall population, as well as increase in culture of non-vegetarianism, there has been a 15% increase in the number of recognized slaughter houses over the last 25 years in the state (Fig. 3.5). Besides there are many illegal slaughter houses. Illegal functioning of such slaughter houses are proving to be a bane for the local bodies as there is no organised system for disposal of solid wastes generated by them. Despite excellent animal protection laws, the animals in such slaughter houses suffer from cruel transport and living conditions, and

Table 3.3 Vegetables and fruits procured by various mandis of Punjab

Districts	Procurement (tons/day)
Gurdaspur	405
Amritsar	689
Kapurthala	298
Jalandhar	830
Nawanshehar	813
Hoshiarpur	458
Roopnagar	214
Ludhiana	1187
Firozpur	347
Faridkot	132
Mukatsar	71
Moga	212
Bathinda	217
Mansa	51
Sangrur	458
Patiala	334
Fatehgarh Sahib	68
Total	**6784**

Source: Punjab Mandi Board, 2007

Fig. 3.5 Number of recognized slaughter houses in Punjab



Source: Statistical Abstract of Punjab, 2005

are slaughtered illegally in unhygienic conditions, posing a threat to the health of the consumers as well as residents of the state and the entire solid waste is collected and disposed of as land fill. It has been observed that in many places severed heads and body parts which are not sold are kept at the roofs of the meat shops to allow natural disposal by birds and animals. These decaying animal parts spread an annoying stench and pose a health risk to the citizens, being breeding grounds of flies and rodents, leading to increasing stray dog population and spreading diseases like cholera, gastroenteritis, tuberculosis and rabies. Data available in this regard is insufficient.

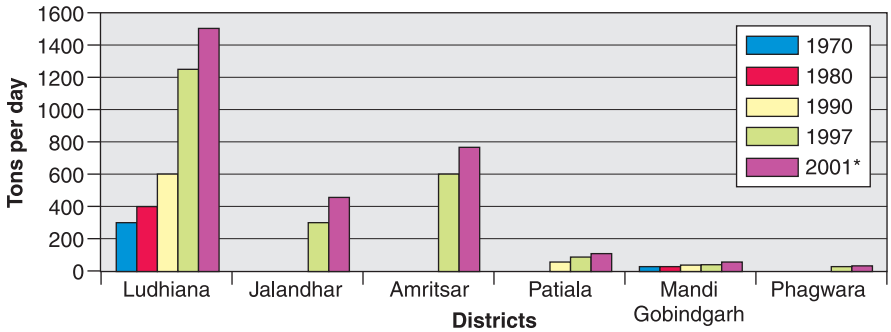
PRESSURES

The pressures caused by the above driving forces include:

Increased waste generation

The continuous growth of population and their many activities are mainly responsible for increase in generation of municipal solid waste and environmental degradation. A study conducted in six towns of Punjab by California Design and Construction (CDC) Inc. at the behest of PSCST with assistance of the Ministry of Environment and Forests, Government of India (Fig. 3.6) shows that with increase in population, the quantum of municipal solid waste increases over the years.

Fig. 3.6 Generation of municipal solid waste in six towns in Punjab



*Projected municipal solid waste generation

Source: CDC, 1999

The Ministry of Urban Development, Government of India, in its manual on solid waste management (2000), has estimated waste generation of 100,000 MT/day in the country. A study carried out by CPCB in 59 cities shows that Ludhiana, with highest population growth in the state, ranks 12th in the country in terms of waste generation (Annexure 3.2).

Change in type of waste due to change in life style

The variety and quantity of consumer goods in the state is on the increase not only because of technological development, but also because of the increasing number of people who can afford such goods. As described earlier, Punjab has been ranked sixth amongst major states in terms of per

Waste disposal site

capita income. Hence, consumerism is high. People can afford to buy new gadgets, games, and devices and upgrade existing gadgets to keep up with advancing technology. Also, the tendency to use disposable products is also high due to convenience. Use of attractively packaged products is also on the rise. This packaging is promptly ripped off and thrown in the trash. Besides, products, which in the past were considered durables, quickly find their way into the trash bin and increase the waste. Consequently quantity and type of waste has increased/changed over the years.

Increase in pressure on existing disposal sites

With increase in population, urbanization, consumerism, etc. the generation of solid waste is increasing considerably, which is exerting load on the existing disposal sites. As per Punjab Pollution Control Board (PPCB), a total of 3034.65 tons per day (TPD) of solid waste is being generated in municipal areas including Cantonment boards. However, all municipal bodies do not have adequate infrastructure for handling the same. The life of existing landfill sites is also expected to be reduced with increase in volume of waste generation. The issue is discussed subsequently.

Pressure on infrastructure handling municipal solid waste due to increased waste disposal

As per Punjab State Council for Science and Technology (PSCST, 2005), the urban local bodies spend approximately Rs. 500 to Rs. 1500 per ton on solid waste collection, transportation, treatment and disposal. About 60-70% of this amount is spent on collection, 20-30% on transportation and less than 5% on final disposal. However, infrastructure available with MC's for collection, transportation and disposal/management is limited and mostly less than the required level for proper handling of

wastes. As a result, waste is not collected from the entire city on a daily basis and goes on accumulating at primary dumping sites. At the same time, continuously increasing waste puts pressure on the existing machinery and infrastructure. Detailed data in this context is, however, not available and warrants proper survey and assessment. A study conducted by PSCST at the behest of PPCB at Kartarpur and Mandi Gobindgarh indicates that the existing infrastructure required for collection of municipal solid waste is grossly inadequate (Table 3.4). However, out of total solid waste collected, on an average, 94% is dumped on land and 5% is composted. Hence, there is immense pressure on infrastructure. The situation in other towns of the state is also expected to be similar.

STATE

Waste generation

With rapid increase in population over the years, there has been an increase in number of Municipal Committees in the state (Table 3.5). There are in all 133 towns which are identified as Municipal Corporations, Municipal Councils, Nagar Panchayats and Improvement trusts (Box 3.2).

As already mentioned 3034.65 tons per day (TPD) of Municipal solid waste is generated in the state. The major waste is from class I cities as more than half of the state's urban population (58.39%) lives in these cities. Further, out of total municipal solid waste generation, 71% of waste is from the five corporations (Ludhiana, Amritsar, Jalandhar, Patiala and Bathinda) alone (Fig. 3.7).

Waste composition

The composition of municipal solid waste (MSW) also varies considerably from place to place. The average physical composition of municipal solid

Table 3.4 Gap in manpower and equipments with municipal bodies for solid waste management

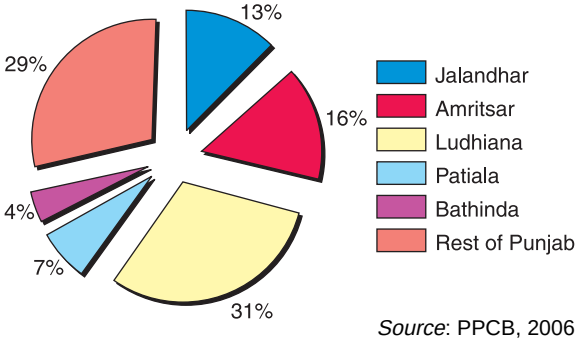
Source: PSCST, 2005

Table 3.5 Municipal bodies in Punjab

Year	Number
1980–81	105
1990–91	108
2004–2005	133

Source: Statistical Abstract of Punjab, 2005

Fig. 3.7 Generation of municipal solid waste in Punjab



Source: PPCB, 2006

waste generated in the state (Table 3.6) indicates that of the total solid waste, 13% is recyclable material, 36-44% is compostable material and 40-50% is inert material. The moisture level is about 50% and density ranges from 250–500 kg/m^3. However, a study carried out by CPCB in 59 cities (2004-2005) reveals that total compostable matter in the waste is in the range of 30-73 percent while recyclable fraction was observed between 10 and 36 percent. The moisture content in the MSW varies from 17 to 65 percent (Annexure 3.3).

The chemical composition (Table 3.7) indicates that the percentage of nitrogen ranges between 0.6-0.8 and that of phosphorus and potassium between 0.56-0.82 & 0.69-0.83 respectively. The carbon/nitrogen (C/N) ratio in the waste generated in the state is 21-31, where as the (C/N) ratio as studied by CPCB was observed to be in the range of 14-52 (Annexure 3.3). Specific studies carried out at Kartarpur and Mandi Gobindgarh indicate a similar trend (Table 3.8).

Waste disposal facilities

In all 137 municipal authorities, including Contonment Boards, are required to identify sites for management of municipal solid waste. Their size varies from town to town depending upon the population and infrastructure available. Only 38 municipal authorities have land adequate to handle municipal solid waste for more than 20 years as per Municipal Solid Waste (Handling and Management) Rules, 2000; 59 municipal authorities have land adequate to handle municipal solid waste for 5 to 20 years; 33 municipal authorities have land adequate to handle municipal solid waste for less than 5 years and 7 municipal authorities do not have land for disposal of their municipal solid waste (Fig. 3.8). It is a common practice that the waste

Table 3.6 Physical composition of MSW generated in Punjab

Source: PPCB, 2003

Table 3.7 Chemical composition of MSW generated in Punjab

Item	Percentage
Nitrogen	0.6–0.8
Phosphorus	0.56–0.82
Potassium	0.69–0.83
C/N	21–31

Source: PPCB, 2003

Seggregation of municipal soild waste by rag pickers

Table 3.8 Test results of MSW of Mandi Gobindgarh carried out by Sri Ram Institute for Industrial Research, Delhi

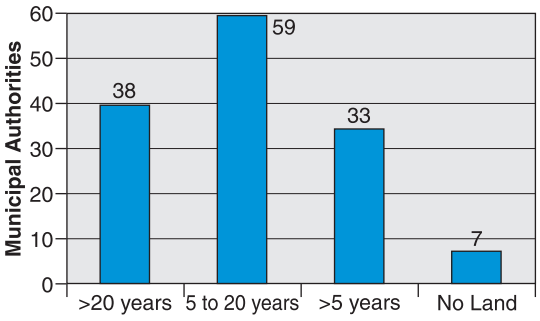
Sr. No.	Tests	Results	Protocol
1.	Moisture Content, % by Mass	39-48	IS9235-1979
2.	Physical Composition (Dry basis)		Mechanical Segregation
i.	Papers, % by mass	0.6-5.8	
ii.	Plastics, % by mass	4.3-13.9	
iii.	Rubber and leather, % by mass	Negligible-5.9	
iv.	Metals, % by mass	0.1-0.2	
v.	Glass and China wares, % by mass	0.2-1.0	
vi.	Clothes, % by mass	3.7-6.9	
vii.	Wood, % by mass	Negligible-0.6	
viii.	Stones and Bricks, % by mass	3.3-10.5	
ix.	Organic Residue, % by mass (Grass, vegetables, leaf, etc.)	18.2-24.0	
	x. Soiled matter and other, % by mass	50.5-59.7	
	a. Volatile matter, (loss at 600°C), % by mass	7.6-11.2	
	b. Non–Volatile matter, % by mass	40.3-48.5	
xi.	Total Compostable matter, % by mass (Organic residue + Volatile + paper + clothes + rubber and leather + wood)	36.0-43.5	
3.	Chemical Analysis		
i.	Volatile matter, (loss at 600°C), % by mass	22.2-24.6	IS 10158-1982
	ii. Non–Volatile matter, % by mass	75.4-77.8	IS 10158-1982
	iii. Ash content, % by mass	72.8-75.9	IS 1350 Pt-I-1970
iv.	Organic matter, % by mass	12.6-15.9	IS 2720 Pt-22
	v. Organic Carbon (as C), % by mass	7.3-9.2	IS 2720 Pt-22
	vi Nitrogen (as N) % by mass	0.6-0.8	IS 10158-1982
	vii. Gross Calorific Value, GCV, cal/gm	1088-1258	IS 1350 Pt-II-1970
D.O.R: 16.03.2005; D.O.C: 30.03.2005			

from households, shopping centres, offices, streets, etc. is generally dumped outside houses or at some designated or undesignated location, and is left for municipal authorities for taking it to a common dumping ground. City/town wise details are presented in Annexure 3.1.

Infrastructure for management of municipal solid waste

Proper collection, transportation and disposal of municipal solid waste requires availability and usage of job specific equipments and infrastructure.

Fig. 3.8 Lifespan of municipal solid waste dumping sites in the state



Source: PPCB, 2006

Equipments necessary for this purpose could include wheel barrows, tricycles, carts, tractor trolleys, dumper placers, etc. The requirement varies from town to town. Data in this respect from all towns of Punjab could not be collected inspite of repeated requests to the concerned departments and municipal bodies. A study was however, carried out by CDC on behalf of PSCST in 1997 for six towns of Punjab (Table 3.9) but this information needs to be updated. Subsequently studies were carried out in Kartarpur and Mandi Gobindgarh by PSCST (Box 3.3).

Table 3.9 Solid waste collection infrastructure (urban areas of six districts)

*RITES, 1998

Source: CDC, 1999

Box 3.3 Charactrization of MSW in Mandi Gobindarh & Kartarpur

Kartarpur

Kartarpur has been divided into 15 wards. As per physical composition, 37% of its waste is compostable, 13% recyclable and 50% is inert matter (Table 3.10). The work of management of MSW is executed through sanitary inspectors and safai-sewaks under the overall supervision of an Executive Officer. The Municipal Council is handling the primary collection of solid waste from 8 wards (Numbers 1-5 and 13-15). The collection from remaining 7 wards (Numbers 6 to 12) has been outsourced to a private contractor. Lifting from all the 15 wards is done by the contractor. The Municipal Council and private contractor have employed 22 safai-sewaks and drivers and 24 safai-sewaks respectively (Table 3.11). The infrastructure employed for MSW management in the town (available with the council and the private contractor) is given in Table 3.12.

Table 3.10 Physical composition of MSW generated in Kartarpur

Table 3.11 Manpower involved in management of MSW at Kartarpur

*Temporary basis

Table 3.12 Infrastructure available for management of MSW at Kartarpur

Source: PSCST, 2005

Mandi Gobindgarh

Mandi Gobindgarh has been divided into 19 wards. Management of MSW is executed under the overall supervision of an Executive Officer, who carries out the work through sanitary inspectors, sanitary supervisor and sanitary mates. One Sanitary mate is in–charge of around 50-60 safai-sewaks. The Municipal Council has employed a total of 132 safai-sewaks and drivers (Table 3.13). Also, safai-sewaks are deployed on temporary basis in addition to the regular staff from time to time as per requirement. The Municipal Council is handling the solid waste of 12 wards (1-5 and 13-19). The remaining 7 wards (from ward nos. 6 to 12) have been outsourced to the private contractor for collection, transportation and disposal of MSW. The private contractor has also engaged 46 safai-sewaks, including drivers and loaders. The

Table 3.13 Manpower involved in management of MSW at Mandi Gobindgarh

N

contd...

infrastructure employed for MSW management in the town (available with the council and the private contractor) is given in Table 3.14.

Table 3.14 Infrastructure available for management of MSW at Mandi Gobindgarh

*Out of the 3 tractor trolleys, only 2 were in good working condition at the time of survey.

Source: PSCST, 2005

IMPACTS

No specific study on impact of municipal solid waste on environment or health of people is available. General impacts due to improper handling/disposal of municipal solid waste are as under:

Health hazards

The municipal solid waste is thrown into municipal waste collection centres near residential localities from where it is collected by the municipal vehicles for putting into the dump site. However, either due to resource crunch or inefficient infrastructure, not all of this waste gets collected and transported to the final dumpsites. At this stage improper management and disposal of municipal solid waste can cause environmental pollution and serious health hazards. On-site burning of the waste, at times can cause air pollution. Besides this waste gets blown with the wind causing unaesthetic sights. It can also flow into the storm water drains especially during rainy season, thus blocking/choking them. Its decomposition at site also results in bad odour and soil pollution. General health hazards due to municipal solid waste are presented in Box 3.4.

Box 3.4 General diseases caused due to municipal solid waste

- Skin and Eye infection
- Dust in the air at dumpsites can cause breathing problems in children and adults
- Flies breed on uncovered rotting garbage and spread disease like diarrhoea, dysentery, hepatitis and cholera. Mosquitoes transmit many types of diseases like malaria and yellow fever.
- Dogs, cats and rats living around refuge carry a variety of diseases including plague and high fever.
- Intestinal, parasitic and skin diseases are found in workers engaged in collecting refuge.

Improper disposal of municipal solid waste

Improper disposal of solid waste affects community health

Pollution of surface and ground water

Pollution of water resources from solid waste dump sites has become one of the major problems today. Dumping of solid wastes in open low lying places is common practice in the state. Even banks of streams have become dumpsites. Otherwise also, the identified landfill sites have not been properly developed and lined. Once the dump site gets filled up, its closure is not done scientifically. Consequently the surface water bodies carry leachates of solid wastes. Through run off during rainy season, it can also percolate into ground and pollute ground water sources. Thus, the municipal solid waste, if not managed and treated properly, results in pollution of the environment.

RESPONSES

Legal and Administrative responses

- Municipal Solid Waste (Management and Handling) Rules, 2000, under Environment (Protection) Act, 1986, are being implemented in the state.
- To control manufacture and use of plastic carry bags from recycled plastic and to prohibit disposal of non-biodegradable plastic waste in public places, drains and sewers, the Government of Punjab has notified "The Punjab Plastic Carry Bags (Manufacture, Usage and Disposal) Control Act, 2005", and "The Punjab Plastic Carry Bags (Manufacturer, Usage and Disposal) Control (Amendment) Act, 2006". The state has also published public notices about ban on plastic carry bags (Box 3.5). A persuasive as well

Box 3.5 Public notice on ban on plastic carry bags

ਨਗਰ ਨਿਗਮ ਜਲੰਧਰ

ਪਬਲਿਕ ਨੋਟਿਸ

ਆਮ ਪਬਲਿਕ ਨੂੰ ਇਸ ਨੋਟਿਸ ਰਾਹੀ ਸੂਚਿਤ ਕੀਤਾ ਜਾਂਦਾ ਹੈ ਕਿ ਮੁਲ ਵਰਤੇ ਰੀਸਾਈਕਲਡ ਪਲਾਸਟਿਕ ਲਿਫਾਫੇ ਜੀਵੇ ਅਤੇ ਪਰਯਾਵਰਣ ਵਾਸਤੇ ਤੇਂ ਖਤਰੇ ਹੋਏ ਹਨ। ਇਹਨਾਂ ਦੀ ਵਰਤਣ ਨਾਲ ਸੀਵਰ ਤੇ ਹੋਰ ਕਈ ਥਾਂਵਾਂ ਬੰਦ ਹੋਣ ਕਾਰਨ ਬੀਮਾਰੀਆਂ ਦੇ ਸਬਵੀਆਂ ਹਨ ਅਤੇ ਇਹ ਪ੍ਰਦੂਸਣ ਵੀ ਫੈਲਾਉਂਦੇ ਹਨ। ਇਸ ਤੋਂ ਇਲਾਵਾ ਇਹ ਲਿਫਾਫੇ ਗਲਣਯੋਗ ਨਹੀ ਹੋਣੇ ਅਤੇ ਕੁਝ ਦੇ ਬੋਝਾਂ ਤੇ ਪਏ ਰਹਿਦੇ ਹਨ ਅਤੇ ਸੀਵਰੇਜ ਆਦਿ ਨੂੰ ਬੰਦ ਕਰਦੇ ਹਨ।

ਇਹਨਾਂ ਗੱਲਾਂ ਨੂੰ ਮੁੱਖ ਰੱਖਦੇ ਹੋਏ ਪੰਜਾਬ ਸਰਕਾਰ ਵਲੋਂ "ਦੀ ਪੰਜਾਬ ਪਲਾਸਟਿਕ ਕੈਰੀ ਬੈਗਸ (ਮੈਨੂਫੈਕਚਰਰ, ਯੂਸੇਜ ਐਂਡ ਡਿਸਪੋਜਲ) ਕੰਟਰੋਲ ਐਕਟ, 2005" ਬਣਾਇਆ ਗਿਆ ਹੈ। ਇਸ ਐਕਟ ਦੀਆਂ ਧਾਰਾਵਾਂ ਨੂੰ ਸਾਧਾਰਣ ਬੰਦਿਆਂ ਤੋਂਇਆ ਅਨਿਹੇ ਪਲਾਸਟਿਕ ਦੇ ਲਿਫਾਫੇ ਬਣਾਉਣ ਵਾਲੇ ਸਨਅਤੀ ਅਦਾਰਿਆਂ ਨੂੰ ਧਯਾਨਦਾਰ ਕੀਤਾ ਜਾਂਦਾ ਹੈ ਕਿ ਉਹ ਰੀਸਾਈਕਲਡ ਅਤੇ ਰੀਸਾਈਕਲਡ ਪਲਾਸਟਿਕ ਲਿਫਾਫੇ ਨਾ ਬਣਾਉਣ ਨਹੀਂ ਤਾਂ ਉਹਨਾਂ ਦੇ ਖਿਲਾਫ ਕਾਨੂੰਨੀ ਕਾਰਵਾਈ ਕੀਤੀ ਜਾਵੇਗੀ। ਇਸੇ ਤਰਾਂ ਲੋਕਾਂ ਨੂੰ ਵੀ ਅਪੀਲ ਕੀਤੀ ਜਾਂਦੀ ਹੈ ਕਿ ਉਹ ਦੁਕਾਨਦਾਰਾਂ, ਢਾਬਿਆਂ ਆਦਿ ਤੋਂ ਅਨਿਹੇ ਲਿਫਾਫਿਆਂ ਵਿਚ ਪਾਈਆਂ ਹੋਇਆ ਵਸਤਾਂ (ਚੀਜਾਂ) ਨਾ ਲੈਣ। ਇਹਨਾਂ ਦਾ ਇਸਤੇਮਾਲ ਨਾ ਕਰਕੇ ਪਬਲਿਕ ਆਪਣੀ, ਆਪਣੇ ਪਰਿਵਾਰ ਅਤੇ ਸਮਾਜ ਦੀ ਸਿਹਤ ਦੀ ਸੁਰੱਖਿਆ ਕਰ ਸਕਦੀ ਹੈ।

ਮੇਯਰ
ਨਗਰ ਨਿਗਮ, ਜਲੰਧਰ।

ਕਮਿਸ਼ਨਰ
ਨਗਰ ਨਿਗਮ, ਜਲੰਧਰ।

as punitive approach is being followed by the state government. Regular meetings are held with representatives of industries as well as municipal authorities in this regard.

- **Legal actions and court cases**

  Punjab Pollution Control Board has taken some legal actions to ensure the proper disposal of municipal solid waste in the state. This includes complaint filed in the court by PPCB vs Municipal Council, Phagwara under Environment Protection Act, 1986. Some public interest litigations have also been filed by individuals and societies (Box 3.6). Further, the implementation of Municipal Solid Waste (Management and Handling) Rules, 2000, and various directions from the court from time to time are being monitored at the highest level in the Government. The Chief Secretary, Government of Punjab took a meeting in October, 2004 with Principal Secretary, Local Government; Director, Local Government, and Principal Secretary, Department of Science, Technology and Environment to discuss the implementation of orders of Hon'ble Supreme Court of India and for compliance of Municipal Solid Waste (Management and Handling) Rules, 2000. A follow up meeting was also taken by Principal Secretary, Department of Science, Technology and Environment in March, 2005 to implement the directions of Hon'ble Supreme Court of India.

Box 3.6 List of court cases in the state w.r.t. municipal solid wastes

Supreme Court of India		CWP No. 888 of 1996 Almitra H. Patel v/s Union of India and others
Punjab and Haryana High Court	–	CWP No.7036 of 2005 Nirbhay Singh, Ludhiana v/s State of Punjab and others.
	–	CWP No. 5866 of 2006 Residents welfare society, Mohali v/s State of Punjab and others.
	–	CWP No. 2032 of 2006 Pollution Control Committee, Amritsar v/s Punjab Pollution Control Board and others.

Source: Punjab Pollution Control Board, 2006

Infrastructural Responses

- To implement the provisions of Municipal Solid Waste (Management and Handling) Rules, 2000, the Department of Local Government, Punjab had constituted District level committees (vide notification No. 8/50/2001–2LG4/20989 dated 29-12-2004) under the Chairmanship of Deputy Commissioners/Additional Deputy Commissioners to identify landfill sites for all the urban local bodies by 31-03-2005, the time frame for which was extended upto 31-03-2007. A state level committee has been constituted under the Chairmanship of Principal Secretary to Local Government, Punjab to monitor and review the progress of District Level Committees. As mentioned earlier 38 Municipal Authorities have identified land adequate to handle municipal solid waste for more than 20 years, 59 Municipal Authorities have identified land adequate to handle municipal solid waste for 5 to 20 years, 33 Municipal Authorities have identified land adequate to handle municipal solid waste for less than 5 years and 7 Municipal Authorities do not have land for disposal of their municipal solid waste and need to identify the same.

Further, Officers of the Department of Local Government and PPCB have studied the municipal waste management procedures including collection and segregation of municipal solid waste, development of landfill sites, waste processing facilities etc. at Ahmedabad, Surat and Vejalpur cities of Gujrat. Officers of the Department of Local Government have also studied municipal solid waste management procedures at Suryapet in Andhra Pradesh to get the same implemented by Urban Local Bodies of the state. The matter regarding management of municipal solid waste by Municipal Authorities in the state was also considered by the State Environment Council in its meeting held under the Chairmanship of Hon'ble Chief Minister, Punjab on 26-07-2006 and decisions were taken to expedite the identification of landfill sites and implementation of the provisions of Municipal Solid Waste (Management and Handling) Rules, 2000. Regular review meetings are also held by Department of Environment for implementation of Municipal Solid Waste (Management and Handling) Rules, 2000 and Plastic Carry Bags (Manufacture, Usage and Disposal) Control Act, 2005.

- The PPCB has got Detail Projects Reports (DPRs) prepared from PSCST, Chandigarh for getting financial assistance from Government of India for installation of pilot projects for solid waste management at Kartarpur and Mandi Gobindgarh. The DPRs have been submitted to the Ministry of Environment and Forests, Government of India for 50 % financial assistance. Central Pollution Control Board, Delhi has recommended the case of Municipal Council, Mandi Gobindgarh for financial assistance to Ministry of Environment and Forests, New Delhi. The matter is under active consideration of the Ministry.
- A combined facility is being developed by M/s National Building Construction Corporation Ltd. for two Municipal Councils of District Jalandhar and one Municipal Council of District Hoshiarpur (Adampur, Alwalpur and Sham Churasi) under Centrally Sponsored Scheme of Ministry of Urban Development and Poverty Allevation, New Delhi. The site for setting up of treatment and disposal facility near Village Pandori, District Hoshiarpur has already been approved by District Administration.
- Similarly, PPCB has proposed a demonstration plant for management of municipal solid waste for Quadian town, District Gurdaspur, as per the Detailed Project Report prepared by National Productivity Council, New Delhi.
- A Municipal Solid Waste processing facility had also been got established by Municipal Corporation, Jalandhar through M/s Punjab Grow More Pvt. Ltd. However, it is not functioning satisfactorily due to marketing problem of the compost produced.

Promotion of appropriate technologies

Besides disposal of municipal solid waste in landfills, appropriate low cost technologies are also being promoted for municipal solid waste treatment in the state. One such technology is vermicomposting which is being promoted at 275 locations in rural areas and 17 locations in urban areas.

Awareness and capacity building

- Besides making efforts to improve the infrastructure, the state government is also making efforts for awareness and capacity building. Orientation programmes were conducted from 31-08-2004 to 09-09-2004 region-wise in the state, to make the Municipal Authorities aware of provisions of Municipal Solid Waste (Management and Handling) Rules, 2000, including development and maintenance of landfill sites.
- The Human Resource Department (HRD) Foundation, New Delhi also conducted a workshop sponsored by Ministry of Environment and Forests, New Delhi in association with PPCB on 28th February to 1st March, 2006 at Chandigarh and on 15-16 December, 2006 at Jalandhar on "Management of Municipal Solid Wastes, and Plastic Wastes" wherein the issue was discussed thoroughly with various Municipal Authorities of the state.
- The officers of the Department of Local Government, Punjab and the State Board also attended an "Advocacy workshop on Scope and Dynamics of Integrated Solid Waste Management System- Moving towards implementations" organized by Ministry of Urban Development, Government of India and Water Supply and Sanitation Program-South Asia at Puri (Orissa) in January, 2007 to appraise themselves of latest technologies and management techniques.

RECOMMENDATIONS

In view of the enormity of the problem it is recommended that:

- The State Government should establish a cell in the Department of Local Government, Punjab consisting of experts with practical experience in the field of municipal solid management and collection and disposal of sewage, for handling environmental problems of all local bodies of the state. The government also needs to provide adequate funds out of state budget, international funding or public private partnerships for such purposes.
- The municipal bodies in the state need to be adequately strengthened in terms of technical manpower and infrastructure. For this, appropriate surveys be conducted by professional bodies.
- Intensive awareness and training programmes be undertaken by the municipal authorities.
- Segregation of waste at source and collection needs to be promoted as per provisions of the Municipal Solid Waste (Management and Handling) Rules, 2000.
- Landfill sites needs to be scientifically developed and maintained to avoid air and water pollution as per provisions of the Municipal Solid Waste (Management and Handling) Rules, 2000.
- Implementation of legal provisions need to be strengthened.
- Epidemiological studies need to be taken up to assess health impacts of municipal solid waste.

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ANNEXURE 3.1

Status of land available for disposal of municipal solid waste and quantity of MSW generated by various municipal authorities of the state

S. No.	Name of the Municipal Committee	Age of land for development of landfill site	Area of existing landfill sites (as on 31.12.2006)	Quantity of Solid waste generated (TPD)
JALANDHAR				
1.	Municipal Corporation, Jalandhar	2 year	2 Acres (low lying land near Suchi Pind) 14 Acre (Vill. Wariyana)	350
2.	Municipal Council, Nakodar	> 20 years	28 Kanals and 9 Marle 5 Acres on Malsian Road	10
3.	Municipal Council, Phillaur	15 years	27 Kanals	3
4.	Municipal Council, Kartarpur	10 years	4 Kanals approx. (at G.T. Road, Jalandhar) 1 Acre, 1 Acre	10
5.	Municipal Council, Alawalpur	> 20 years	4 Kanals Common disposal site is being developed at Sham Churasi	1.5
6.	Municipal Council, Adampur	> 20 years	4 Acres Common disposal site is being developed at Sham Churasi	3.75
7.	Municipal Council, Noor Mahal	2 years	2 Kanals	4
8.	Nagar Panchayat, Bhogpur	> 20 years	9.5 Acres	2
9.	Nagar Panchayat, Lohian Khas	6 years	6 Kanals	0.5
10.	Nagar Panchayat, Shahkot	> 20 years	2 Acres on Sarngoyal Road 4 Acres on Moga Road	0.5
11.	Municipal Council, Goraya	10 years	2 Kanals + 13 Kanal and 9 Marlas	2.8
12.	Cantonment Board, Jalandhar	4½ years	2.15 Acres (at village Subhana)	8
KAPURTHALA				
1.	Municipal Council, Kapurthala	> 20 years	12 Acres	30
2.	Municipal Council, Phagwara	4 ½ years	5 Acres	17
3.	Municipal Council, Sultanpur	6 years	1 Acre	4
4.	Nagar Panchayat, Dhillwan	2 years	2 Kanals and 3 Marlas (at Patti Mamad ki)	1.5
5.	Nagar Panchayat, Bagowal	10 years	1.0 Acre	5

6.	Nagar Panchayat, Bhulath	> 20 years	30 Kanals	0.55
AMRITSAR				
1.	Municipal Corporation, Amritsar	2 years	28 Acres	450
2.	Municipal Council, Jandiala Guru	> 20 years	7.5 Acres	2.25
3.	Municipal Council, Tarn Taran	3 years	1.25 Acres	5
4.	Municipal Council, Patti	7 years	2 Acre	4.5
5.	Municipal Council, Ramdass	18 years	2 Acres	1.5
6	Municipal Council, Majitha	16 years	1.5 Acres	3
7.	Nagar Panchayat, Ajnala	4 years	4 Kanals	6
8.	Nagar Panchayat, Khemkaran	> 20 years	2.9 Acres	1
9.	Nagar Panchayat, Rayya	10 years	1 Acre	2
10.	Municipal Council, Raja Sansi	16 years	1.5 Acres	2
11.	Cantonment Board, Amritsar	> 20 years	5 Acres	5
BATHINDA				
1.	Municipal Council, Bathinda	16 years	36 Acres	85
2.	Municipal Council, Rampura Phul	4 years	2 Acre (on Phul Road)	18
3.	Municipal Council, Goniana Mandi	> 20 years	3 Acres (on Jaitu Road)	2.5
4.	Municipal Council, Rama Mandi	10 years	2 Acres	8
5.	Municipal Council, Bhucho Mandi	8 years	1 Acre (At present). MC is arranging 2 Acres more land.	1.5
6.	Municipal Council, Kot Fatteh	15 years	7 Kanals 11 Malras (site is outside MC limits)	0.5
7.	Municipal Council, Sangat	> 20 years	1 Acres (on Rambagh Road)	1
MANSA				
1.	Municipal Council, Mansa	15 years	8 Acres	30

2.	Municipal Council, Budhlada	8 years	1.5 Acres	9
3.	Municipal Council, Maur Mandi	> 20 years	8 Acres	3
4.	Municipal Council, Bareta	> 20 years	4 Acre in shape of big ponds	2
5.	Nagar Panchayat, Bhikhi	14 years	2.1 Acres (on Budhlada Road)	5
6.	Nagar Panchayat, Sardulgarh	> 20 years	5.4 Acres	5
MUKATSAR				
1	Municipal Council, Muktsar	4 years	1.5 Acres + 2.25 = 3.75 Acres	17
2.	Municipal Council, Malout	3 years	2.5 Acres (on Burja Road near Abohar Railway line)	35
3	Municipal Council, Gidderbaha	12 years	4 Acres (on Peori Kubey Road)	16
4.	Nagar Panchayat, Bariwala	12 years	1 Acres (on Telephone Exchange Road)	2
SANGRUR				
1.	Municipal Council, Barnala	7 years	6.4 Acres	34
2.	Municipal Council, Malerkotla	10 years	3 Acres + 3 ½ Acres	44
3.	Municipal Council, Sangrur	7 years	5.5 Acres (on lease on Ubhewal Badrukhan Road)	30
4.	Municipal Council, Sunam	3 years	1.5 Acres	20
5.	Municipal Council, Ahmedgarh	7 years	1.5 Acres	4
6.	Municipal Council, Dhuri	6 years	3.5 Acres	10
7.	Municipal Council, Lehragaga	1½ years	0.33 Acre	2.5
8.	Municipal Council, Dhanaula	No land	No land of its own	4
9.	Municipal Council, Longowal	5 years	8 Kanals	1.5
10.	Municipal Council, Bhawanigarh	15 years	2½ Acres (Outside Chehalan Pati)	4
11.	Municipal Council, Bhadaur	2 years	½ Acres	1
12.	Municipal Council, Tappa	No land	No land of its own	2.5

13.	Nagar Panchayat, Moonak	13 years	2 Acres (on Tohana Road)	3
14.	Municipal Council, Khanauri	> 20 years	2.5 Acres in shape of pond	4
15.	Nagar Panchayat, Dirba	16 years	2 Acres	6
16.	Nagar Panchayat, Cheema	> 20 years	2 Acres	2
17.	Nagar Panchayat, Handiaya	10 years	1 Acres	3
PATIALA				
1.	Municipal Corporation, Patiala	8 years	14 Acres14.75 Acres	180
2.	Municipal Council, Nabha	> 20 years	5 Acres	18
3.	Municipal Council, Rajpura	> 20years	16 Acres	2.5
4.	Municipal Council, Patran	15 years	1 Acre land of committee. 2 Acres land on lease from Municipal Council, Ghagga	4
5.	Municipal Council, Samana	6 years	3 Acres (on lease)	12
6.	Municipal Council, Sanour	8 years	1.5 Acres	3
7.	Municipal Council, Banur	> 20 years	7 Acres	1.5
8.	Nagar Panchayat, Ghanour	> 20 years	2 Acres	0.5
9.	Nagar Panchayat, Ghagga	> 20 years	2 Acres	0.5
FATEHGARH SAHIB				
1.	Municipal Council, Mandi Gobindgarh	3 years	2 Acres	44
2.	Municipal Council, Sirhind	6 years	3 Acres	15
3.	Municipal Council, Amloh	12 years	2 Acres	4
4.	Municipal Council, Bassi Pathana	> 20 years	2.5 Acres (on Khamano Road) 2.5 Acres (on Sanghol Road)	22
5.	Nagar Panchayat, Khamano	> 20 years	3.5 Acres	1
FARIDKOT				
1.	Municipal Council, Kotkapura	3½ years	3 Acres	15

2.	Municipal Council, Faridkot	2½ years	2 Acres	12
3.	Municipal Council, Jaitu	> 20 years	7.5 Acres (located near Mela Ground)	10
FEROZPUR				
1.	Municipal Council, Ferozepur City	5 years	5 Acres (Private land)	12
2.	Municipal Council, Fazilka	> 20 years	13.25 Acres	27
3.	Municipal Council, Abohar	4 years	5 Acres	30
4.	Municipal Council, Talwandi Bhai	> 20 years	2 Acres 7 Kanals	1.5
5.	Municipal Council, Guru Harsahai	No land	No land of its own	1
6.	Municipal Council, Jalalabad	> 20 years	6 Acres	3.5
7.	Municipal Council, Zira	9 years	3 Acres	2.5
8.	Nagar Panchayat, Makhu	2 years	3 Kanal (at Jalandhar Byepass Road)	1.5
9.	Cantonment Board, Ferozepur Cantt.	8 years	5 Acres (Army land along the Border Road)	22
MOGA				
1.	Municipal Council, Moga	3 years	4 Acres	36
2.	Municipal Council, Dharmkot	2 years	4 Kanals	2
3.	Nagar Panchayat, Bagha Purana	No land	No land of its own	5
4.	Nagar Panchayat, Badhni Kalan	No land	No land of its own	0.2
HOSHIARPUR				
1.	Municipal Council, Hoshiarpur	> 20 years	28 Acres	25
2	Municipal Council, Dasuya	12 years	21 Kanals	3.8
3.	Municipal Council, Mukerian	> 20 years	6 Acres near Talwara bypass	3
4.	BBMB, Township, Talwara	> 20 years	5 Acres	3
5.	Municipal Council, Tanda Urmar	4 years	7 Kanals	3.5

6.	Municipal Council, Gardiwala	> 20 years	38 Kanals and 10 Marla	2.4
7.	Municipal Council, Sham Churasi	> 20 years	66 Kanals, 13 Marla at vill. Pandori for central scheme of Adampur	1
8.	Municipal Council, Garshankar	4 years	5 Kanals	4
9.	Municipal Council, Hariana	4 years	3 Kanal on road leading to Sham Churasi	4
10.	Municipal Council, Mahilpur	12 years	10 Kanals along Garh Shankar Road	7
NAWANSHEHAR				
1.	Municipal Council, Nawanshehar	5 years	1.8 Acre on Musapur road	12
2.	Municipal Council, Banga	3 years	5 Kanals	1.5
3.	Municipal Council, Rahon	10 years	1.22 Acres on Jadla Rahon road	4
4.	Municipal Council, Balachaur	9 years	14 Kanals 11 Marlas Madhani-Jagatpur road	2.2
LUDHIANA				
1.	Municipal Corporation, Ludhiana	6 years	21 Acres 40 Acres	850
2.	Municipal Council, Jagraon	3 years	2 Acres	26
3.	Municipal Council, Khanna	10 years	3.5 Acres and 13 Acres	43
4.	Municipal Council, Samrala	10 years	2 Acres	6
5.	Municipal Council, Raikot	6 years	2.25 Acres	6
6.	Nagar Panchayat, Doraha	5 years	1 Acre	2.8
7.	Municipal Council, Payal	6 years	½ Acre	1
8.	Municipal Council, Machiwara	> 20 years	5 Acres	4.5
9.	Nagar Panchayat, Sahwnewal	14 years	20 Kanals	1
10.	Nagar Panchayat, Mullanpur	No land	No land of its own	4.5
11.	Nagar Panchayat, Maloud	5 years	4 Bigah (on Kup Road)	2

MOHALI				
1.	Municipal Council, Dera Bassi	12 years	2 Acres (at Choe near River Ghaggar)	6
2	Municipal Council, Mohali	12 years	15 Acres land of Sohana Panchayat is used for disposal of solid waste	49
3.	Nagar Panchayat, Zirakpur	8 years	2 Acres (village Bishanpur within MC limits)	3.5
ROPAR				
1.	Municipal Council, Nangal	> 20 years	92 Kanals out of which 22 Kanals is presently used	6
2.	Municipal Council, Morinda	> 20 years	4 Acres	4
3.	Municipal Council, Kharar	10 years	5 Acres	8
4.	Municipal Council, Ropar	No land	No land	25
5.	Municipal Council, Anandpur Sahib	18 years	2.3 Acres	2
6.	Municipal Council, Kurali	> 20 years	6 Acres	0.3
GURDASPUR				
1.	Municipal Council, Gurdaspur	1½ years	1 Acre (Land is in shape of big pond)	20
2.	Municipal Council, Pathankot	4 years	7 Acres	9
3.	Municipal Council, Batala	< 1 year	4 Kanals and 4 Marlas (at Bhukar Khanna), 3 Kanals and 7 Marlas (at outside the city)	9
4.	Municipal Council, Dhariwal	2 years	4 Kanals	2
5.	Municipal Council, Dina Nagar	6 years	10.2 Kanals (near G.T. Road, Village Parmanand)	4
6.	Municipal Council, Quadian	7 years	140 Marlas (at Batala Road)	10
7.	Municipal Council, Sujjanpur	4 years	7 Kanals (near Bridge No. 3 Sujjanpur)	8.9
8.	Municipal Council, Fatehgarh Churian	> 20 years	39 Kanals 6 Marlas in shape of ponds	2
9.	Municipal Council, Shri Hargobindpur	< 1 years	10 marlas on Banko Bias River	2
10.	Municipal Council, Dera Baba Nanak	< 1 year	1 Kanal and 9 Marlas (near Shamshangat Dera Baba Nanak)	0.2

Source: Punjab Pollution Control Board, 2007

ANNEXURE 3.2

Quantities and waste generation rates in 59 cities of India studied by CPCB with the assistance of NEERI

S.No.	Name of City	Population (As per 2001 census)	Area (sq km)	Waste Quantity (TPD)	Waste Generation Rate (kg/c/day)
1.	Kavaratti	10,119	4	3	0.30
2.	Gangtok	29,354	15	13	0.44
3.	Itanagar	35,022	22	12	0.34
4.	Daman	35,770	7	15	0.42
5.	Silvassa	50,463	17	16	0.32
6.	Panjim	59,066	69	32	0.54
7.	Kohima	77,030	30	13	0.17
8.	Port Blair	99,984	18	76	0.76
9.	Shillong	1,32,867	10	45	0.34
10.	Simla	1,42,555	20	39	0.27
11.	Agartala	1,89,998	63	77	0.40
12.	Gandhinagar	1,95,985	57	44	0.22
13.	Dhanbad	1,99,258	24	77	0.39
14.	Pondicherry	2,20,865	19	130	0.59
15.	Imphal	2,21,492	34	43	0.19
16.	Aizwal	2,28,280	117	57	0.25
17.	Jammu	3,69,959	102	215	0.58
18.	Dehradun	4,26,674	67	131	0.31
19.	Asansol	4,75,439	127	207	0.44
20.	Kochi	5,95,575	98	400	0.67
21.	Raipur	6,05,747	56	184	0.30
22.	Bhubaneswar	6,48,032	135	234	0.36
23.	Tiruvanantapuram	7,44,983	142	171	0.23
24.	Chandigarh	8,08,515	114	326	0.40
25.	Guwahati	8,09,895	218	166	0.20
26.	Ranchi	8,47,093	224	208	0.25
27.	Vijaywada	8,51,282	58	374	0.44
28.	Srinagar	8,98,440	341	428	0.48
29.	Madurai	9,28,868	52	275	0.30
30.	Coimbatore	9,30,882	107	530	0.57
31.	Jabalpur	9,32,484	134	216	0.23

32.	**Amritsar**	**9,66,862**	**77**	**438**	**0.45**
33.	Rajkot	9,67,476	105	207	0.21
34.	Allahabad	9,75,393	71	509	0.52
35.	Vishakhapatnam	9.82,904	110	584	0.59
36.	Faridabad	10,55,938	216	448	0.42
37.	Meerut	10,68,772	142	490	0.46
38.	Nashik	10,77,236	269	200	0.19
39.	Varanasi	10,91,918	80	425	0.39
40.	Jamshedpur	11,04,713	64	338	0.31
41.	Agra	12,75,135	140	654	0.51
42.	Vadodara	13,06,227	240	357	0.27
43.	Patna	13,66,444	107	511	0.37
44.	**Ludhiana**	**13,98,467**	**159**	**735**	**0.53**
45.	Bhopal	14,37,354	286	574	0.40
46.	Indore	14,74,968	130	557	0.38
47.	Nagpur	20,52,066	218	504	0.25
48.	Lucknow	21,85,927	310	475	0.22
49.	Jaipur	23,22,575	518	904	0.39
50.	Surat	24,33,835	112	1000	0.41
51.	Pune	25,38,473	244	1175	0.46
52.	Kanpur	25,51,337	267	1100	0.43
53.	Ahmedabad	35,20,085	191	1302	0.37
54.	Hyderabad	38,43,585	169	2187	0.57
55.	Banglore	43,01,326	226	1669	0.39
56.	Chennai	43,43,645	174	3036	0.62
57.	Kolkata	45,72,876	187	2653	0.58
58.	Delhi	1,03,06,452	1483	5922	0.57
59.	Greater Mumbai	1,19,78,450	437	5320	0.45

Source: Central Pollution Control Board, 2006

Annexure 3.3

Waste characterisation in 59 cities of India studied by CPCB with the assistance of NEERI

S.No.	Name of City	Compostables) (%)	Recyclables (%)	C/N Ratio	HCV* (kcal/kg)	Moisture (%)
1.	Kavarati	46.01	27.20	18.04	2242	25
2.	Gangtok	46.52	16.48	25.61	1234	44
3.	Itanagar	52.02	20.57	17.68	3414	50
4.	Daman	29.60	22.02	22.34	2588	53
5.	Silvassa	71.67	13.97	35.24	1281	42
6.	Panjim	61.75	17.44	23.77	2211	47
7.	Kohima	57.48	22.67	30.87	2844	65
8.	Port Blair	48.25	27.66	35.88	1474	63
9.	Shillong	62.54	17.27	28.86	2736	63
10.	Simla	43.02	36.64	23.76	2572	60
11.	Agartala	58.57	13.68	30.02	2427	60
12.	Gandhinagar	34.30	13.20	36.05	698	24
13.	Dhanbad	46.93	16.16	18.22	591	50
14.	Pondicherry	49.96	24.29	36.86	1846	54
15.	Imphal	60.00	18.51	22.34	3766	40
16.	Aizwal	54.24	20.97	27.45	3766	43
17.	Jammu	51.51	21.08	26.79	1782	40
18.	Dehradun	51.37	19.58	25.90	2445	60
19.	Asansol	50.33	14.21	14.08	1156	54
20.	Kochi	57.34	19.36	18.22	591	50
21.	Raipur	51.40	16.31	223.50	1273	29
22.	Bhubaneswar	49.81	12.69	20.57	742	59
23.	Tiruvananthapuram	72.96	14.36	35.19	2378	60
24.	Chandigarh	57.18	10.91	20.52	1408	64
25.	Guwahati	53.69	23.28	17.71	1519	61
26.	Ranchi	51.49	9.86	20.23	1060	49
27.	Vijaywada	59.43	17.40	33.90	1910	46
28.	Srinagar	6177	17.76	22.46	1264	61
29.	Madurai	55.32	17.25	32.69	1813	46
30.	Coimbatore	50.06	15.52	45.83	2381	54
31.	Jabalpur	58.07	16.61	28.22	2051	35
32.	**Amritsar**	**65.02**	**13.94**	**30.69**	**1836**	**61**
33.	Rajkot	41.50	11.20	52.56	687	17

34.	Allahabad	35.49	19.22	19.00	1180	18
35.	Visakhapatnam	45.96	24.20	41.70	1602	53
36.	Faridabad	42.06	23.31	18.58	1319	34
37.	Meerut	54.54	10.96	19.24	1089	32
38.	Nasik	39.52	25.11	37.20	2762	62
39.	Varanasi	45.18	17.23	19.40	804	44
40.	Jamshedpur	43.36	15.69	19.69	1009	48
41.	Agra	46.38	15.79	21.56	520	28
42.	Vadodara	47.43	14.50	40.34	1781	25
43.	Patna	51.96	12.57	18.62	819	36
44.	**Ludhiana**	**49.80**	**19.32**	**52.17**	**2559**	**65**
45.	Bhopal	52.44	22.33	21.58	1421	43
46.	Indore	48.97	12.57	29.30	1437	31
47.	Nagpur	47.41	15.53	26.37	2632	41
48.	Lucknow	47.41	15.53	21.41	1557	60
49.	Jaipur	45.50	12.10	43.29	834	21
50.	Surat	56.87	11.21	42.16	990	51
51.	Pune	62.44	16.66	35.54	2531	63
52.	Kanpur	47.52	11.93	27.64	1571	46
53.	Ahemdabad	40.81	11.65	29.64	1180	32
54.	Hyderabad	54.20	21.60	25.90	1969	46
55.	Bangalore	51.84	22.43	35.12	2386	55
56.	Chennai	41.34	16.34	29.25	2594	47
57.	Kolkata	50.56	11.48	31.81	1201	46
58.	Delhi	54.42	15.52	34.87	1802	49
59.	Greater Mumbai	62.44	16.66	39.04	1786	54

Source: Central Pollution Control Board, 2006

4

Hazardous Waste

4

Hazardous Waste

Hazardous waste means any waste which by reason of any of its physical, chemical, reactive, toxic, inflammable, explosive or corrosive characteristics causes danger or is likely to cause danger to health or environment, whether alone or in contact with other wastes and substances (Hazardous Wastes (Management and Handling) Amendment Rules, 2003). It includes:

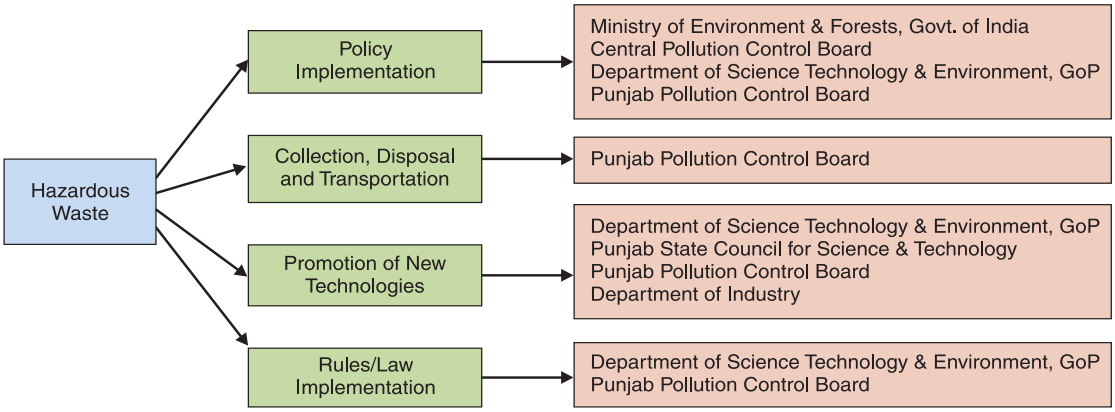
a) Wastes listed in column (3) of Schedule-1 of the Hazardous Waste (Management and Handling) Rules, 1989 (framed under the Environment Protection Act, 1986), as amended in 2000 and 2003 (Annexure 4.1).

b) Wastes having constituents listed in Schedule-2 of the amendment Rules, if their concentration is equal to more than the limit indicated in the said Schedule (Annexure 4.2).

c) Wastes listed in lists A and B of Schedule-3 (Part-A) of the above Rules applicable only in cases of import or export of hazardous waste in accordance with Rule-12,13 and 14, if they possess any of the hazardous characteristics listed in Part-B of Schedule-3 (Annexure 4.3).

During the past couple of decades, concern for the diversity and quantity of hazardous wastes generated by industrial activities and its effect on health and environment has increased considerably. Such wastes are usually residues of industrial operations involving heavy metals such as nickel, chrome, lead, mercury, etc; or utilizing different categories of oil and petrochemicals. Wastes from photocopiers and electronic equipments; chemicals such as Polychlorinated Biphenyls (PCBs); and by-products such as dioxins and furans are also recognized as extremely hazardous affecting all forms of life. Hazardous wastes in certain cases are also generated from process of treatment of wastewater and emissions of industries. Depending upon their characteristics, nature, and concentration of contaminants, some of these wastes are extremely toxic.

INSTITUTIONAL FRAME WORK



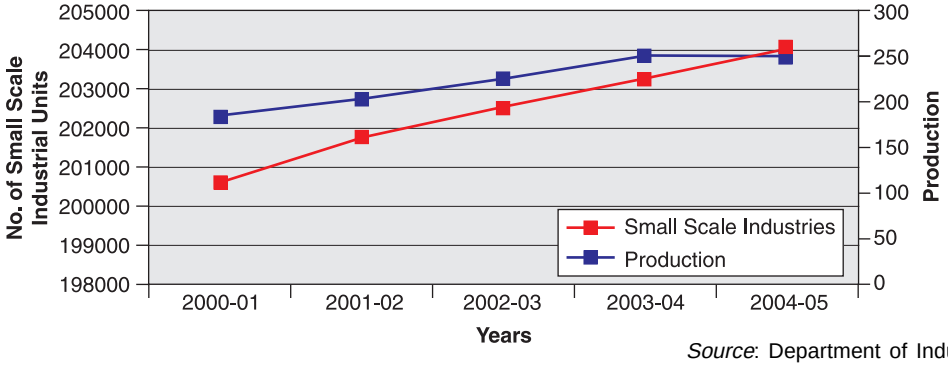
DRIVING FORCES

Major factors leading to generation of hazardous wastes in the state are, increase in production of industrial goods, increased use of lead acid batteries, increase in electronic equipments and use of inefficient technologies in several industries.

Increase in production of industrial goods

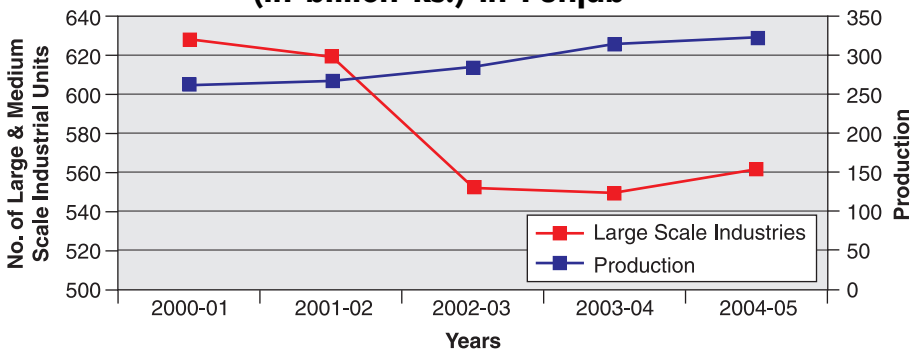
The economic development of a region is generally determined by the level of industrial development. Punjab, which has done remarkably well in the field of agriculture, is now well on its way to rapid industrialization through development of Small, Medium and Large scale industries. Around 2 lakhs small scale industries (Fig. 4.1) and 562 large and medium scale industries (Fig. 4.2) are functioning in the state with total production of over Rs. 570 billion. The state produces around 75% of bicycle and bicycle parts, sewing machines, woollen and other hosiery items, blankets, jacket cloth and sports goods. Out of these, 2628 industries have been identified as hazardous waste generating industries by Punjab Pollution Control Board (as on 28-02-2007).

Fig. 4.1 Number of small scale industries and their production (in billion Rs.) in Punjab



Source: Department of Industries, 2006

Fig. 4.2 Number of large & medium scale industries and their production (in billion Rs.) in Punjab



Source: Department of Industries, 2006

Increase in use of lead acid batteries

Punjab has a well developed road communication system. Due to this, a large number of goods and passenger transport vehicles ply in the state. The total number of motorized vehicles in the state has increased by approximately 10.2 times from 3.6 lacs in 1980-81 to more than 37.0 lacs in 2004-05 (Fig. 1.5).

Increase in vehicles has increased the demand of lead acid batteries over the years. The SLI (Starting, Lighting, Ignition) batteries used in cars, trucks and buses are the largest category of end users of lead. A new car contains about 12 kg of lead. In its lifetime, it may require about 56.7 kg of lead, out of which about 7 kg is released as direct emissions causing environmental pollution (www.cleancarcampaign.org). There are some lead acid battery manufacturing and assembling industries in operation particularly at Jalandhar, Ludhiana, Mohali, Fatehgarh Sahib, Moga, Malout, Mansa and Pathankot. Some of these are in the unorganized sector and are tiny units. Never-the-less, they contribute to hazardous waste generation in the state. Further, there are some importers of lead acid batteries in the state also.

Increase in electronic equipments

The era of seventies witnessed the foundation of electronics production. The Punjab government has set up an Electronics Township (called ELTOP) on a 290-acre site in Mohali, near Chandigarh. This township has emerged as one of the fastest growing centres for electronics production in the country. Projects set up in the township produce micro-electronic devices, computers, computer peripherals, communication equipments, electronic typewriters, nickel cadmium batteries, uninterrupted power supply systems, colour picture TV tubes, medical electronics, X-ray equipment, EPABX systems, etc. Some of these are with technical collaboration with international companies (www.punjabgov.nic.com). Many of these electronic equipments contribute to hazardous waste, once discarded.

Inefficient technologies

It is presumed that several industries are using inefficient technologies resulting in higher generation of wastes, including hazardous wastes. The High Powered Committee constituted by the Hon'ble Supreme Court of India has cautioned against the import of certain technologies and processes

which have been banned abroad, like production of H-acid, use of asbestoes, etc. as these technologies generate high amount of hazardous wastes. However, at present no data bank is available in this regard in Punjab.

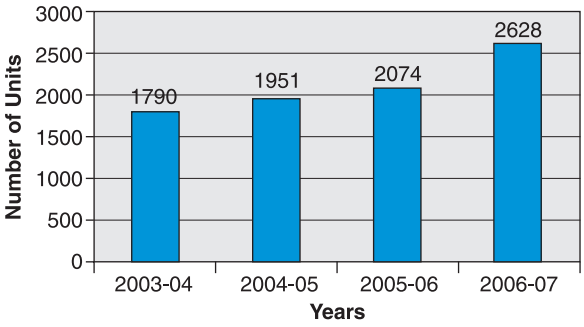
PRESSURES

The above-mentioned driving forces have directly or indirectly contributed to the generation of the hazardous waste in the state.

Increase in number of hazardous waste industry

With increase in small-scale, large and medium industrial units in the state, the number of hazardous waste generating industries is also increasing. At present there are 2628 hazardous waste generating units in the state (Fig. 4.3).

Fig. 4.3 Number of hazardous waste gerating industries in Punjab



Source: PPCB, 2007

Increase in lead pollution

With increase in use of vehicles, the use of lead acid batteries in the state has also increased manifold. The average life of a lead acid battery is estimated to be two years i.e. it has to be replaced by a new one. With a tenfold increase in vehicles in the state there has been a proportionate increase in use of lead acid batteries also. With so many batteries in use, their disposal and recycling is of paramount importance. The battery reprocessing units collect used batteries from different dealers, break them and recover the lead (The CPCB/MoEF has registered the industries which procure and process waste and manufacture lead/lead acid batteries in Punjab). The Ministry of Environment and Forests, Government of India, New Delhi vide its notification No. SO. 432 (E) dated 16.05.2001 has notified the Batteries (Management and Handling) Rules, 2001, to regulate the use and disposal of batteries.

Increase in E-waste

Electronic waste or e-waste includes used T.Vs, computers, mobile phones, electronic devices, etc. With increase in production and use of electronic goods, the generation of e-waste is also increasing. Though the IT industry has had a positive effect on the economy, however, it also has an ecological backlash. Computer waste is one of the most significant e-waste with respect to the rate at which it is being generated. In addition, its recycling is a complex process which involves many hazardous materials. It is estimated that in future, with the growth of IT industry, the situation will turn from bad to worse. According to a report on the Indian IT Sector by Gopalan (2002), the rate of obsolescence of computers in India is 2 % per week i.e in 50 weeks times the value of a computer becomes effectively zero. Table 4.1 shows the toxic elements of a computer which, when dumped without proper treatment/ recycling, could be a major source of toxic pollution and a threat to our lives and the natural environment. However, at present no data is available on the quantum of e-waste being generated in the state.

Table 4.1 Toxic elements of a computer

Components of PCs	Toxic constituents
Printed circuit boards	Lead and cadmium
Cathode Ray Tubes (CRTs)	Lead oxide and cadmium
Switches and flat-screen monitors	Mercury
Computer batteries	Cadmium
Capacitors and transformers	Poly Chlorinated Biphenyls (PCBs)
Printed circuit boards, plastic casing cable	Brominated Flame Retardants (BFRs)
Cable insulation	Poly Vinyl Chloride (PVC), releases highly toxic dioxins and furans when burned to retrieve copper from the wires

Source: Toxicslink.org

STATE

Hazardous waste generation

As discussed earlier, there are 2628 hazardous waste generating industries in the state. The total hazardous waste generated from these industries is 124674.70 tons per annum (TPA) out of which 96992.12 TPA is recyclable, 15108.75 TPA is incinerable and 12573.83 TPA is storable. All the major industries which generate incinerable hazardous waste have installed captive incinerators in their premises. The district wise generation of Hazardous wastes is given in Table 4.2.

Table 4.2 District wise generation of hazardous waste (TPA) in Punjab

District	Storable	Recyclable	Incinerable	Total
Amritsar	213.882	830.40	Nil	1044.282
Bathinda	91.148	353.75	Nil	444.898
Mansa	1.460	50.00	Nil	51.460
Mukatsar	59.040	168.00	Nil	227.040
Gurdaspur	105.387	423.63	Nil	529.017
Ropar	13.2076	161.00	Nil	174.207
Mohali	2283.779	51517.15	14849.02	68649.943
Faridkot	23.574	159.48	Nil	183.054
Moga	3.175	82.58	Nil	85.757
Ferozepur	42.660	106.32	Nil	148.980
Hoshiarpur	1252.810	2597.30	65.00	3915.110
Nawanshehar	408.417	1407.65	89.50	1905.567
Jalandhar	1602.515	147.31	30.00	1779.826
Kapurthala	299.151	2.52	Nil	301.681
Ludhiana	4549.017	6428.85	34.90	11012.763
Sangrur	574.151	32331.06	32.78	32937.993
Patiala	303.000	97.00	7.55	407.550
Fatehgarh Sahib	747.460	128.10	Nil	875.560
Total	**12573.834**	**96992.12**	**15108.75**	**124674.700**

Source: PPCB, 2007

Disposal of hazardous waste

Presently the hazardous waste generated by industries in the state is being stored in the premises of the industries in an environmentally sound manner. However, a common Treatment Storage and Disposal Facility (TSDF) is being developed in the state at Village Nimbuan, Tehsil Dera Bassi, District Mohali. The PPCB has leased land measuring 20.64 acres for TSDF on a nominal lease amount. The major generators in the state have formed a company namely M/s Nimbuan Greenfield Punjab Ltd. (NGPL) for development of the facility through M/s Ramky Enviro Engineers Ltd., Hyderabad on DBO (design, build and operate) basis. The construction of the facility has already started and it is likely to be commissioned by June, 2007. The expected life of this facility is about 15 years.

Industrial technologies used for refining/recycling hazardous waste

Waste oil is an important hazardous waste in Punjab. As per Rule 19 and 20 of the Hazardous Waste (Management and Handling) Rules, 1989, as amended in 2003, every person desirous of recycling or refining used waste oil shall register with Central Pollution Control Board. Till date six units with a total recycling/refining capacity of 13,600 kl/annum of waste oil have obtained authorization from CPCB and PPCB. These units use vacuum distillation technology.

Some efforts are also being made to develop and demonstrate low waste and no-waste technologies in the state by Punjab State Council for Science and Technology.

IMPACTS

Affect on environment

Hazardous wastes, if not treated and disposed off properly can adversely affect the soil and water, especially ground water, in an area. Specific studies are, however, lacking with respect to Punjab.

Health effects on humans

Most hazardous wastes contain heavy metals which are toxic. They enter the human/animal body through food, water, air, or absorption through the skin when they come in contact with humans in agriculture and in manufacturing, pharmaceutical, industrial, or residential settings. They are not metabolized by the body and accumulate in the soft tissues. Industrial exposure accounts for a common route of exposure for adults. Presently, no specefic study is available on health effects due to hazardous waste. Box 4.1 shows general health effects of metals on humans.

RESPONSES

The state government has initiated several actions for management of hazardous wastes. Some initiatives include:

Legal and Administrative set up

- Hazardous waste (Management and Handling) Rules, 1989 (amended in 2000 and 2003) under Environment (Protection) Act, 1986, are implementable in the state.

Box 4.1 Health effects of some metals found in hazardous wastes

Toxic Metals	Health Affects
Lead	Damages kidneys and central nervous system particularly in children and can affect their IQ.
Mercury	Permanent damage to brain, kidneys and developing foetus.
Chromium	Stomach upset, ulcers, liver damage and even death.
Nickel	Skin irritation, decreased body weight, heart and liver damage.
Copper	Gastrointestinal distress.
Zinc	Fever, pain, fatigue, shivering, sweating.

- The Punjab Pollution Control Board is responsible for collecting data on hazardous waste generation in the state, as well as, inspects and ensures its proper storage. The Board has set up a hazardous waste cell.
- The Board tries to ensure that waste emission standards specified by Government of India with respect to major polluting categories of industries are complied with, by providing adequate pollution control measures. It takes legal action against the defaulting units. The status of hazardous waste industries in Punjab is shown as Table 4.3.

Table 4.3 Status of hazardous waste industries in Punjab as on 28.02.2007

Source: PPCB, 2007

Infrastructure facilities

- The Punjab Pollution Control Board is encouraging industries to replace outdated or inefficient technologies with latest technologies to decrease hazardous waste generation and consequent pollution. Rule 21 of the Hazardous Waste (Management and Handling) Rules, 1989, as amended in 2003, provides for the technology and standards for re-refining/recycling of used oil/waste in an environmentally sound manner.
- As already stated above, the state government is developing a common hazardous waste management storage and disposal facility at village Nimbuan, tehsil Dera Bassi, District Mohali.The construction is likely to be completed by June 2007. A committee constituted by the Supreme Court of India is monitoring the progress of site in this respect.

Common TSDF under construction

Waste minimization

- The industries which have complied with the Hazardous Waste (Management and Handling) Rules are granted authorization on the condition that they will adopt technologies which minimize the waste generation.
- On the initiative taken by Punjab Pollution Control Board, USAID adopted a cluster of textile/ dyeing industries in Ludhiana under cleaner technology initiative (CTI) programme. The programme focused on waste minimization by way of better fuel efficiency, water conservation, better process efficiency and also replacement of chemicals wherever required and possible. The industries informed that the programme had resulted in a cost reduction of about 25%. Moreover, some of the industries under the programme got ISO-14001 certification as a result of this programme.

Awareness and training programs

The Punjab Pollution Control Board and Consultancy Cell of PSCST are organizing awareness programs from time to time. Fifteen representatives from various State Pollution Control Boards (SPCB) attended training programme on Clean Technologies and Waste Minimization for Prevention of Industrial Pollution held by PSCST in Chandigarh in December, 2005.

RECOMMENDATIONS

For better management of hazardous wastes generated from various processes the following steps are suggested:

- The industry should go for cleaner technology processes so as to reduce the generation of hazardous waste at source site.
- The persons handling hazardous waste should be given proper training for handling such waste in a proper manner. They should also be provided with gloves, goggles and masks, etc.
- The transportation of hazardous wastes should be done as per the provisions of Hazardous Waste (Management and Handling) Rules, 1989, as amended in 2003.
- The hazardous wastes should be disposed off in the common secured landfill site after required treatment/neutralization.
- A common incineration facility be provided for effective control of the incinerable hazardous wastes.

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Annexure 4.1

Schedule 1

[*See* rule 3(14)(a)]

List of Hazardous Wastes

S.No.	Processes	Hazardous Wastes
1.	Petrochemical processes and pyrolytic operations	1.1 Furnace/reactor residue and debris* 1.2 Tarry residues 1.3 Oily sludge emulsion 1.4 Organic residues 1.5 Residues from alkali wash of fuels 1.6 Still bottoms from distillation process 1.7 Spent catalyst and molecular sieves 1.8 Slop oil from wastewater 1.9 ETP sludge containing hazardous constituents
2.	Drilling operation for oil and gas Production	2.1 Drill cuttings containing oil 2.2 Sludge containing oil 2.3 Drilling mud and other drilling wastes*
3.	Cleaning, emptying and maintenance of petroleum oil storage tanks including ships	3.1 Oil-containing cargo residue, washing water and sludge 3.2 Chemical-containing cargo residue and sludge 3.3 Sludge and filters contaminated with oil 3.4 Ballast water containing oil from ships.
4.	Petroleum refining/re-refining of used oil/recycling of waste oil	4.1 Oily sludge/emulsion 4.2 Spent catalyst 4.3 Slop oil 4.4 Organic residues from process 4.5 Chemical sludge from waste water treatment 4.6 Spent clay containing oil
5.	Industrial operations usingmineral/ synthetic oil as lubricant in hydraulic systems or other applications	5.1 Used/spent oil 5.2 Wastes/residues containing oil
6.	Secondary production and/or use of Zinc sulphate production	6.1 Sludge and filter press cake arising out of zinc 6.2 Zinc fines/dust/ash/skimmings (dispersible form) 6.3 Other residues from processing of zinc ash/skimmings 6.4 Flue gas dust and other particulates*
7.	Primary production ofzinc/lead/copper and other non-ferrous metals except aluminium	7.1 Flue gas dust from roasting* 7.2 Process residues 7.3 Arsenic-bearing sludge 7.3 Metal bearing sludge and residue including jarosite 7.4 Sludge from ETP and scrubbers
8.	Secondary production of copper	8.1 Spent electrolytic solutions 8.2 Sludges and filter cakes 8.3 Flue gas dust and other particulates*
9.	Secondary production of lead	9.1 Lead slag/Lead bearing residues 9.2 Lead ash/particulate from flue gas

S.No.	Processes	Hazardous Wastes
10.	Production and/or use of cadmium and arsenic and their compounds	10.1 Residues containing cadmium and arsenic
11.	Production of primary and secondary aluminium	11.1 Sludges from gas treatment 11.2 Cathode residues including pot lining wastes 11.3 Tar containing wastes 11.4 Flue gas dust and other particulates* 11.5 Wastes from treatment of salt slags and black drosses*
12.	Metal surface treatment, such asetching, staining, polishing, galvanising, cleaning, degreasing, plating, etc.	12.1 Acid residues 12.2 Alkali residues 12.3 Spent bath/sludge containing sulphide, cyanide and toxic metals 12.4 Sludge from bath containing organic solvents 12.5 Phosphate sludge 12.6 Sludge from staining bath 12.7 Copper etching residues 12.8 Plating metal sludge 12.9 Chemical sludge from waste water treatment
13.	Production of iron and steel including other ferrous alloys (electric furnaces; steel rolling and finishing mills; Coke oven and by product plant)	13.1 Process dust* 13.2 Sludge from acid recovery unit 13.3 Benzol acid sludge 13.4 Decanter tank tar sludge 13.5 Tar storage tank residue
14.	Hardening of steel	14.1 Cyanide-, nitrate-, or nitrite-containing sludge 14.2 Spent hardening salt
15.	Production of asbestos or asbestos-containing materials	15.1 Asbestos-containing residues 15.2 Discarded asbestos 15.3 Dust/particulates from exhaust gas treatment.
16.	Production of caustic soda and Chlorine containing materials	16.1 Mercury bearing sludge 16.2 Residue/sludges and filter cakes* 16.3 Brine sludge containing mercury
17.	Production of acids	17.1 Residues, dusts or filter cakes* 17.2 Spent catalyst*
18.	Production of nitrogenous and complex fertilizers	18.1 Spent catalyst* 18.2 Spent carbon* 18.3 Sludge/residue containing arsenic 18.4 Chromium sludge from water cooling tower 18.5 Chemical sludge from waste waster treatment
19.	Production of phenol	19.1 Residue/sludge containing phenol
20.	Production and/or industrial use of solvents	20.1 Contaminated aromatic, aliphatic or napthenic solvents not fit for originally intended use 20.2 Spent solvents 20.3 Distillation residues
21.	Production and/or industrial use of paints, pigments, lacquers,varnishes, plastics and inks	21.1 Wastes and residues 21.2 Fillers residues

S.No.	Processes	Hazardous Wastes
22.	Production of plastic raw materials	22.1 Residues of additives used in plastics manufacture like dyestuffs, stabilizers, flame retardants, etc. 22.2 Residues of platicisers 22.3 Residues from vinylchloride monomer production 22.4 Residues from acrylonitrile production 22.5 Non-polymerised residues
23.	Production and/or industrial use of glues, cements, adhesive and resins	23.1 Wastes/residues (not made with vegetable or animal materials)*
24.	Production of canvas and textiles	24.1 Textile chemical residues* 24.2 Chemical sludge from waste water treatment
25.	Industrial production and formulation of wood preservatives	25.1 Chemical residues 25.2 Residues from wood alkali bath
26.	Production or industrial use of synthetic dyes, dye-intermediates and pigments	26.1 Process waste sludge/residues containing acid or other toxic metals or organic complexes 26.2 Chemical sludge from waste water treatment 26.3 Dust from air filtration system
27.	Production or industrial use of materials made with organo-silicone compounds	27.1 Silicone -containing residues 27.2 Silicone oil residues
28.	Production/formulation of drugs/ pharmaceuticals	28.1 Residues and wastes* 28.2 Spent catalyst/spent carbon 28.2 Off specification products 28.3 Date-expired, discarded and off- specification drugs/ medicines 28.4 Spent mother liquor 28.5 Spent organic solvents
29.	Production, use and formulation of pesticides including stock-piles	29.1 Wastes/residues containing pesticides 29.2 Chemical sludge from waste water treatment 29.3 Date-expired and off-specification pesticides
30.	Leather tanneries	30.1 Chromium bearing residue and sludge 30.2 Chemical sludge from waste water treatment
31.	Electronic Industry	31.1 Residues and wastes* 31.2 Spent etching chemicals and solvents
32.	Pulp and Paper Industry	32.1 Spent chemicals 32.2 Corrosive wastes arising from use of strong acid and bases 32.3 Sludge containing adsorbable organic Halides
33.	Disposal of barrels/containers used for handling of hazardous wastes/chemicals	33.1 Chemical-containing residue from decontamination and disposal 33.2 Sludge from treatment of waste water arising out of cleaning/disposal of barrels/containers 33.3 Discarded containers/barrels/liners used for hazardous wastes/chemicals
34.	Purification processes for air andwater	34.1 Flue gas cleaning residue* 34.2 Toxic metal-containing residue from used-ion exchange material in water purification

S.No.	Processes	Hazardous Wastes
		34.3 Chemical sludge from waste water treatment 34.4 Chemical sludge, oil and grease skimming residues from common industrial effluent treatment plants (CETPs) and industry-specific effluent treatment plants (ETPs) 34.5 Chromium sludge from cooling water treatment
35.	Purification process for organiccompounds/ solvents	35.1 Filters and filter material which have organic liquids in them, e.g. mineral oil, synthetic oil and organic chlorine compounds 35.2 Spent catalyst* 35.3 Spent carbon*
36.	Waste treatment processes, e.g. incineration, distillation, separation and concentration techniques	36.1 Sludge from wet scrubbers 36.2 Ash from incineration of hazardous waste, flue gas cleaning residues 36.3 Spent acid from batteries 36.4 Distillation residues from contaminated organic solvents

* Unless proved otherwise by the occupier based on sampling and analysis carried out by a laboratory recognized under the Act not to contain any of the constituents mentioned in Schedule 2 to the extent of concentration limits specified therein.

Annexure 4.2

Schedule-2

[See rule 3 (14) (b)]

List of Wastes Constituents with Concentration Limits*

Class A

Concentration limit: 50 mg/kg

A1 Antimony and antimony compounds
A2 Arsenic and arsenic compounds
A3 Beryllium and beryllium compounds
A4 Cadmium and cadmium compounds
A5 Chromium (VI) compounds
A6 Mercury and mercury compounds
A7 Selenium and selenium compounds
A8 Tellurium and tellurium compounds
A9 Thallium and thallium compounds
A10 Inorganic cyanide compounds
A11 Metal carbonyls
A12 Napthalene
A13 Anthracene
A14 Phenanthrene
A15 Chrysene, benzo (a) anthracene, fluoranthene, benzo (a) pyrene, benzo (K) fluoranthene, indeno (1, 2, 3-cd) pyrene and benzo (ghi) perylene
A16 halogenated compounds of aromatic rings, e.g. polychlorinated biphenyls, polychloroterphenyls and their derivatives
A17 Halogenated aromatic compounds
A18 Benzene
A19 Organo-chlorine pesticides
A20 Organo-tin Compounds

Class B

Concentration limit: 5, 000 mg/kg

B1 Chromium (III) compounds
B2 Cobalt compounds
B3 Copper compounds
B4 Lead and lead compounds
B5 Molybdenum compounds
B6 Nickel compounds
B7 Inorganic Tin compounds
B8 Vanadium compounds
B9 Tungsten compounds
B10 Silver compounds
B11 Halogenated aliphatic compounds
B12 Organo phosphorus compounds
B13 Organic peroxides
B14 Organic nitro-and nitroso-compounds
B15 Organic azo-and azooxy compounds
B16 Nitriles
B17 Amines
B18 (Iso-and thio-) cyanates
B19 Phenol and phenolic compounds
B20 Mercaptans
B21 Asbestos
B22 Halogen-silanes
B23 Hydrazine (s)
B24 Flourine
B25 Chlorine
B26 Bromine
B27 White and red phosphorus
B28 Ferro-silicate and alloys
B29 Manganese-silicate
B30 Halogen-containing compounds which produce acidic vapours on contact with humid air or water, e.g. silicon tetrachloride, aluminium chloride, titanium tetrachloride

Class C

Concentration limit; 20, 000 mg/kg

C1 Ammonia and ammonium compounds
C2 Inorganic peroxides
C3 Barium compounds except barium sulphate
C4 Fluorine compounds
C5 Phosphate compounds except phosphates of aluminium, calcium and iron
C6 Bromates, (hypo-bromites)
C7 Chlorates, (hypo-chlorites)
C8 Aromatic compounds other than those listed under A12 to A18
C9 Organic silicone compounds
C10 Organic sulphur compounds
C11 Iodates
C12 Nitrates, nitrites
C13 Sulphides
C14 Zinc compounds

C15 Salts of per-acids

C16 Acid amides

C17 Acid anhydrides

Class D

Concentration limit: □ 50, 000 mg/kg

D1 Total Sulphur

D2 Inorganic acids

D3 Metal hydrogen sulphates

D4 Oxides and hydroxides except those of hydrogen, carbon, silicon, iron, aluminum, titanium, manganese, magnesium, calcium

D5 Total hydrocarbons other than those listed under A12 to A18

D6 Organic oxygen compounds

D7 Organic nitrogen compounds expressed as nitrogen

D8 Nitrides

D9 Hydrides

Class E

Regardless of concentration limit; Classified as hazardous wastes at all concentrations

E1 Flammable substances

E2 Substances which generate hazardous quantities of flammable gases on contact with water or damp air

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*Waste constituents and their concentration limits given in this list are based on BAGA the Netherlands Environment Protection Agency) List of Hazardous Substances. In order to decide whether a specific material listed above is hazardous or not, following points be taken into consideration:

(i) If a component of the waste appears in one of the five risk classes listed above (A, B, C, D or E) and the concentration of the component is equal to or more than the limit for the relevant risks class, the material is then classified as hazardous waste.

(ii) If a chemical compound containing a hazardous constituent is present in the waste, the concentration limit does not apply to the compound, but only to the hazardous constituent itself.

(iii) If multiple hazardous constituents from the same class are present in the waste, the concentrations are added together.

(iv) If multiple hazardous constituents from different classes are present in the waste, the lowest concentration limit corresponding to the constituent(s) applies.

(v) For substances in water solution, the concentration limit for dry matter must be used. If the dry matter content is less than 0.1% by weight, the concentration limit, reduced by a factor of one thousand, applies to the solution.

Annexure 4.3

Schedule-3

[See rules 3 (14) (c) and 12(a)]

Part A: Lists of Wastes Applicable for Import and Export

List-A*

Basel No.	Description of Wastes	Annex-I**	Annex -III#	OECDNo.	Customs Code
AI	**Metal and Metal bearingwastes**				
A1010	Metal waste and waste consisting of alloys of the following metals, but excluding such wastes specified on list B (corresponding mirror entry under List B in brackets)				
	– Antimony	Y27	6.1, 11, 12	AA070	ex 2620.90
	– Cadmium	Y26	6.1, 11, 12	AA070	ex 2620.90
	– Tellurium	Y28	6.1, 11, 12	AA070	ex 2620.90
	– Lead	Y31	6.1, 11, 12		
A1020	Waste having as constituents or contaminants, excluding metal wastes in massive form, any of the following:				
	– Cadmium, cadmium compounds. (see B1020)	Y26	6.1, 11, 12	AA070	ex 2620.90
	– Antimony, antimony compounds. (see B1020)	Y27			
	– Tellurium, tellurium compounds. (see B1020)	Y28	6.1, 11, 12	AA070	ex 2620.90
	– Lead, lead compounds. (see B1020)	Y31	6.1, 11, 12	AA030	ex 2620.20
A1040	Wastes having as constituents any of the following:				
	– Metal carbonyls	Y19	6.1, 11, 12		
A1050	Galvanic sludges	Y17	6.1, 12	AA120	
A1060	Wastes Liquors from the pickling of metals.	Y17	6.1, 12	AA130	
A1070	Leaching residues from zinc processing, dusts & sludges such as jarosite, hematite, geoethite, etc.	Y23	12	AA140	
A1080	Waste Zinc residues not included on list B containing lead and cadmium in concentrations sufficient to exhibit hazard characteristics indicated in part B of this schedule (see B1080 andB1100)	Y23	4.3, 12	AA020	ex 262019 ex 2620.1 ex 2817
A1090	Ashes from the incineration of insulated copper wire	Y22	12		
A1100	Dust and residues from gas cleaning systems of copper smelters	Y18 Y22	12		ex 2620.30
A1110	Spent electrolytic solutions from copper electro refining and electro winning operations	Y22	12		ex 2620.30
A1120	Wastes sludges, excluding anode slimes, from electrolytic purification systems in copper electro refining and electrowinning operations	Y18 Y22	12		ex 2620.30

Basel No.	Description of Wastes	Annex-I**	Annex -III#	OECDNo.	Customs Code
A1130	Spent etching solutions containing dissolved copper	Y22	12		ex 3824.90
A1150	Precious metal ash from incineration of printed circuit boards not included on list 'B' (see B-1160)			AA161	ex7112.10
A1160	Waste Lead acid batteries whole or crushed	Y31	6.1, 11, 12	AA170	
A1170	Unsorted waste batteries excluding mixtures of only List B batteries. Waste batteries not specified on List B containing schedule 2 constituents to an extent to render them hazardous (seeB1090)	Y26 Y29 Y31	6.1, 11, 12		ex 8548.10 ex 8548.90
A1180	Waste Electrical and electronic assembles or scrap containing, compounds such as accumulators and other batteries included on list A, mercury-switches, glass from cathode -ray tubes and other activated glass and PCB capacitors, or contaminated with Schedule 2 constituents (e.g. cadmium, mercury, lead,polychlorinated biphenyl) toan extent that they exhibithazard characteristics indicated in part B of this Schedule (see B1110)				
A2	**Wastes containing principally inorganic constituents, which may contain metals and organic materials**				
A2010	Glass waste from cathode ray tubes and other activated glasses	Y31	6.1, 11, 12	AB040	ex 7001.00
A2030	Wastes catalysts but excluding such wastes specified on List B	Y31			
A3	**Wastes containing principally organic constituents which may contain metals and inorganic materials**				
A3010	Waste from the production or processing of petroleum coke and bitumen	Y11		AC010	ex 2713.90
A3020	Waste mineral oils unfit for their originally intended use	Y8		AC030	2710.00 3823.90
A3050	Wastes from production formulation and use of resins, latex, plasticisers, glues/adhesives excluding such wastes specified in List B (B4020)	Y13		AC090	
A3070	Waste phenol, phenol compounds including chlorophenol in the form of liquids or sludges	Y39		AC110	
A3080	Waste ethers not including those specified in List B			AC 130	
A3120	Fluff: light fraction from shredding			AC190	

Basel No.	Description of Wastes	Annex-I**	Annex -III#	OECDNo.	Customs Code
A3130	Waste organic phosphorus compounds	Y37		AC200	
A3140	Waste non-halogenated organic solvents (but excluding such wastes specified on List B)	Y42		AC210	
A3160	Waste halogenated or unhalogenated non-aqueous distillation residues arising from organic solvent recovery operations	Y18		AC230	
A3170	Waste arising from the production of aliphatic halogenated hydrocarbons (such as chloromethanes, dichloroethane, vinylchloride, vinylidene chloride, allylchloride and epichlorhy drin)	Y45		AC240	
A4	Wastes which may contain either inorganic or organic constituents				
A4010	Wastes from the production and preparation and use of pharmaceutical products but excluding such wastes specified on List B	Y2			ADVISE R010
A4040	Wastes from the manufacture formulation and use of wood preserving chemicals	Y5 Y22 Y24			ADVISE R030
A4070	Waste from the production, formulation and use of inks, dyes, pigments, paints, lacquers, varnish excluding those specified in List B(B4010)	Y12			ADVISE R070
A4080	Wastes of an explosive nature excluding such wastes specified on List B	Y15			
A4090	Waste acidic or basic solutions excluding those specified in List B (B2120)	Y34 Y35			AB110 ADVISE R110
A4100	Wastes from industrial pollution control devices for cleaning of industrial off -gases excluding such wastes specified on List B	Y18			
A4110	Wastes that contain, consist of or are contaminated with any of the following: • Any congenor of polychlorinated dibenzofuran • Any congenor of polychlorinated dibenzodioxin	Y43			RC010
A4120	Wastes that contain, consistof or are contaminated with peroxides				
A4130	Waste packages and containers containing any of the constituents mentioned in Schedule 2 to the extent of concentration limits specified therein				

Basel No.	Description of Wastes	Annex-I**	Annex -III#	OECDNo.	Customs Code
A4140	Waste consisting of or containing off specification or out-dated chemicals containing any of the constituents mentioned in Schedule 2 to the extent of concentration limits specified therein	Y3			
A4150	Waste chemical substances arising from research and development or teaching activities which are not identified and/or are new and whose effects on human health and/or the environment are not known	Y14			
A4160	Spent activated carbon not included on List B (B2060)				ex 2803

* List A given as Annex.VIII of the Basel Convention on Transboundary Movement of Hazardous Wastes and their disposal comprises of wastes characterized as hazardous under Article 1, paragraph 1(a) of the Convention. Inclusion of wastes on this list does not preclude the use of hazard characteristics given in Annex.III of Basel Convention to demonstrate that the wastes are not hazardous. Above list is modified to the extent that certain waste categories given in List 'A' (Annex VIII) of Basel Convention have been prohibited for import and export under the Environment(Protection) Act, 1986 and are listed separately under Schedule 8 of these Rules. Hazardous wastes in the above list are restricted and cannot be allowed to be imported into the country without DGFT licence.

** Annex.I of Basel Convention denoting serial no. of the category of wastes to be controlled.

Annex.III of Basel Convention denoting serial numbers of the hazard characteristics (Part B of this Schedule).

LIST-B*

Basel No.	Description of Wastes	OECD No.	Customs Code
B1	Metal and metal-bearing wastes		
B1010	Metal and metal-alloy wastes in metallic, non-dispersible form:		
	– Precious metals (gold, silver, platinum)**		
	– Iron and steel scrap**		
	– Nickel scrap****		
	– Aluminum scrap****	GA130	750300
	– Zinc scrap****		
	– Tin scrap****		
	– Tungsten scrap**		
	– Molybdenum scrap***	GA190	ex 810291
	– Tantalum scrap***	GA200	ex 810310
	– Cobalt scrap***	GA220	ex 810510
	– Bismuth scrap***	GA230	ex 810600
	– Titanium scrap***	GA250	ex 810810
	– Zirconium scrap***	GA260	ex 810910
	– Manganse scrap***	GA280	ex 811100
	– Germanium scrap***	GA310	ex 811230
	– Vanadium scrap***	GA320	ex 811240
	– Hafnium scrap***	GA330	ex 8112.91
	– Indium scrap***	GA340	ex 8112.91
	– Niobium scrap***	GA350	ex 8112.91
	– Rhenium scrap***	GA360	ex 8112.91
	– Gallium scrap***	GA370	ex 8112.91
	– Magnesium scrap****	GA210	810420
	– Copper scrap*****	GA120	740400
	– Thorium scrap		
	– Rare earths scrap		

* List B given as Annex. IX of the Basel Convention on Transboundary Movement of Hazardous Wastes and their Disposal comprises of wastes not covered by Article 1, paragraph 1(a) of the Convention, unless they contain material listed under Annex. I of the Convention to an extent causing them to exhibit Annex. III characteristics. Status of wastes in the above list with regard to their import in the country is indicated in respective footnotes. (for details, refer to ITC-HS Classification (EXIM Policy) brought out by the Directorate General of Foreign Trade, Ministry of Commerce). Other residual and waste products of chemical and allied industries appearing in the above list but not specified in the EXIM Policy are restricted and cannot be allowed to be imported into the country without DGFT licence.

** Import permitted in the country without any licence or restriction.

*** Restricted, import permitted in the country with DGFT licence only for the purpose of re-processing or reuse.

**** Import of material covered by ISRI code is permitted without licence; for other material, DGFT licence is necessary.

***** Import of copper scrap namely copper wire covered under ISRI code “Druid” and Jelly filled copper cables is permitted without a licence to units registered with the Ministry of Environment and Forests.

Basel No.	Description of Wastes	OECD No.	Customs Code
B1020	Clean, uncontaminated metal scrap, including alloys, in bulk finished form (sheet, place, beams, rods, etc.) , of: – Antimony scrap* – Cadmium scrap* – Lead scrap** – Tellurium scrap***	 GA270 GA240	 ex 8110.00 ex 8107.10
B1030	Refractory metals containing Residues		
B1040	Scrap assemblies from electrical power generation not contaminated with lubricating oil, PCB or PCTto an extent to render them hazardous		
B1050	Mixed non-ferrous metal, heavy fraction scrap, notcontaining any of the constituents mentioned in Schedule 2 to the extent of concentration limits specified therein		
B1060	Waste tellurium in metallicelemental form including powder		

* Restricted, import permitted in the country with DGFT licence only for the purpose of reprocessing or reuse.

** Restricted, import of the following material covered under Battery scrap is permitted in the country with DGFT licence:

– Battery scrap, namely the following: Lead battery plates covered by ISRI, Code word Rails Battery lugs covered by ISRI, Code word Rakes.

– Battery wastes, namely the following: Scrap drained/dry while intact, lead batteries covered by ISRI, Code word Rains, Scrap wet whole intact lead batteries covered by ISRI, Code word Rink, Scrap industrial intact lead cells covered by ISRI Code word Rono, Scrap whole intact industrial lead batteries covered by ISRI, Code word Roper, Edison batteries covered by ISRI, Code word Vaunt.

– Other waste and scrap.

*** Import permitted in the country without any licence or restriction.

Basel No.	Description of Wastes	OECD No.	Customs Code
B1070	Waste of copper and copper alloys in dispersible form, unless they contain any of the constituents mentioned in Schedule 2 to the extent of concentration limits specified therein*		ex 2620.30
B1080	Zinc ash and residues including zinc alloys residues in dispersible form unless they contain any of the constituents mentioned in Schedule 2 to the extent of concentration limits specified therein**		ex 2620.10 ex 2620.19 ex 2817.00
B1090	Waste batteries conforming to specification,		ex 8548.10

Basel No.	Description of Wastes	OECD No.	Customs Code
	excluding those made with lead, cadmium or mercury		ex 8548.90
B1100	Metal bearing wastes arising from melting, smelting and refining of metals: – Hard Zinc Spelter** – Zinc-containing drosses**: • Galvanizing slab zinc top dross (>90% Zn) • Galvanizing slab zinc bottom dross (>92% Zn) • Zinc die casting dross (>85% Zn) • Hot dip galvanizers slab zinc dross (batch) (>92% Zn) • Zinc skimmings	GB	
	– Slags from copper processing for further processing or refining containing arsenic, lead or cadmium unless they contain any of the constituents mentioned in Schedule 2 to the extent of concentration limits specified therein		ex 262030
	– Slags from precious metals processing for further refining	GB40	ex 2620.90
	– Wastes of refractory linings, including crucibles, originating from copper smelting		
	– Aluminum skimmings (or skims) excluding salt slag	AA50	
	– Tantalum-bearing tin slagswith less than 0.5% tin	GB050	ex 2620.90
B1110	Electrical and electronic assemblies – Electronic assemblies consisting only of metals or alloys	GC GC010	
	– Waste Electrical and electronic assemblies scrap (including printed circuit boards, electronic components and wires) destined for direct reuse and not for recycling or final disposal	GC020	
	– Waste electrical and electronic assemblies scrap (including printed circuit boards) not containing components such as accumulators and other batteries included on list A, mercury-switches, glass from cathode-ray tubes and other activated glass and PCB-capacitors, or not contaminated with constituents such as cadmium, mercury, lead, polychlorinated biphenyl) or from which these have been removed,		

Basel No.	Description of Wastes	OECD No.	Customs Code
	to an extent that they do not possess any of the constituents mentioned in Schedule 2 to the extent of concentration limits specified therein – Electrical and electronic assemblies (including printed circuit boards, electronic components and wires) destined for direct reuse and not for recycling or final disposal		

* Copper dross containing copper greater than 65% and lead and cadmium equal to or less than 1.25% and 0.1% respectively; spent cleaned metal catalyst containing copper; and Copper reverts, cake and residues containing lead and cadmium equal to or less than 1.25% and 0.1% respectively are allowed for import without DGFT licence to units (actual users) registered with MoEF upto an annual quantity limit indicated in the Registration letter. Copper reverts, cake and residues containing lead and cadmium greater than 1.25% and 0.1% respectively are under restricted category for which import is permitted only against DGFT licence for the purpose of processing or reuse by units registered with MoEF (actual users).

** Zinc ash/skimmings in dispersible form containing zinc more than 65% and lead and cadmium equal to or less than 1.25% and 0.1% respectively and spent cleaned metal catalyst containing zinc are allowed for import without DGFT licence to units registered with MoEF (actual users) upto an annual quantity limit indicated in Registration Letter. Zinc ash and skimmings containing less than 65% zinc and lead and cadmium equal to or more than 1.25% and 0.1% respectively and hard zinc spelter and brass dross containing lead greater than 1.25% are under restricted category for which import is permitted against DGFT licence and only for purpose of processing or reuse by units registered with MoEF (actual users).

Basel No.	Description of Wastes	OECD No.	Customs Code
B1120	Spent catalysts excluding liquids used as catalysts, containing any of: Transition metals, excluding waste catalysts (spent catalysts, liquid used catalysts or other catalysts) on list A: Scandium, Titanium Vanadium, Chromium Manganese, Iron Cobalt, Nickel Copper, Zinc Yttrium, Zirconium Niobium, Molybdenum Hafnium, Tantalum Tungsten, Rhenium Lanthanaides (rare earth metals): Lanthanum, Cerium Praseodymium, Neody Samarium, Europium Gadolinium, Terbium		

Basel No.	Description of Wastes	OECD No.	Customs Code
	Dysprosium Holmium Erbium Thulium Ytterbium Lutetium		
B1130	Cleaned spent precious metal bearing catalysts		ex 381510 ex 711510
B1140	Precious metal bearing residues in solid form which contain traces of inorganic cyanides		ex 381510 ex 711510
B1150	Precious metals and alloy wastes (gold, silver, the platinum group) in a dispersible form		ex 381510 ex 711510
B1160	Precious-metal ash from the incineration of printed circuit boards (note the related entry on list A A1150)		
B1170	Precious metal ash from the incineration of photographic film		ex 284310
B1180	Waste photographic film containing silver halides and metallic silver		
B1190	Waste photographic paper containing silver halides and metallic silver		
B1200	Granulated slag arising from the manufacture of iron and steel*	GC080	ex 261900
B1210	Slag arising from the manufacture of iron and steel including slag as a source of Titanium dioxide and Vanadium**		ex 261900

* Import permitted in the country without any licence or restriction.

**Slag and dross other than granulated, scalings and other wastes are restricted; import permitted with DGFT licence only for the purpose of reprocessing or reuse.

Basel No.	Description of Wastes	OECD No.	Customs Code
B1220	Slag from zinc production, chemically stabilized, having a high iron content (above 20%) and processed according to industrial specifications mainly for construction*		ex 262030
B1230	Mill scaling arising from manufacture of iron and steel		ex 261900
B1240	Copper Oxide mill-scale**		
B2	**Wastes containing principally inorganic constituents, which may contain metals and organic materials**		
B2010	Wastes from mining operations in non-dispersible form: – Natural graphite waste*	GD010	250400

Basel No.	Description of Wastes	Annex-I**	Annex -III#	OECDNo.	Customs Code
–	Slate wastes*** – Mica wastes* – Leucite, nepheline and nepheline syenite waste* – Feldspar waste (lumps and powder)* – Fluorspar waste* – Silica wastes in solid form excluding those used in foundry operations			 GD040 GD050 GD060	 252930 252910 252921 252922
B2020	Glass wastes in nondispersible form: – Cullet and other wastes and scrap of glass except for glass from cathode ray tubes and other activated glasses*				

* Import permitted in the country without any licence or restriction.

** Copper oxide mill scale are allowed for import in the country without DGFT licence to units (actual users) registered with MoEF upto an annual quantity limit indicated in the Registration Letter.

*** Restricted, import permitted in the country with DGFT licence only for the purpose of reprocessing or reuse.

Basel No.	Description of Wastes	OECD No.	Customs Code
B2030	Ceramic wastes in nondispersible form: Cermet wastes and scrap (metal ceramic composites)* – Ceramic based fibres	 GFGF020	 ex 8113.00
B2040	Other wastes containing principally inorganic constituents: – Partially refined calcium sulphate produced from flue gas desulphurization (FGD) – Waste gypsum wallboard or plasterboard arising from the demolition of buildings** – Sulphur in solid form** – Limestone from production of calcium cyanamide (pH<9)*** – Sodium, potassium, calcium chlorides** – Carborundum (silicon carbide) – Broken concrete – Lithium tantalum and Lillium-Niobium containing glass scraps	GC GC010	 ex 262100

* Restricted, import permitted in the country with DGFT licence only for the purpose of reprocessing or reuse.

** Import permitted the country without any licence or restriction

*** Import of limestone and other calcareous stones of a kind used for manufacture of lime or cement permitted in the country without any licence or restriction.

Basel No.	Description of Wastes	OECD No.	Customs Code
B2050	Coal-fired power plant flyash unless it contains any of the constituents mentioned in Schedule 2 to the extent of concentration limits specified therein		
B2060	Spent activated carbon resulting from the treatment of potable water and processes of the food industry and vitamin production (notethe related entry on listAA4160)		
B2070	Calcium fluoride sludge	AB050	ex 281800
B2080	Waste gypsum arising from chemical industry processes unless it contains any of the constituents mentioned in Schedule 2 to the extent of concentration limits specified therein		
B2090	Waste anode butts from steel or aluminium production made of petroleum coke or bitumen and cleaned to normal industry specifications (excluding anode butts from chlor alkali electrolyses and from metallurgical industry)		
B2100	Waste hydrates of aluminum and waste alumina and residues from alumina production, arising from gas cleaning, flocculation or filtration process		ex 281800
B2110	Bauxite residue (“red mud”) (pH moderated to less than11.5) (Note related entry on List A A4090)		ex 260600
B2120	Waste acidic or basic solutions with a pH greater than 2 and less than 11.5, which are not corrosive or otherwise hazardous (note the related entry on list A A4090)		
B3	**Wastes containing principally organic constituents, which may contain metals and inorganic materials**		
B3010	Solid plastic waste*: The following plastic or mixed plastic materials, provided they are not mixed with other wastes and are prepared to a specification: – Scrap plastic of nonhalogenated polymers and copolymers, including but not limited to the following:	GH	
	ethylene	GH011	391590
	styrene	GH012	391520
	polypropylene	GH014	391590
	polyethylene erephthalate	GH014	391590
	acrylonitrile	GH014	ex 391590
	butadiene	GH014	ex 391590
	Polyacetals Polyamides	GH014	ex 391590

Basel No.	Description of Wastes	OECD No.	Customs Code
	polybutylene terephthalate	GH014	ex 391590
	polycarbonates	GH014	ex 391590
	polyetherspolyphenylene sulphides	GH014	ex 391590
	acrylic polymers	GH014	ex 391590
	alkanes C10-C13 (plasticiser)		
	polyurethane (not containing CFC's)	GH014	ex 391590
	polysiloxanes	GH014	ex 391520
	polymethyl methacrylate	GH014	ex 391520
	polyvinyl alcohol	GH014	ex 391520
	polyvinyl butyral	GH014	ex 391520
	Polyvinyl acetate	GH014	ex 391520
	– Cured waste resins or condensation products including the following:		
	urea formaldehyde resins	GH015	ex 391520
	phenol formaldehyde resins	GH015	ex 391520
	melamine formaldehyde resins	GH015	ex 391520
	epoxy resins	GH015	ex 391520
	alkyd resins	GH015	ex 391520
	polyamides	GH015	ex 391520
	– The following fluorinated polymer wastes (excluding post-consumer wastes): Perfluoroethylene/propylene		
	Perfluoroalkoxy alkane alkane Metafluoroalkoxy Polyvinylfluoride polyvinylidenefluoride		
B3020	Paper, paperboard and paperproduct wastes		
	The following materials, provided they are not mixedwith hazardous wastes:		
	Waste and scrap of paperor paperboard of:		
	– unbleached paper or paperboard or of corrugated paper or paperboard		
	– other paper or paperboard, made mainly of bleached chemical pulp, not coloured in the mass		
	– paper or paperboard made mainly of mechanical pulp (for example, newspapers, journals and similar printed matter)		
	– other, including but not limited to 1) laminated paperboard 2) unsorted scrap		
B3030	Textile wastes		
	The following materials, provided they are not mixed with other wastes and are prepared to a specification:		

Basel No.	Description of Wastes	OECD No.	Customs Code
	Silk waste (including cocoons unsuitable for reeling, yarn waste and garnetted stock)* – not carded or combed – other		
	Waste of wool or of fine or coarse animal hair, including yarn waste but excluding garnetted stock* – noils of wool or of fine animal hair – other waste wool or of fine animal hair – waste of coarse animal hair		
	Cotton waste (including yarn waste and garnetted stock)* – yarn waste (including thread waste) – garnetted stock – other		
	Flax tow and waste*		

*Restricted import permitted in the country with DGFT licence only for reprocessing or reuse. Import permitted without DGFT licence, if material is in completely mutilated from conforming to the requirement specified by customs authorities.

	Tow and waste (including yarn waste and garnetted stock) of true hemp (*Cannabis sativa* L.)**		
	Tow and waste (including yarn waste and garnetted stock) of jute and other textile bast fibres (excluding flax,true hemp and ramie)**		
	Tow and waste (including yarn waste and garnetted stock) of sisal and other textile fibres of the genus *Agave**		
	Tow, noils and waste (including yarn waste and garnetted stock) of coconut*		
	Tow, noils and waste (including yarn waste and garnetted stock) of abaca (Manila hemp or *Musa textilis* Nee)*		
	Tow, noils and waste (including yarn waste and garnetted stock of ramie and other vegetable textile fibres, not elsewhere specified or includedWaste (including noils, yarn waste and garnetted stock) of man-made fibres* – of synthetic fibres – of artificial fibres		
	Worn clothing and other worn textile articles		
	Used rags**, scrap twine, cordage, rope and cables andworn out articles of twine, cordage, rope or cables of textile materials-sorted		

*Import permitted in the country without any licence or restriction

**Restricted import permitted in the country with DGFT licence only for reprocessing or reuse: Import of woolen rags/ synthetic rags/shoddy wool permitted without licence if material is in completely mutilated form subject to the condition that mutilation must conform to the requirements as specified by Customs authorities.

Basel No.	Description of Wastes	OECD No.	Customs Code
B3040	Rubber wastes*		
	The following materials, provided they are not mixed with other wastes:		
	– Waste and scrap of hard rubber (e.g. ebonite)*		
	– Other rubber wastes (excluding such wastes specified elsewhere)		
B3050	Untreated cork and wood waste		
	Wood waste and scrap,whether or not agglomeratedin logs, briquettes, pellets or similar forms*		
	Cork waste: crushed, granulated or ground cork*		
B3060	Wastes arising from agrofood industries provided it is not infectious:		
	Wine lees*		
	Dried and sterilized vegetable waste, residues and byproducts, whether or not in the form of pellets, of a kind used in animal feeding, not elsewhere specified or included*	GM100	050690
	Degras: residues resulting from the treatment of fatty substances or animal or vegetable waxes**	GM110	ex 051191
	Waste of bones or horn cores unworked, defatted, simply prepared (but not cut toshape), treated with acid or degelatinised**		
	Fish waste**		

*Import permitted in the country without any licence or restriction.

**Prohibited under EXIM Policy (ITC- HS Classification)

	Cocoa shells, husks, skins and other cocoa waste*		
	Other wastes arising from agro-food industry excluding by-products which meet national and international requirements and standards for human or animal consumption		

Basel No.	Description of Wastes	OECD No.	Customs Code
B3070	The following wastes:* – Waste of human hair* – Waste straw* – Deactivated fungus mycelium from penicillin production to be used as animal feed		
B3080	Waste parings and scrap of rubber**		
B3090	Paring and other wastes of leather or of composition leather not suitable for the manufacture of leather articles, excluding leather sludges, not containing hexavalent chromium compounds and biocides (note the related entry on list A A3100)		
B3100	Leather dust, ash, sludges or flours not containing hexavalent chromium compounds or biocides		
B3110	Fellmongery wastes not containing hexavalent chromium compounds or biocides or infectious substances		
B3120	Wastes consisting of food dyes*		

*Import permitted in the country without any licence or restriction
**Restricted, import permitted in the country with DGFT licence only for reprocessing or reuse.

B3130	Waste polymer ethers and waste non-hazardous monomer ethers incapable of forming peroxides		
B3140	Waste pneumatic tyres, excluding those which do not lead to resource recovery, recycling, reclamation or direct reuse*		
B4	Wastes which may contain either inorganic or organic constituents		
B4010	Wastes consisting mainly of water-based/ latex paints, inks and hardened varnishes not containing organic solvents, heavy metals or biocides toan extent to render them hazardous (note the related entry on list A A4070)		
B4020	Wastes from production, formulation and use of resins, latex, plasticizers, glues/adhesives, not listed on list A, free of solvents andother contaminants to an extent that they do not exhibit Annex III characteristics, e.g. water-based, or glues based on casein starch, dextrin,cellulose ethers, polyvinyl alcohols (note the related entry on list A A3050)		
B4030	Used single-use cameras,with batteries not included onlist A		

*Import permitted in the country without any licence or restriction

Part B: List of Hazardous Characteristics

Code	Characteristic
1	**Explosive:** An explosive substance or waste is a solid or liquid substance or waste (or mixture of substances or wastes) which is in itself capable by chemical reaction of producing gas at such a temperature and pressure and at such speed as to cause damage to the surroundings (UN Class 1; HI)
3	**Flammable Liquids:** The word "flammable" has the same meaning as "inflammable". Flammable liquids are liquids, or mixtures of liquids, or liquids containing solids in solution or suspension (for example, paints, varnishes, lacquers, etc. but not including substances or wastes otherwise classified on account of their dangerous characteristics) which give off a flammable vapour at temperatures of not more than 60.5ºC, closed-cup test, or not more than 65.5ºC, open-cup test. (Since the results of open-cup tests and of closed-cup tests are not strictly comparable and even individual results by the same test are often variable, regulations varying from the above figures to make allowance for such differences would be within the spirit of this definition).
4.1	**Flammable Solids:** Solids, or waste solids, other than those classed as explosives, which under conditions encountered in transport are readily combustible, or may cause or contribute to fire through friction.
4.2	**Substances or wastes liable to spontaneous combustion:** Substances or wastes which are liable to spontaneous heating under normal conditions encountered in transport, or to heating up on contact with air, and being then liable to catch fire.
4.3	**Substances or wastes which, in contact with water emit flammable gases:** Substances or wastes which, by interaction with water, are liable to become spontaneously flammable or to give off flammable gases in dangerous quantities.
5.1	**Oxidizing:** Substances or wastes which, while in themselves not necessarily combustible, may, generally by yielding oxygen cause, or contribute to, the combustion of other materials
5.2	**Organic Peroxides:** Organic substances or wastes which contain the bivalent-O-O-structure are thermally unstable substances which may undergo exothermic self-accelerating decomposition.
6.1	**Poisons (Acute)**: Substances or wastes liable either to cause death or serious injury or to harm health if swallowed or inhaled or by skin contact.
6.2	**Infectious substances:** Substances or wastes containing viable micro organisms or their toxins which are known or suspected to cause disease in animals or humans.
8	**Corrosives:** Substances or wastes which, by chemical action, will cause severe damage when in contact with living tissue, or, in the case of leakage, will materially damage, or even destroy, other goods or the means of transport; they may also cause other hazards.
10	**Liberation of toxic gases in contact with air or water:** Substances or wastes which, by interaction with air or water, are liable to give off toxic gases in dangerous quantities.
11	**Toxic (Delayed or chronic)**: Substances or wastes which, if they are inhaled or ingested or if they penetrate the skin, may involve delayed or chronic effects, including carcinogenicity).
12	**Ecotoxic:** Substances or wastes which if released present or may present immediate or delayed adverse impacts to the environment by means of bioaccumulation and/or toxic effects upon biotic systems.
13	Capable by any means, after disposal, of yielding another material, e.g., leachate, which possesses any of the characteristics listed above.

5

Biomedical Waste

5

Biomedical Waste

Biomedical waste means any solid or liquid waste, which is generated during the diagnosis, treatment or immunization of human beings or animals or in research activities pertaining there to or in the production or testing of biologicals including categories mentioned in Box 5.1 (Bio-Medical Waste (Management & Handling, Rules, 1998). Non-liquid biomedical waste includes human and animal tissue, organs and body parts, discarded sharps and medicines, human blood products that contain disease-causing agents and body fluids, discarded medical accessories like tubes, IV sets, soiled bandages, plastics, etc. Liquid waste includes waste generated from laboratory washings, cleaning, housekeeping and disinfection activities. Biomedical waste is a special area wherein hazards and risks are not just for the generators and operators but also for the general community. Generally, biomedical waste is broadly classified into infectious waste and non-infectious waste categories. However, with respect to its collection and treatment, biomedical waste has been categorized under 10 categories as per Biomedical Waste (Handling & Management) Rules, 1998, amended in 2000 (Box 5.1).

Box 5.1 Categories of Biomedical waste

Waste Category	Type of Waste Category	Treatment and Disposal Option+
Category No. 1	**Human Anatomical Waste** (Human tissues, organs, body parts)	Incineration@/deep burial*
Category No. 2	**Animal Waste** (Animal tissues, organs, body parts, carcasses, bleeding parts, fluid, blood and experimental animals used in research, waste generated by veterinary hospitals, colleges, discharge from hospitals, animal houses)	Incineration@/deep burial*

Contd....

Waste Category	Type of Waste Category	Treatment and Disposal Option+
Category No. 3	**Microbiology and Biotechnology Wastes** (Wastes from laboratory cultures, stocks or specimen of micro organisms, live or attenuated vaccines, human and animal cell cultures used in research and infectious agents from research and industrial laboratories, wastes from production of biologicals, toxins and devices used for transfer of cultures)	Local autoclaving/ microwaving/incineration@
Category No. 4	**Waste sharps** (Needles, syringes, scalpels, blades, glass, etc. that may cause puncture and cuts. This includes both used and unused sharps)	Disinfecting (chemical treatment@@/autoclaving/ microwaving and mutilation/ shredding##)
Category No. 5	**Discarded medicines and cytotoxic drugs** (Wastes comprising of outdated, contaminated and discarded medicines)	Incineration@/destruction and drugs disposal in secured landfills
Category No. 6	**Soiled waste** (Items contaminated with body fluids including cotton, dressings, soiled plaster casts, lines, bedding, other materials contaminated with blood)	Incineration@/autoclaving/ microwaving
Category No. 7	**Solid waste** (Waste generated from disposable items other than waste sharps such as tubing, catheters, intravenous sets, etc.)	Disinfecting by chemical treatment@@ autoclaving/ microwaving and mutilation/ shredding##
Category No. 8	**Liquid waste** (Waste generated from laboratory and washing, cleaning, house keeping and disinfecting activities)	Disinfecting by chemical treatment@@ and discharge into drains
Category No. 9	**Incineration ash** (Ash from incineration of any biomedical waste)	Disposal in municipal landfill
Category No. 10	**Chemical waste** (Chemicals used in production of biologicals, chemicals used in disinfecting, as insecticides, etc.)	Chemical treatment@@ and discharge into drains for liquids and secured landfill for solids

Source: Ministry of Environment & Forests, Govt. of India, 2000

+ Options given above are based on available technologies. Occupier/operator wishing to use other State-of-the art technologies shall approach the Central Pollution Control Board to get the standards laid down to enable the prescribed authority to consider grant of authorization.

@ There will be no chemical pre-treatment before incineration. Chlorinated plastics shall not be incinerated.

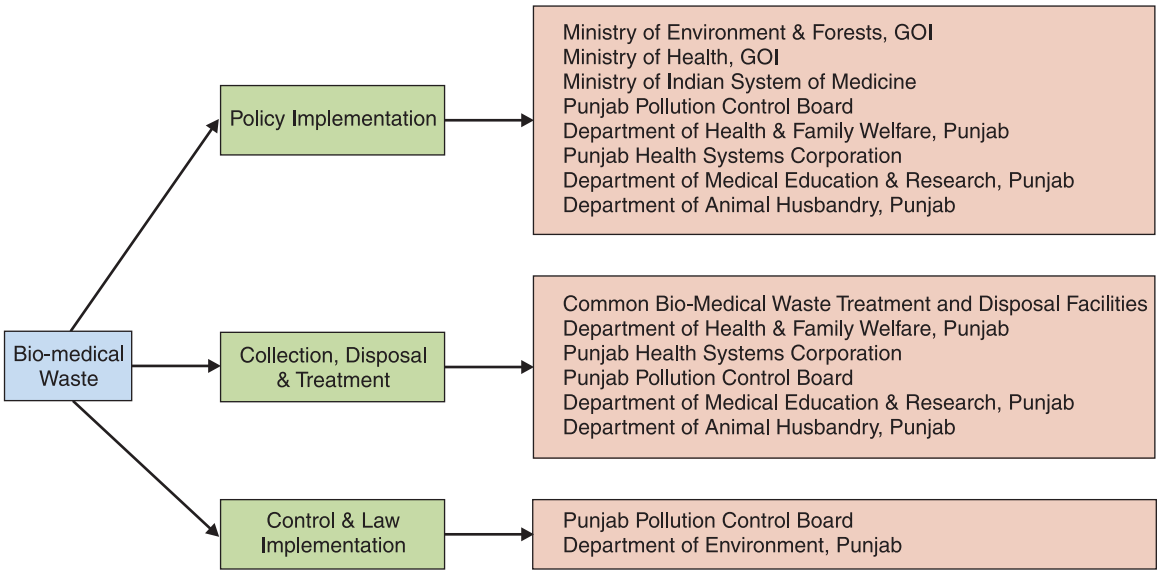
* Deep burial shall be an option available only in towns with population less than five lakh and in rural areas.

Mutilation/Shredding must be such so as to prevent unauthorised reuse.

@@ Chemical treatment using at least 1% hypochlorite solution or any other equivalent chemical reagent. It must be ensured that chemical treatment ensures disinfection.

With increase in medical facilities there has been an increasing concern about the harmful effects of biomedical waste generated by them. Law enforcement agencies of the Government, the media, social activists and also general public are continuously focusing on the lack of concerted effort in management of biomedical waste in our country. Waste management in the hospitals and health care establishments is being monitored by agencies like State Pollution Control Boards and Licensing Authorities of health care establishments (HCEs).

INSTITUTIONAL FRAMEWORK



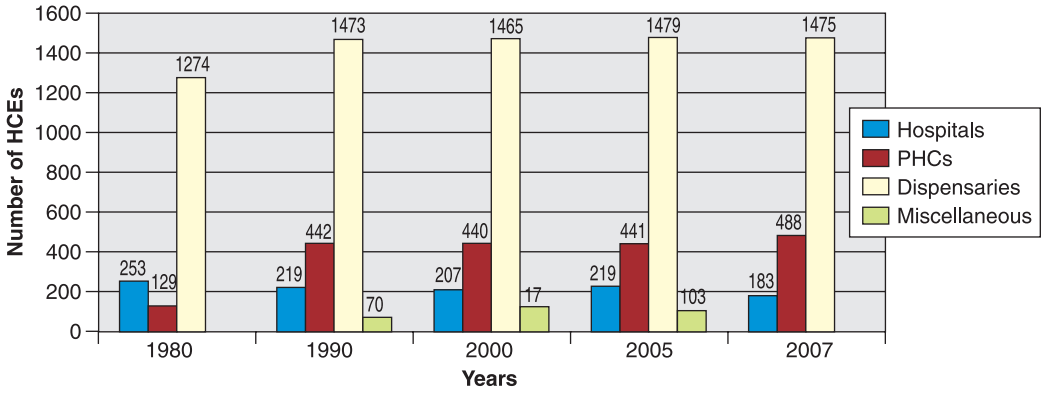
DRIVING FORCES

The major factors leading to increased generation of biomedical wastes in the state include increase health and veterinary care facilities, besides increase in disposables and low level of awareness in the medical sector.

Medical infrastructure

There has been a substantial increase in health care establishments to meet the growing demand of increasing population over the years. The number of health care establishments has increased considerably both in Public and Private sector in the past 25 years (Fig. 5.1). The number of doctors has also gone up from 8809 in 1980 to 18594 in 2004. Hence, whereas in 1980 there was one doctor per 1894 persons in the state, the number has improved to one doctor per 1468 persons in 2004. Further, the number of nurses and paramedical staff has also improved from one nurse per 3662 persons in 1980 to one per 1293 persons in 2004 and one paramedic per 3807 persons in 1980 to one paramedic per 1010 persons in 2004. With increase in medical facilities the total amount of biomedical

Fig. 5.1 Number of health care establishments in public sector in Punjab (1980-2007)



Source: Statistical Abstract of Punjab, 2005 & Punjab Health Systems Corporation, 2007

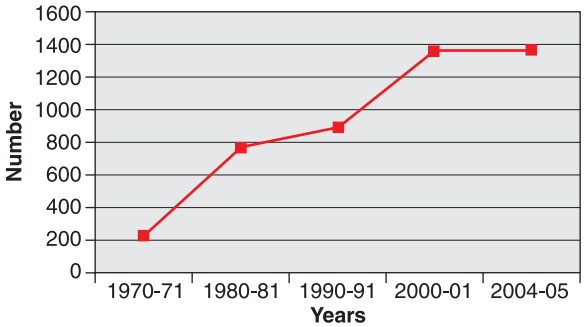
waste generation has also increased. However, smaller health care establishments like rural subcentres, mini Primary Health Centres (PHCs) and urban slum dispensaries which generate small volumes of biomedical waste are required to collect and make local arrangement for treatment and disposal as per Bio-Medical Waste (Management & Handling) Rules, 1998. All other large health care establishments like Medical Colleges, District Hospitals, Subdivisional hospitals and Community Health Centres (CHCs), which generate larger quantities of biomedical waste, are required to collect their waste and send it for proper treatment/disposal.

Out of the above HCEs approximately 20% are in urban areas and the rest are in rural areas. Further, rationalization is being done as some PHCs are being upgraded to CHCs and some Subdivisional hospitals are being upgraded to District hospitals with the formation of new districts.

Veterinary hospitals

The provision of adequate veterinary services is extremely necessary to provide sufficient health coverage to animal husbandry in the state. In order to promote the white revolution, it is necessary to provide basic health care facilities to animals within reasonable distance and remedial measures taken in time with respect to infections and communicable diseases. Consequently, there has been a rise of about 83 percent (Fig. 5.2) in veterinary hospitals from 1970 to 2001, after which a platue has been reached. One reason behind the constancy of veterinary hospitals from 2001 to 2005 is that

Fig. 5.2 Number of veterinary hospitals in Punjab (1970-2005)



Source: Statistical Abstract of Punjab, 2005

the net production of livestock has substantially decreased (even though the number of buffaloes has increased). The number of veterinary officers in the state has also increased from 281 to 1094 from 1970 to 2005. The Punjab government has also established Sri Guru Angad University of Animal and Veterinary Sciences at Ludhiana for research in animal sciences. Increase in number of veterinary institutions has also led to increased generation of biomedical waste from such institutions.

Increase in disposables

In an effort to reduce interpatient infections use of disposable medical equipments (like syringes, gloves, IV sets, etc.) in all modern health care establishments has increased considerably. Though this is in the interest of patients it contributes significantly to biomedical waste generation. Further, their packaging materials (glass/plastics/paper/card board) also add to gross hospital waste.

Low level of awareness

As per data provided by PHSC and PPCB only 2340 health care establishments in the state are required to obtain authorization of Punjab Pollution Control Board (PPCB) and handle biomedical waste generated by them as per Bio-Medical (Management and Handling) Rules, 1998. This amounts to about 4477.65 kg/day (Punjab Pollution Control Board, 2007). These establishments are required to make waste treatment and disposal arrangements either with Common Biomedical Waste Treatment Facility (CBWTF) or on their own. However, very few establishments are segregating biomedical waste at source as per provisions under Bio-Medical Waste (Management and Handling) Rules. This causes handling problems at the Biomedical Waste Treatment Facility (BMWTF). Remaining HCEs are small clinics/health consultants which generate negligible quantities of biomedical waste.

Low level of awareness about the seggregation of biomedical waste

Some of these HCEs have made their own arrangement for disposal of bio-medical waste generated by them. Sufficient information is not available about the HCEs which have no indoor facility. Some of these HCEs (exact number not known) are dumping their waste in municipal bins posing health hazards to the general public. This is because of lack of proper awareness. As per information available, only 5% doctors and 2% paramedical staff in the PHSC have been trained *(*PHSC, 2006) in biomedical waste handling. Though the State Pollution Control Board (SPCB) has also organized one training programme at Sri Guru Teg Bahadur (SGTB) hospital Amritsar, two workshops sponsored by Ministry of Environment and Forests (MoEF) at Chandigarh and Jalandhar and a number of camps in collaboration with Indian Medical Association (IMA), but the desired level of awareness has not been achieved as yet.

PRESSURES

The above-mentioned driving forces have directly or indirectly contributed to increased generation and lack of proper management of biomedical waste in the state.

Increase in quantity of biomedical waste

With increase in population of humans and cattle, consequent increase in medical facilities and increase in number of institutions carrying out R & D and clinical trials on humans and animals, the total amount of biomedical waste generation has increased in the state. As per PPCB total waste generated amounts to 4477.65 kg/day (however, as stated earlier this does not include biomedical waste generated from small clinics, dispensaries, etc. which do not require authorization from PPCB).

Improper handling of biomedical waste

Biomedical waste needs to be disposed off as per procedure specified under Bio-Medical Waste (Management & Handling) Rules, 1998, ammended in 2000, framed under Environment (Protection) Act, 1986 (29 of 1986). As already discussed, only 2340 health care facilities in the state are required to obtain authorization of the Board and handle biomedical waste as per provisions of the Rules and ensure collection after proper segregation and its subsequent disposal. Table 5.1 indicates four recommended colours for containers used for the collection and segregation of biomedical waste in the hospitals. However, some hospitals/nursing homes/clinics do not follow these rules and dump the biomedical waste along with municipal solid waste. Data in this respect needs to be generated. There are some other smaller nursing homes or hospitals which are required to use the common waste treatment and disposal facility promoted by the government with private enterpreneurs. Data with respect to compliance by such institutions also needs to be collected. Improper disposal without segregation or dumping (dumping of heaps of infectious and hazardous medical waste consisting of infected bandages, syringes, plastics and aluminium equipments along with municipal solid waste) can severly affect the health of all who come in contact with this waste. It also has an adverse affect on the environment. Rag pickers try to collect these discarded materials from the waste dump sites to make a living. Hence, not only are they themselves exposed to the risk of injuries from contaminated needles and other sharp objects and to various infectious diseases, but other population is also exposed

Table 5.1 Colour coding and type of containers for disposal of biomedical wastes

Colour coding	Type of container	Waste category	Treatment option as per Schedule-I
Yellow	Plastic bag	Cat.1, Cat. 2, Cat. 3, Cat.6	Incineration/deep burial
Red	Disinfected container/plastic bag	Cat.3, Cat.6, Cat. 7	Autoclaving/Microwaving/Chemical Treatment
Blue/White translucent	Plastic bag/puncture proof container	Cat.4, Cat.7	Autoclaving/Microwaving/Chemical Treatment and Distruction/Shredding
Black	Plastic bag	Cat.5,Cat.9 & Cat. 10 (Solid)	Disposal in secured landfill

Source: Bio-Medical Waste (Management & Handling) Rules,1998

to such hazards due to illegal entry of these materials in the market and their re-use as a cheap substitute by clinics and nursing homes. Disposable plastic tubings, catheters, bottles, etc. have also been found to be used in making of cheap toys and containers which can adversely affect health of unassuming users. Unconfirmed and unpublished data also indicates that only 10% Primary Health Centres (PHC) in the state dispose of used syringes properly. These are reused in village/slum areas without disinfection especially by drug abusers. This has been identified as one of the factors responsible for Human Immuno Deficiency Virus (HIV) infection and emergence of dreaded diseases like, Acquired Immuno Deficiency Syndrome (AIDS). There are 180 recorded patients of AIDS in the state (PHSC, 2005). According to new classification by the National AIDS Control Organisation (NACO) Ludhiana and Amritsar districts have been included in 163 districts affected by AIDS (where over 1% of the general population and more than 5% of high-risk groups are infected with the virus).

STATE

Number of health institutions

As per data provided by Punjab Health Systems Corporation, in the public sector, the state has 3 Medical colleges, 2 dental colleges, 20 district hospitals, 3 special hospitals (Gynae Hospital, Patiala; Children Hospital, Bathinda; Institute of Mental Health, Amritsar), 39 sub-divisional hospitals,

Stipulated coloured bins for collection of biomedical waste

116 community health centres, 488 primary health centres, 1475 subsidiary health centres/ dispensaries and 2858 sub centres which provide preventive, promotive and curative health care. Apart from this there are 7 ESI hospitals and 73 ESI dispensaries to provide health care to the industrial workers. The combined bed capacity of these institutions is 19,500. In the private sector, there are 3 medical colleges, 4 dental colleges, 241 hospitals, 658 nursing homes, 86 polyclinics and 3046 clinics having a combined bed capcity of 16,022 in the state, besides several new registered and unregistered facilities, a survey of which needs to be conducted. In all, the state has one sub-centre for every 8523.09 persons (against the government stipulated norm of one sub centre for 5000 persons), one primary health centre for every 50328.5 persons (against a norm of 30,000 persons) and one community health centre for every 1,93,325.3 persons (against a norm of 1.2 lac persons). Further, as reported earlier only one doctor per 1468 persons, one nurse per 1293 persons and one midwife per 1010 persons is available. Hence, the available facilities are much lower than stipulated norms.

Quantity, transportation and treatment of biomedical waste

On an average a hospital bed generates 1 kg of waste per day, out of which 10-15 percent is infectious, 5 percent is hazardous and rest is general waste (www.toxicslink.org). As per PPCB the total bed capacity in the state is approximately 35000. Hence, according to Toxics Link a total of approximately 35000 kg/day of waste is being generated from these institutions, if the occupancy of the beds is 100%. Out of total waste generated by these HCEs 4478 kg/day (approx. 12.9%) of infectious biomedical waste is being collected and treated. Many clinics, PHCs and dispensaries generate small quantities of biomedical waste and dispose it at their level. As regarding treatment of hospital sewage, all the Government Medical Colleges are yet to install proper treatment plants.

In Punjab, there are 4 Common Bio-Medical Waste Treatment Facilities (CBWTF) at Ludhiana, Mohali, Amritsar and Pathankot which collect, transport and treat this waste. The segregated waste is collected from the HCEs and is brought to these CBWTF for treatment and disposal. These agencies disinfect the syringes, needles and other plastic materials in Autoclaves and then subject the same to shredding to eliminate the possibility of reuse. The shredded material is then processed to make some other items for non-health use. The detailed status of biomedical waste treated by these four agencies is given in Table 5.2.

Table 5.2 Common Bio-Medical Waste Treatment Facility in Punjab

(Status as on 31.12.2006)

Source: Information provided by PPCB, 2007

IMPACTS

Spread of infectious diseases

Medical waste mismanagement is not only linked with the spread of infectious agents like, Human Immuno deficiency Virus (HIV) and Hepatitis B Virus (HBV), but also with indirect problems like endocrine disruption, cancers, reproductive disorders, immune suppression, nervous disorders, etc. Equipments and chemicals used in hospitals, like mercury-containing instruments, radioactive isotopes, glutaraldehyde, cytotoxic drugs, etc. pose a big threat if they are not disposed off properly. The most dangerous of all is the sharps waste, which is capable of transmitting infections. It is commonly known that a number of waste products are reused either by drug addicts or picked by rag pickers. This could pose a serious health hazard. However, no specific data is available.

Release of toxic gases during incineration

Incineration is a common method of disposal of infectious wastes and body parts. However, high temperature burning can cause air pollution by release of dioxins and furan (especially while incinerating plastics used in medical equipments). Hence, several developed countries are switching over to alternate technologies. In Punjab, presently double chamber incinerators are used by all the four CBWTF's. These facilities are regularly visited by the officers of the Board and by a committee constituted by the Advisory Committee established by the government under the provisions of BMW Rules.

RESPONSES

Legal and Administrative set up

In congizance of the adverse affect of biomedical waste on human health and environment the state government has taken up several initiatives. Some of these are:

- Bio-medical Waste (Management and Handling) Rules, 1998, amended in 2000, are enforceable in the state.
- As stated earlier, the Punjab Pollution Control Board has authorized four private agencies for collection, transport and tratment of biomedical waste.
- To expand and improve curative and preventive secondary level health care in the state, Punjab Health Systems Corporation (PHSC) was created as a statutory Corporation in 1996 vide Punjab Act No. 6 of 1996. The Corporation is also responsible for ensuring appropriate biomedical waste treatment and disposal. The World Bank has sanctioned the Second State Health Systems Development Project of US$ 106.10 million to the Corporation to upgrade health care facilities including biomedical waste treatment. PHSC has also put up its own autoclaves and shredder plants which are in operation in some hospitals. However, these hospitals have also joined the CBWTF.

- Under the latest Immunization Action Plan submitted to Government of India, special provision has been made to construct properly designed pits in 50 Primary Health centres for disposal of biomedical waste.

Technology upgradation

Better technologies for treatment of Biomedical waste are under consideration. A proposal to set up a plasma pyrolysis demonstration unit in Punjab for safe disposal of medical and plastic waste developed by Facilitation Centre for Industrial Plasma Technology, Gandhinagar is under consideration.

Inspection and monitoring

The PPCB is regularly monitoring the functioning of Common Bio-Medical Waste Treatment Facilities, as well as, actions taken for waste treatment by smaller health care establishments (which do not require authorization from PPCB). The CBWTF is also being regularly inspected by a committee constituted by the government comprising members of the Board and representatives from Department of Health and Family Welfare.

Awareness and training

- PHSC has provided training to 955 doctors, 2032 paramedical staff and 2142 class-IV employees (Safai Karamcharies) about Bio-Medical Waste (Management and Handling) Rules. It is monitoring 169 HCFs in the state. It has initiated a program of 'quality circles', for management and minimization of biomedical waste generated by these HCFs.
- PPCB has also provided training to the paramedical staff of SGTB Hospital, Amritsar on the handling of biomedical waste. It has also conducted workshops at Chandigarh and Jalandhar. In addition to this, workshops/camps are being organized by the Regional Offices (RO's) of the Board for bringing awareness amongst the medical fraternity.
- Phamplets have been prepared by the Board highlighting the responsibility of various medical/ paramedical staff on the handling of biomedical waste. These phamphlets have been distributed in the annual meetings of IMA (Indian Medical Association-Punjab Chapter) and through PHSC, Department of Health and Family Welfare, Department of Medical Education and Research and all major hospitals of the state. Notices have also been published in leading newspapers for public awareness.
- A documentary film on handling of biomedical waste was also got prepared by the Board which was telecast by Doordarshan Kendra, Jalandhar.

RECOMMENDATIONS

In order to ensure adequate biomedical waste treatment in the state, it is recommended that:

- Blockwise surveys be conducted to enlist all functional health care establishments in the state along with bed capacity and assess the quantum of biomedical waste being generated by them

and facilities available for waste segregation. All such HCEs be persuaded to join CBWTFs for treatment and disposal of bio-medical waste.

- Since awareness and a conscientious attitude is key to motivating all medical personnel (especially paramedical staff) for ensuring appropriate segregation, disposal and treatment of biomedical waste, large scale awareness programmes be conducted at block and district levels.
- Capacity building programmes be taken up especially for class III and class IV employees working in wards and OPDs for segregation of waste. Adequate safety equipments should also be provided to such employees.
- Epidemiological studies on impacts of improper disposal of biomedical waste on human health need to be taken up.
- In addition to the above, awareness be created amongst general public, especially rag pickers and rag dealers to make them aware of the medical hazards of re-using disposables like, metal, glass and plastic wastes discarded as part of biomedical waste.

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