Impact of Laws, Awareness and Local Participation in Prevention and Control of Crop Residue Burning: A Case Study of Bathinda District

Dissertation Submitted to the Central University of Punjab

for the award of

Master of Laws

In

Environmental Law

BY

Ramandeep Singh Sidhu

Dissertation Coordinator – Dr. Deepak Kumar Chauhan

Administrative Supervisor – Prof. P. Ramarao

Centre for Environmental Law

School of Legal Studies and Governance

Central University of Punjab, Bathinda

January, 2014

DECLARATION

I declare that the dissertation entitled **Impact of Laws, Awareness and Local Participation in Prevention and Control of Crop Residue Burning: A Case Study of Bathinda District** has been prepared by me under the guidance of Dr. Deepak Kumar Chauhan, Assistant Professor (Dissertation Coordinator) and Prof. P. Ramarao (Administrative Supervisor), Centre for Environmental Law, School of Legal Studies and Governance, Central University of Punjab. No part of this dissertation has formed the basis for the award of any degree or fellowship previously.

Ramandeep Singh Sidhu

Centre for Environmental Law,

School of Legal Studies and Governance,

Central University of Punjab,

Bathinda-151001

Date: January 2014

CERTIFICATE

We certify that **Ramandeep Singh Sidhu** has prepared his dissertation entitled **Impact of Laws, Awareness and Local Participation in Prevention and Control of Crop Residue Burning: A Case Study of Bathinda District,** for the award of LL.M. Degree of the Central University of Punjab, under our guidance. He has carried out his work at the Centre for Environmental Law, School of Legal Studies and Governance, Central University of Punjab.

Dr. Deepak Kumar Chauhan

Assistant Professor,

Centre for Environmental Law,

School of Legal Studies and Governance,

Central University of Punjab,

Bathinda-151001

Date: January 2014

Prof. P. Ramarao

Dean,

Centre for Environmental Law,

School of Legal Studies and Governance,

Central University of Punjab,

Bathinda-151001

Date: January 2014

ABSTRACT

Impact of Laws, Awareness and Local Participation in Prevention and Control of Crop Residue Burning: A Case Study of Bathinda District

Name of student	: Ramandeep Singh Sidhu
Registration Number	: CUP/LL.M.-PhD//SLSG/CEL/2011-12/02
Degree for which submitted	: Master of Laws
Dissertation Coordinator	: Dr. Deepak Kumar Chauhan
Administrative Supervisor	: Prof. P. Ramarao
Centre	: Centre for Environmental Law
School of Studies	: School of Legal Studies and Governance
Key words	: Crop residue burning, Laws on pollution control, Government policy, Environmental pollution, Happy seeder

The present study entitled 'Impact of Laws, Awareness and Local Participation in Prevention and Control of Crop Residue Burning: A Case Study of Bathinda District' is an attempt to explore the serious environmental and agricultural issue of 'crop residue burning' in relation to 'laws, awareness and local participation' in Punjab. Crop residue burning is one of the significant sources of air pollution particularly during harvesting season. It is important to mitigate impacts of burning of crop residue in open fields and its effect on soil, air and living organisms. It adversely affects the air quality, leads to nutrient loss, degrade soil properties and cause waste of residue that is now considered tremendous resource worldwide. There are various laws to control air pollution in India, including, Air (Prevention and Control of Pollution) Act 1981; The Environment Protection Act 1986; Biological Diversity Act 2002; National Green Tribunal Act 2010 and various provisions are also available under other Acts such as Criminal Procedure Code, Civil Procedure Code and Indian Penal Code.

Under these different Acts, various provisions are made to protect the environment from all kinds of pollution generated by industrial and agricultural activities. Disposal of crop residue in a very short time available between harvesting of rice and sowing of wheat is a potential problem for the agriculturists in the rice-wheat cropping pattern, which is widely practiced in all the districts of Punjab. Other available options lack motivation and feasibility and farmers find it easier to opt for burning the residue in open fields. The impact of existing laws, awareness and local participation is very less as compared to the severity of the issue. The impact of crop residue burning need to be arrested fast through various strategic policies, scientific, technical, social and legal measures for sustaining and protecting environment and agricultural resources of the state.

Ramandeep Singh Sidhu

Prof. P. Ramarao
Administrative Supervisor

Dr. Deepak Kumar Chauhan
Dissertation Coordinator

ACKNOWLEDGEMENT

I would like to express my gratitude to all those who gave me the opportunity to complete this dissertation and make my life's very precious and memorable experience. First, I would like to thank the Almighty and my family who encourage me for this study.

I pay my gratitude to Prof. P. Ramarao, Dean, Centre for Environmental Law, Central University of Punjab. I admire the continues support and blessings of Prof. R. G. Saini, Controller of Examination, Central University of Punjab, Bathinda.

I specially pay my deep gratitude to my guide teacher Dr. Deepak Kumar Chahan, Assistant Professor, Centre for Environmental Law, Central University of Punjab who supported me every minute for research work and without his help I could not be able to complete this work. I am thankful to Dr. H. R. Arora and Dr. Puneet Pathak, Assistant Professors, Central University of Punjab. I am also thankful to Bhupinder Singh, Professional Assistant (Library), Central University of Punjab.

I am thankful to my friends and batch mates, Kamalpreet Singh Dhillon, Jitin VJ and Abhishek Kumar for their support. I would like to thank all who blessed me for this study.

Ramandeep Singh Sidhu

TABLE OF CONTENTS

List of Tables

List of Pictures

List of Abbreviations

CACP	Commission on Agricultural Cost and prices
CDM	Clean Development Mechanism
CPCB	Central Pollution Control Board
CrPC	Criminal Procedure Code
CWP	Civil Writ Petition
EBRI	European Bio-energy Research Institute
FIR	First Information Report
GHG	Green House Gases
HYV	High Yield Variety
IGP	Indo-Gangetic Plains
IFPRI	International Food and Policy Research Institute
IISER	Indian Institute of Science, Education and Research
IIT	Indian Institute of Technology
NASA	National Aeronautical and Space Agency
NCR	National Capital region
NFS	National Food Security
NGO	Non-Government Organization
NGT	National Green Tribunal
NHM	National Horticulture Mission
NRSA	National Remote Sensing Authority

PAU	Punjab Agriculture University
PAFC	Punjab Agro Food Corporation
PEDA	Punjab Energy Development Authority
PPCB	Punjab Pollution Control Board
PSCST	Punjab State Council for Science and Technology
PSFC	Punjab State Farmers Commission
RWS	Rice-Wheat System
SPRERI	Sardar Patel Renewable Energy Research Institute

Chapter - 1

Introduction

The crop residue management is a universal problem. Crop residue burning is one among the many sources of air pollution. Nature has always had the ability to absorb the entire residue being generated by farming since the beginning of time. However, due to technological advancement in agricultural sector, waste accumulation goes beyond certain limits thereby disturbing the balance. Crop residue burning adversely affects the nutrient budget in the soil. Straw carbon, nitrogen and sulphur are completely burnt and lost to the atmosphere in the process of burning and also contribute indirectly to the increased ozone pollution. An important source of atmospheric pollution in the area of research is crop residue burning during rice and wheat harvesting.

The green revolution has placed Punjab at the forefront of agricultural productivity. Punjab is an agricultural State with wheat & rice as the major crops. Rice is the most important Kharif crop of Punjab. With the increase in production of rice there has been a concomitant increase in the production of residue (paddy straw). The total production of rice & wheat straw in Punjab is about 40 million tons of which 23 million tons is rice straw and 17 million tons is wheat straw. Whereas wheat straw is used as fodder, rice straw is not preferred as fodder, being rich in silica and high pesticide content. Although paddy straw can be put to many other usages, at present about 80 percent of the same, whether harvested, or stubble standing in the fields, is burnt in the fields itself, as the farmers are in a hurry to prepare the fields to sow the next wheat crop. This practice has far reaching negative impacts on the overall environment of the state, which have been overlooked for want of better alternatives. Significant examples are the degradation of regional air quality and loss of organic material for soil enrichment. It is estimated that burning of paddy straw results in nutrient losses viz 3.85 million tons of organic carbon, 59,000 tons of nitrogen, 20,000 tons of phosphorus and 34,000 tons of

potassium[1]. This also adversely affects the nutrient budget in the soil. Straw carbon, nitrogen and sulphur are completely burnt and lost to the atmosphere in the process of burning. This releases a cocktail of ash, soot, acids and other damaging air borne particles. These chemicals are dispersible into the atmosphere. Several studies have been conducted by various agencies to assess the impact of straw/stubble burning in the field on the environment.

A study conducted by National Remote Sensing Agency in Punjab indicated that wheat crop residue burning contributed about 113 Gg (Giga Gram = 10 billion gram) of CO, 8.6 Gg Of Nox, 1.33 Gg of CH_4, 13 Gg PM10 & 12 Gg of PM2.5 during May, 2005 and paddy straw/stubble burning was estimated to contribute 261 Gg of CO, 19.8 Gg of NOx, 3 Gg of CH_4, 30 Gg of PM10 & 28.3 Gg of PM2.5 during October, 2005[2]. As per information provided by Punjab Agriculture University (PAU) to the State Environment Council also it was estimated that the crop residues contained about 6.0 million tons of Carbon, which on burning could produce about 22.0 million tons of Carbon Dioxide in a short span of 15-20 days. Additionally, the smoke plumes contained particulates of partially combusted materials as soot, which became airborne and were transported downwind especially during winters when inversion sets in. Studies conducted by Punjab Pollution Control Board (PPCB) in 2006 in villages Dhanouri, Simbro & Agnodakalan in district Patiala also indicated that CO and particulates were pollutants of major concern. CO appeared to be most critical as concentrations of 114.5 mg/m^3 or more were observed at 30 m distance from burning fields and 20.6 mg/m^3 CO was recorded at residences which were even 150 m away. Since the Permissible Limit of CO in ambient air is 4.0 ug/m^3, this was a major health hazard for residents and road travelers in the area. Further, particulates were

---

[1] The Tribune, “A Burning Cause: Paddy Straw”, Sarbjit Dhaliwal, 15th November 2012.

[2] Badrinath,K.V.S. and T.R. Chandkiran 2006, Agriculture Crop Residue Burning in Indo-Gangetic Plains-A study using IRSP6 WIFS satellite data. Current Science,91(8);1085-1089.

also being released in large quantities. PM2.5 ranged between 146 - 221 jjg/rrr; in critically affected areas and average PM10 values were around 300 ug/m^3 (against a Permissible Limit of 60 ug/m^3 for residential rural or other area). Significant amounts (40-50 ug/m^3) of NOx and NH_3 were also recorded during burning, at residences located 200 - 400 m away from burning site, though concentration of SO_2 was less. Further, concentrations of organic pollutants were also found to be significantly high. The smoke was also found to be toxic due to presence of heavy metals, especially iron & zinc. Iron concentrations were in the range of 8778 to 13240 ng/m^3 whereas zinc concentrations were in the range of 1021 to 4854 ng/m^3.[3]

The above data clearly establishes that mass agricultural residue burning in the fields is seriously damaging the environment and natural resources of the state. Further, open burning of residue in the fields also leads to death of soil micro flora and fauna and may also damage nearby trees near roads and canals, in addition to adjoining standing crops. Further, the ash left after burning is a very good absorbent and if not mixed properly, adsorbs the applied weedicides, which results in decreased efficacy of herbicides.

Thus, the on-site impact of crop residue burning in the fields includes removal of a large portion of the organic material from the soil, denying the soil an opportunity to enhance its organic matter and incorporate important chemicals such as nitrogen, phosphorous and other micro nutrients, as well as, loss of useful micro flora and fauna of the region. The off-site impacts are health related due to general air quality degradation of the region resulting in aggravation of respiratory problems (like cough, asthma, bronchitis), eye and skin diseases, eye and skin diseases which not only increases individuals' diseases mitigation expenses but also affect their productivity in general,

---

[3] Air Pollution Discharged from the Burning of Crop Residue in Agriculture Fields in Punjab, (2006), Envirotech Instruments Private Limited, Punjab Pollution Control Board.

affects on regional climate and crop output[4]. Most of the studies involving health impacts of air pollution and implementation of pollution control laws remain confined to urban areas as air pollution is considered mainly the problem of urban areas in developing countries. The health consequences from burning of agriculture residue on population and soil are not fully understood. Fine particles also can aggravate chronic heart and lung diseases and have been linked to premature deaths in people already suffering from these diseases. The black soot generated during burning also results in poor visibility which could lead to increased road side incidence of accidents.

Punjab has empowered district magistrates to invoke Section 144 Criminal Procedure Code (imposed for preventing disturbance and maintaining law and order), with cases against farmers setting their fields on fire. A case is made out under Section 188 Indian Penal Code for violating of this order. Punjab needs at least 40000 happy Seeders to tackle paddy residue burning but only 200 such machines being used[5]. Punjab Governments ban on sowing paddy before 10th June to check falling of groundwater level delays paddy harvest. This results in delayed harvest[6]. Ultimately farmers have few days to clear fields of paddy straw before planting wheat. Due to narrow period, farmers choose the quicker way. Moreover the cost of getting it manually removed cost about Rs 2500-3000 an acre and the ever increasing labor charges has made it economically Unviable.

However currently the biomass generated in the state is either

---

[4] Kumar, P and Kumar, S. "Valuing the Health Effects of Air Pollution from Agriculture Residue Burning".

[5] The Times of India, "Delhi Chokes on Punjab Smoke", Priya Yadav, 07th November 2012.

[6] The Punjab Reservation of Subsoil Water Act 2009, Punjab Act No.6 of 2009.

underutilized or burnt. The wasted biomass holds promising potential for generating power of more than 3000 MW[7]. Crop residues are natural resources with tremendous value to farmers. These residues are used as animal feed, compositing, mulching material for crops, thatching for rural homes and fuel for domestic and industrial use. About 25% of nitrogen, 25% of phosphorus, 50% of sulphur and 75% of potassium uptake by cereal crops are retained in residue, but this huge quantity of nutrients are mainly burned in the fields primarily to clear the field from straw and stubble after the harvest of the preceding crop[8].

It is thus essential to mitigate impacts due to the burning of agricultural waste in the open fields and its consequent effects on soil, ambient air and living organisms.

The Problem

In the present study, the researcher therefore looks for answers to the following questions:

1. What is the seriousness of the problem of crop residue burning and to understand the same and various stake holders?
2. What are the factors responsible for the open-field burning of crop residue?
3. What are the available alternatives to this practice and their cost effectiveness?
4. To find out the reasons of non-effectiveness of laws, lack of awareness and less participation at local level in prevention and control of crop residue burning in open fields?

---

[7] The Indian Express, "3 Crore tones paddy straw that Punjab burns can generate 3000 MW power", 13th November 2012.

[8] Draft Base Paper, "Management of Crop Residue Burning in the Context of Conservation Agriculture".

Understanding why farmers resort to burning, role of laws, level of awareness and extent of local participation is essential for policy makers to arrive at suitable mitigation policies which would reduce paddy wheat open field residue burning in the region which is very essential for the protection of overall environment. Increased mechanization, particularly use of combine-harvester, declining number of livestock, long period required for compositing and no economically viable alternate use of residue are some of the reasons for residue being burnt in the open fields. The number of combine harvester in the country, particularly in the IGP has increased dramatically from nearly 2000 in 1986 to 10000 in 2010. Northwestern part (Punjab, Haryana and western Uttar Pradesh) of the IGP has about 75 % of the cropped area under combine harvesting.

Other reason for intentional burning includes clearing of fields, soil fertility enhancement, and pest and pasture management. Burning traditionally provides a fast way to clear the agriculture field of residual biomass and facilitating further land preparation and planting. It also provides a fast way of controlling weeds, insects and disease, both by eliminating them directly or by altering their natural habitat. The time gap between rice harvesting and wheat sowing in northwest India is 15-20 days. In this short duration farmers prefer burning the rice stubble in the open field instead of harvesting it for fodder and other alternative uses. Burning is also perceived to boost soil fertility, although burning actually has a differential impact on soil fertility. It increase the short-term availability of some nutrients e.g. P and K and reduces soil acidity, but leads to a loss of other nutrients e.g. N and S and organic matter. There are various long term impacts of crop residue burning in open fields on the health of the soil and wastage of essential nutrients required by the crops[9].

---

[9] Draft Base Paper, “Management of Crop Residue Burning in the Context of Conservation Agriculture”.

Significance of the Study

The present study is based on the practical approach of the principle of "Think Global, Act Local." Various studies have addressed the issue of burning of the crop residue and its adverse implications on soil, air, human and animal health. But there is a limited research examining the important factors such as the impact of laws, regulations, level of awareness and status of local participation in prevention and control of crop residue burning in open fields.

This research study is about the existing legislation in India on air pollution and specifically focuses on Punjab Government's existing policies, level of awareness and local participation to address air pollution caused by crop residue burning in open fields. The policies that Punjab Government has put in place to prevent this wrong practice from taking place and to study about the bottlenecks in the practical implementation of these laws and policies and suggest some practical and economically viable alternates to check the wrong practice of crop residue burning in open fields. The present research is very significant due to the fact that it is directly related with the issue of pollution of soil and air. Pollution is one of the major area of concern at International, regional, national and local level.

a. The Hon'ble Supreme Court of India appointed Environment Pollution Control Authority (EPCA) directed Punjab and Haryana to ensure a complete ban on the environmentally hazardous practice of burning paddy stubble in open fields within two years. Punjab has been asked to immediately issue a notification making agriculture residue burning an offence in the state. Punjab and Haryana were told to promote alternative use of paddy stubble such as power generation and bio-methanation in the next two years. EPCA directed these States to issue notification under Section 19(5) of the AIR (Prevention and Control of Pollution) Act 1981. The Central Government directed the

Indian Institute of Technology, Kanpur, to study the causes and phenomenon of smog as well as to come out with remedial measures. The study earlier conceptualized for just Delhi will now look at the entire northern region[10].

b. The Hon'ble Punjab and Haryana High Court in C.W.P.No 10138 of 2006 and 7501 of 2007 decided on 16th April 2012, pertaining to the formulation of a policy by the States to ban the burning of wheat/paddy stubble as such a process pollutes the environment[11]. The Court said that this is an issue where promulgation of a law banning such activity possibly may not yield the desired result. A flat or a diktat by an authority necessarily involves penal consequences upon its violation and booking the farmers for violating the ban on burning of wheat/paddy stubble would hardly be a situation which any government and citizen would want. It has also to be understood that a farmer feeds a nation and, therefore, holding him responsible alone would not be a relish able idea. The issue, therefore, has to be seen from the perspective where the society and the government, who are beneficiaries of the industrious activity of a farmer, take proactive measures by providing solutions to a farmer which are affordable and readily available and thus save both the farming community and also the general public from the hazards ensuing the polluting activity of burning straw. The government reaches out to the farmers at the grass-root level who are not only to be educated but are to be given alternatives to get rid of this problem.

c. The practice of burning post harvest plant stubble in the agricultural fields of Punjab has received International attention with the National

---

[10] The Tribune, "S.C. panel tells Punjab, Haryana to stop burning paddy straw", 11th November 2012.

[11] http://indiankanoon.org/doc/135616164/Capt. Sarbjit Singh V. State of Punjab and Others, assessed on 12th November 2012.

Aeronautical and Space Administration (NASA) releasing a satellite image that resembles those taken during forest fires. The Aqua satellite images captured by NASA shows large number of fires over millions of hectares of agricultural fields of Punjab. “The fires could very well be agricultural fires. Smoke from hundreds of fires obscure most of the Punjab region of India,” said NASA while releasing the image on October 31st, 2012. The images taken by NASA on 5th November 2012, shows that burned paddy stubble has increased the suspended particles in the air in Punjab, resulting in haze. The suspended particles in the air have increased from 200 ppbv (part per billion by volume) on October 31, 2012 to 220 ppbv on November 5, 2012. Data obtained by the University of Maryland, Which has been supported by NASA and ISRO, have found that agriculture plumes have risen up to 2.28 km[12].

d. There are reports of FIRs being registered in various districts of Punjab against the farmers for open field crop residue burning. The PAU and state Agriculture department have been regularly issuing guidelines and alerting farmers against stubble burning but with limited impact due to lack of economically viable alternates. These fires could well be compounding the smoggy conditions prevailing over the National Capital in recent days. R.K. Jenamani, director in-charge at the Met department office at IGI Airport, said no scientific assessment is being made to ascertain the contribution of these fires to the Delhi’s smog. “However the wind direction is towards city; so a quarter of total smog in the air at present can be attributed to this factor”. However, the Punjab Government strongly refuted the “unsubstantiated allegations” saying that there was no scientific evidence to hold it responsible. Regarding paddy-husk burning, it seems, Punjab, after registering some gains last year is back to square one[13].

---

[12] Source URL: http://www.downtoearth.org.in/content/nasa-draws-attention-fires-punjab-fields, assessed on 12th November 2012.

[13] The Tribune, “Not to blame for Delhi smog: Punjab”, 09th November 2012.

Objectives

Aims and objectives of this research are to:

1. To find out and scrutinize the reasons why farmers of this region burn crop residue in open fields;
2. To monitor the effects of present laws and policies to check crop residue burning in the commencing period of the study;
3. To find out the loopholes in laws and policies regarding this problem;
4. To propose solutions to protect the public health and welfare and natural resources of the state getting affected due to open field burning of crop residue.

Study Area

Punjab: The state of Punjab located in the North West India, bordering Pakistan, extends from 29°32' to 32°32' North and 73°55' to 76°50' East. It is surrounded by the Indian states of Jammu and Kashmir in the north; the hilly state of Himachal Pradesh in the east; and by the state of Haryana and Rajasthan in the south. It covers a geographical area of 50,362 square kilometers and is one of the smallest states in India. Punjab was the fourth largest producer of rice and second largest producer of wheat in India, producing 19 percent of the country's wheat output and 11 percent of its rice output from 12.4% and 6.7% of the total area under wheat and rice, respectively. It has contributed 25-50% of rice and 38-75% of wheat to the central pool of food grains over the last four decades. With rice and wheat yields of 3741 Kg per hectare and 5097 Kg per hectare respectively in 2011-12(E), the state occupied the top position in the country in terms of food grain yield. Punjab ranks 7th as gross producer of wheat in the world, it generates third largest marketable surplus after Canada and Australia, which is about

one tenth of the global trade in wheat. In case of rice its marketable surplus is 2nd only to Thailand[14].

Case Study: Socio-culturally the state is classified into three regions – Majha, Malwa and Doaba. Our case study is located in the Malwa region, south of the river Satluj i.e. Bathinda District is situated in the southern part of Punjab State. The study area comprises of three tehsils, namely Bathinda, Rampura Phul and and Talwandi Sabo. Consisting 8 blocks and 285 villages. The total area of the District is 3335 sq. km or 336725 hectares[15]. The District is surrounded with Sirsa, Fatehabad, Sangrur, Mansa, Moga, Faridkot and Sri Muktsar Sahib.

Methodology

This study will based on the data analysis at various levels and micro investigation at the same level, field survey in the various areas of Bathinda District, views of the farmers and the opinion of the various experts such as agriculture scientists, environmental experts, legal experts, medical experts, officials of various agencies like PPCB, NGOs working in the field of environment and agriculture will also be the base of this study.

The process to find out the cost effective and easy methods or technology to suggest the farmers to reduce and prevent the problem of crop residue burning in open fields, the data and information for the present study is also collected from various sources such as Regional Centre of PAU, PPCB, Agriculture Department of Punjab Government, Punjab State Farmers Commission, various official websites, contemporary media and available secondary literature regarding alternatives for crop diversification like

---

[14] Statistical Abstracts of Punjab, 2012.

[15] Ibid

horticulture particularly citrus plantation, vegetables and other alternative crops like maize to reduce the area under paddy cultivation. The analysis of existing laws and policies also has been done to find out some solutions required to solve the problem. Overall a mixed approach has been adopted in the drafting of the present work.

The Chapters

The study is presented in three chapters apart from this short introduction of the issue and a concluding section.

Chapter 2 attempts to review the relevant literature related with the study in general and particularly laws and policies to control air pollution in India includes: Air (Prevention and Control of Pollution) Act 1981, The Environment Protection Act 1986, The National Green Tribunal Act 2010, Biological Diversity Act 2002, and the Policies and Regulations of the Government of Punjab deals with the prevention and control of the crop residue burning in open fields and provision like Section 144 Cr.P.C., under which the Deputy Commissioner of the concerned District banned the open field burning of crop residue.

Chapter-3 presents the impact of laws, level of public awareness and local participation. Study all the implementation of legislative aspects, measures available and policies, programmes and regulations to prevent and control the pollution caused by the open field burning of crop residue. The provisions under the scope of Punjab Pollution Control Board (PPCB), role of various departments and institutions of Punjab Government like Punjab Agriculture University, Punjab State Farmers Commission, Department of Agriculture, Department of Animal Husbandry, Department of Rural Development and Panchayat and PEDA are also discussed.

Chapter 4 is an attempt to analyze the existing laws and policies, programmes and the regulations of the Punjab Government and on the issue of open field crop residue burning and make some analytical notes. This chapter find out the reasons for non-implementation of the laws and regulations. This chapter also try to authenticate or prove the reasons for non-implementation of various laws, policies and regulations to control the open field burning of crop residue.

In the concluding section, chapter 5 summarizes the findings of the study. It also include some possible suggestions for policy building to address the serious environmental and agricultural issue of open field crop residue burning in Punjab.

Chapter 2

Literature Review

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. During 1964-65 drought conditions, India imported 13 million tons of food grain. This has put heavy drain on foreign reserves of the nation. Hence the policy to adopt agriculture 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, Gujarat, etc., with Punjab emerging as a frontrunner. The innovative and hard working farmers of the state adopted green revolution and made it a great success. 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 29.07 million tons in 2011-12(E), thus contributing more than 50% of grains into the central pool leading India from a famine affected and grain importing country to a self reliant, self sufficient and export surplus nation[16]. 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 (MSP) for grains, subsidy for chemical fertilizers and irrigation facilities improved, in the interest of National Food Security (NFS), farmers in the state continued to bring more and more areas under paddy and wheat.

The state is now at the cross roads. The state's agriculture has reached a platue under the available technologies and natural resources base and has become unsustainable and non profitable. The existing policies forced the farmers to over use their land by increasing cropping intensity (cropping intensity has increased from 126% in 1960-61 to 189% in 2005) and adopting the wheat-

---

[16] Statistical Abstracts of Punjab, 2012.

Paddy mono-cropping practices. The various centre and state level policies like MSP and effective procurement of selected crops, subsidies on agriculture inputs and energy and available credit facility 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 use of groundwater resources due to cultivation of water-guzzler crops like paddy.

The above driving forces have induced several pressures on the agriculture pattern and environment. The area under paddy has increased twelve fold from 227 th ha in 1960-61 to 2818 th ha in the year 2011-12(E). This has lead to decline in the 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 2011-12, from 1400 th ha to 3528 th ha, respectively.

The rapid adoption of green revolution technology in Punjab has also led to a sharp increase in farm mechanization. The 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. Intensive agriculture is also a contributor to greenhouse gases (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 omissions. These include emissions from enteric fermentation in livestock, manure management, rice cultivation and burning of agriculture crop residues[17].

A study taken up in 1985, by Committee on Agricultural Diversification in Punjab recommended that 20% area under paddy crop should be replaced by other crops. However, Government of India in the interest of NFS increased MSP, fertilizer subsidy, promoted High Yield Varieties (HYV) of wheat and paddy.

---

[17] State of Environment Punjab-2007, report by Punjab State Council for Science and Technology, Chandigarh.

The natural response of the farmers of Punjab to this lucrative price, secure technology and high production was to bring more area under paddy and wheat cultivation. This result 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. The Advisory Committee on "Agricultural Policy and Restructuring, 2002" recommended crop diversification.

A study, 'Withering Punjab Agriculture: Can it regain its leadership' by International Food Policy Research Institute (IFPRI) has put out a red alert on the farm sector in Punjab. The study has warned that Punjab needs to diversify from wheat and paddy, urgently; otherwise the food bowl of India could well turn into a begging bowl by 2030. As per the study, the yield of paddy 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 Indian average of 3.2%). Paddy production has come, at the expense of other crops too.

The Government of India introduced MSP system under the Agriculture Price Policy since 1965. The MSPs are announced by the Government with a view to encourage food grain production, ensuring remunerative prices to farmers for their produce on the basis of the Commission for Agricultural Costs and prices (CACP) recommendations. In Punjab, the MSP of wheat and paddy crops were effectively implemented. This encourages farmers to make investments on large scale on land and water development and increase the area under HYV of these two crops. In case of other crops, there had been hardly any procurement and market prices in many cases have ruled lower than the MSP. Despite decline in the margins 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 as compared to other crops. The cultivation of wheat and paddy crop rotation is causing irreparable damage to state's ecology especially depletion of groundwater table, deterioration of soil health and

environmental pollution, but it is very difficult to break this rotation under the present circumstances.

The subsidy on electricity is also one of the reasons for adoption of paddy cultivation. The operation cost of paddy, if there were no electrical subsidy, would have increased by 36% in 2000-01 and by as much as 38% in 2010-11. Likewise, the increase in the operation cost of wheat, due to much lower requirement of irrigation was 10.2% in 2000-01 and 10.7% in 2010-11. These cost increases were for the Punjab as a whole. For the pure tube well irrigated farmers, the increase would be much higher. The operational cost of the pure tube well irrigated farmer during 2010-11, which was Rs 21315 and Rs 18832 per hectare of paddy and wheat respectively with electricity subsidy would have increased without electricity subsidy by as much as 47% for paddy and 13% for wheat in 2010-11[18].

The three pillars of the agricultural liberalization in India and in Punjab state – crop monocultures, subsidized access to electricity for drawing water for irrigation and increased fertilizer use – have culminated in several negative ecological externalities such as depletion in underground water and negative impacts on soil fertility. The intensive production has led not only to over emphasis on rice-wheat monocultures, but also higher incidence of pests and diseases within these two crops in particular. Even though the government intention of late has been to move away from paddy cultivation in Punjab; a remunerative price regime and significant subsides on fertilizers and electricity have created a perverse scenario: from excessive depletion of groundwater resources, decline in soil quality and productivity, loss of biodiversity and environment pollution from agricultural activities. Thus, intensification of food production can put pressure on ecosystems; threaten their resilience and the services that they provide. The

---

[18] Singh, Karam (2012), Electricity Subsidy in Punjab Agriculture: Extent and Impact, Indian Journal of Agriculture Economics Vol. 67, no.4, Oct-Dec 2012.

Sustainability of these initiatives is still unknown and there is a strong need for such an analysis.

In response to this situation, The Ecosystem Services Economics (ESE) Unit of the Division of Environmental Policy Implementation of UNEP, in collaboration with GIST Advisory, is implementing a United Nations Development Account 7th Tranche – funded project entitled, "Capacity – building in national planning for food security" in Punjab state in India as well as in Uganda which was initiated in 2011. The proposed project will add value in identifying the trade-offs and enhancing the understanding of the linkages between ecosystem services and food security through capacity – building activities, and will allow us to understand the costs and benefits of food production policies on ecosystems.

Area under Rice & Wheat Cultivation in India

As a result of the green revolution, the total area under rice cultivation in India increased from 34,130 thousand hectares (with Punjab accounting for 227 thousand hectares; i.e., 0.66 per cent of total area) in 1960-61 to over 42.560 thousand hectares in 2010-11. Similarly, total area under wheat cultivation in India increased from 12,930 thousand hectares (with Punjab accounting for 1400 thousand hectares; i.e., 10.82 per cent of total area) in 1960-61 to over 29,250 thousand hectares in 2010-11 (Table 2.1).

Crop	**Table 2.1. Area Under Rice and Wheat Cultivation in India ('000 ha)**										
	1960-61	**1965-66**	**1970-71**	**1975-76**	**1980-81**	**1985-86**	**1990-91**	**1995-96**	**2000-01**	**2005-06**	**2010-11**
Rice	34130	35470	37590	39480	40150	41140	42690	42840	44710	43660	42560
Wheat	12930	12570	18240	20450	22280	23000	24170	25010	25730	26480	29250

Source: Compiled from Various Editions of Statistical Abstract of Punjab, Directorate of Economics and Statistic

Simultaneously, additional costs such as the ecological and health impacts of soil and water degradation as a result of increased fertilizer and pesticide usage, caused by attempts to increase yields, are increasing steadily. One of the key concerns is that in the absence of any productivity growth, the consumptive water use (evapotranspiration) demand is set to exceed the utilizable water resources in the country. To meet future crop demands, India will need to increase water productivity. Therefore, better water saving techniques, efficient irrigation systems, soil – centric rather than crop- centric policies and better awareness with regards to conservation techniques are the need of the hour. It is clear that increasing agricultural production via mono – cropping and intensification cannot be the solution. What is required is an efficient and holistic approach that keeps in mind the effects of trade – offs such as ecosystem losses, nutrition losses, etc. while providing effective food security for an increasing population.

State of Punjab: Profile

The State of Punjab derives its name from the Persian words “panj” meaning five and “aab” meaning water; which joined together mean “land of five rivers”. Originally located in the confluence of the rivers Beas, Chenab, Jhelum, Ravi and Sutlej; post India – Pakistan partition in 1947, only two of these rivers, the Sutlej and the Beas, lie within Indian Punjab’s territory, while Ravi flows along a part of its western border with Pakistan. Having an area of 50,362 km^2 (1.5 per cent of total geographic area of India), the state of Punjab extends from the latitudes 29.33° North to 32.32° North and longitudes 73.55° East to 76.56° East.

Punjab‘s Contribution to National Production and National Pool of Food grains

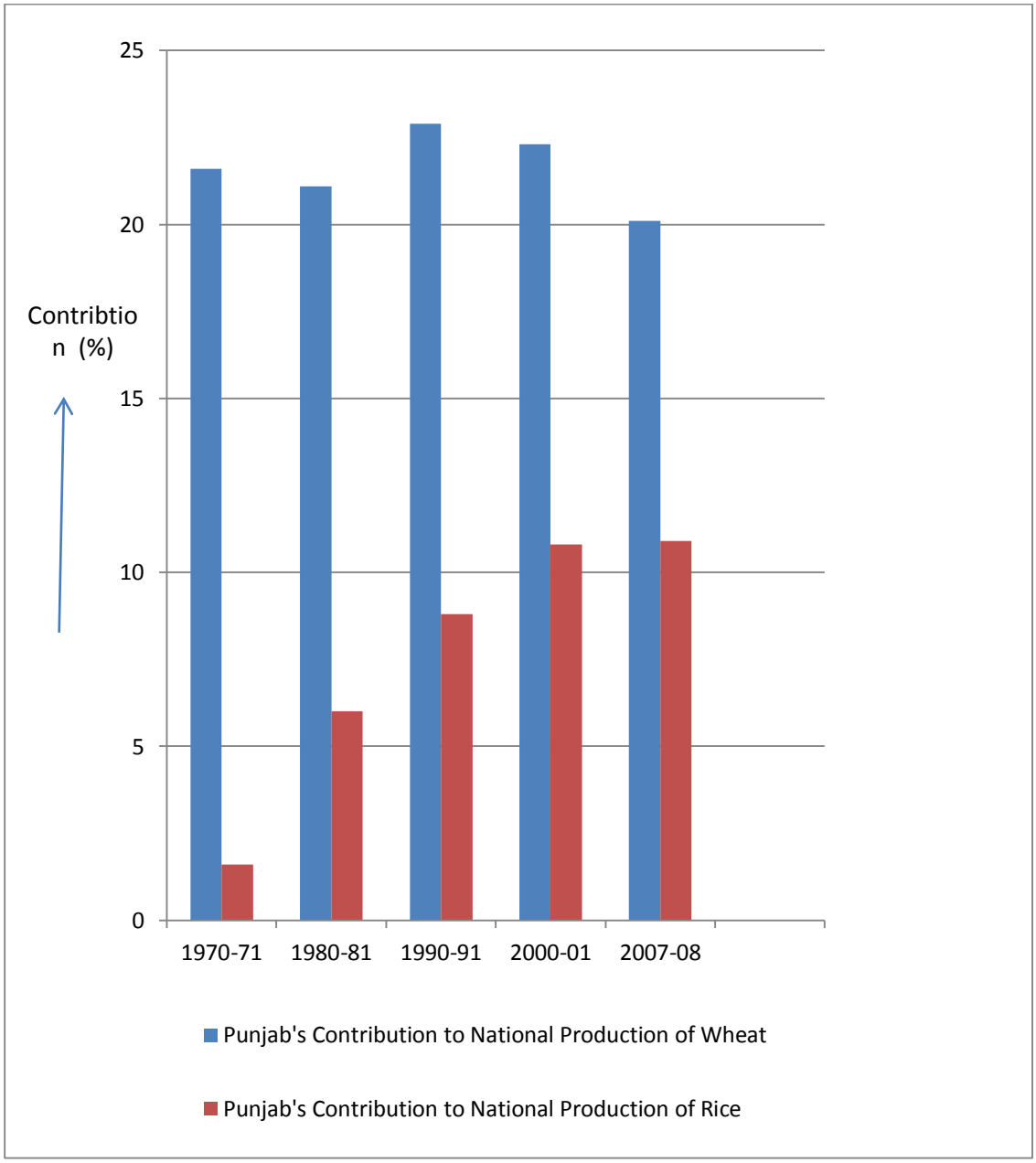
Known as the “Granary of India”, the state produces 20.1 per cent of India

---

[19] FSI, (2011), India State of Forest report 2011, Ministry of Environment and Forest, GOI.

wheat and 10.9 per cent of India's rice states (Table 2.2); and contributes a major share towards food security in India. By the peak of the green revolution in the 1980s, the state contributed 73 per cent of the wheat and 45 per cent of rice to the national pool.

Table 2.2. Punjab's Contribution to National Production of Rice and Wheat.



Despite increasing its production contributions significantly for rice, there has been a decline in the state's contribution to the national pool of food grains due to the spread of rice and wheat cultivation in other states. Still, Punjab continues to make significant additions to towards the national pool – contributing 61 per cent of wheat and 30 per cent of rice in 2007-08 (Table 2.3).

Table 2.3 Punjab's Contribution to National Pool of Food grains for Rice & Wheat

Year	Contribution to National Pool for Wheat (%)	Contribution to National Pool for Rice (%)
1970-71	74.00	16.00
1980-81	73.00	45.00
1990-91	61.00	41.00
2000-01	58.00	33.00
2007-08	61.00	30.00

Source: B. S. Dhillon, et al., 2010

Food grain Production in Punjab

From 1980-81 to 2010-11, in Punjab, total food grain production increased by 129 per cent, with rice production (235 per cent growth) outweighing wheat

production (106 per cent growth) during the same period. However, contrary to national figures, coarse cereal and pulses registered negative 33 per cent and negative 91 per cent growth respectively.

Area under cultivation in Punjab

As a result of the spread of the green revolution in Punjab, the share of rice has increased from 4.8 per cent of gross cropped area in 1960-61 to 33 per cent in 2004-05. The increase in area under rice and wheat has led to decline in area under other major kharif crops like maize, jowar, bajra, sugarcane, groundnut, pulses, etc.; compounding the fear that the state is growing only two crops – wheat and rice – which accounted for 71 per cent of the gross cropped area. The area under pulses has continued to decline from 19.08 per cent in 1960-61 to 0.45 per cent in 2004-05, with oilseeds having declined from 3.9 per cent to 1.9 per cent during the same period (Table 2.4).

Table 2.4. Area Under Cultivation in Punjab ('000 Ha)

Year	Rice	Wheat	Coarse Cereals	Pulses
	Area under Cultivation	Area under Cultivation	Area under Cultivation	Area under Cultivation
1960-61	227	1400	533	903
1970-71	390	2299	825	414
1980-81	1183	2812	518	341
1990-91	2024	3272	236.3	146.4
2000-01	2611	3408	202.1	60
2010-11	2831	3510	148	21.2

Source: Compiled from various editions of Statistical Abstract; B.S. Dhillon et al., 2010

Legislations to control air pollution in India

1. Air Prevention and Control of Pollution Act 1981
2. The Environment Protection Act 1986
3. Biological Diversity Act 2002
4. National Green Tribunal Act 2010
5. Policies, Regulations of the Government of Punjab dealing with the prevention and control of the air pollution due to crop residue burning in open fields.

Some other Acts are also having provisions to control air pollution such as Criminal Procedure Code, Civil Procedure Code and Indian Penal Code. These Acts, policies and regulations is discussed in the next chapter.

Judgment of Punjab and Haryana High Court

On 16th April 2012, the Hon'ble Punjab and Haryana High Court disposed of CWP Nos. 10138 of 2006[20] and 7501 of 2007[21] jointly as both these petitions raise a common but an important question pertaining to the formulation of a policy by these states to ban the burning of wheat-paddy residue, as such a process pollutes the environment. Having found the issue to be of importance and in public interest the court sought the response from these states. The petitions have remained alive for six long years in the court which has seen the exchange of various reports, studies, suggestions and action taken by the states. In the judgment the court observed that law banning such activity possibly may not yield the desired result. A fiat or a diktat by an authority necessarily involves penal consequences upon its violation and booking the farmers for violating the ban of burning wheat-paddy residue would hardly be a solution which any government or a citizen would want. The court also observed that a farmer feeds

---

[20] Captain Sarbjit Singh v State of Punjab and Others

[21] Jagmohan Singh Bhatti v Union of India and Others

a nation and, therefore, holding him responsible alone would not be a relish able idea. The court observed that the issue, therefore, has to be seen from the perspective where the society and the government, who are the beneficiaries of the industrious activity of a farmer, take proactive measures by providing solutions to a farmer which are affordable and readily available and thus save both the farming community as also the general public from the hazards ensuing the polluting activity of crop residue burning in open fields.

Crop residue burning in United States and Control Mechanism

Crop residue burning occurs in all the fifty states of United States of America. In the contiguous United States nearly 20% of land is dedicated to crops. Residue from corn, cotton, rice, soybean. Sugarcane, Wheat, grass seed and horticulture crops are most commonly burned. Crop residue burning in United States takes two form: (1) the practice of burning residue post-harvest whereby the residues consists of a layer of ground-level senescent vegetation, and; (2) the practice of burning residue pre-harvest whereby leaves and other bio-mass are burned prior to the harvest. In addition to burning crop residue both during and after harvest, fire is also used in cropland areas for pest and weed control and to prepare fields for planting. Crop residue burning helps growers stay competitive as it is an inexpensive and effective method to remove excess residue. This excess residue prevents future seeding by shading out the next crop and facilitating mold growth. Crop residue burning also provides a short term ash fertilization effect.

The spectrum of technologies and systems used to set cropland fires and monitor crop residue burning in the United States ranges from very basic to complex. Depending upon where a farmer lives, he or she may simply wake up and decide to burn without any requirement from local, state, or federal laws or agencies. However, he or she may have to plan their burn weeks in advance, pay for a permit to burn, and to burn only on days that have been forecasted by state agencies as appropriate ‘burn’ days given local meteorological conditions. Some farmers retrofit old, metal gasoline cans for drip torches while others have

equipped small farm machinery with actual torches. In both Arkansas and Idaho, local officials have reported seeing farmers set fire to old tractor tires and then drag these burning tires across the field in order to burn residues. In all cases, farmers aim to completely burn the crop residues within the field boundary.

Most states in U.S. are so-called 'freedom to farm' or 'right to farm' states, whereby the state legislature cannot pass a law which limits or prejudices agricultural activities or allows for nuisance lawsuits against agricultural activities. However, concerns over impaired air quality and visibility related to the smoke from crop residue burning have forced many states to rethink past hats-off legislation on agriculture burning. Seven states, including Louisiana and Idaho, require that farmers must burn during the daytime only and that certified Burn Managers must be present at all fire events. Because of proximity of large urban areas such as West Palm Beach, Naples, and Miami, corporate and cooperative sugarcane farmers in Florida requested a burn policy and permit system to limit nuisance complaints. Since 2004, the Florida Department of Forestry issue daily burn permits, based on wind conditions, directions and flammability. Agricultural burn policy in Washington is enforced by the Washington Department of Ecology under The Clean Air Act, 1991 of Washington. The Washington Department of Ecology issues all burning permits and has the legal right to fine farmers $ 10,000 for any illegal residue burning[22].

Crop residue burning regulations in different states of United States

California: (a) Requires a burning permit;

(b) Burning only on burn days determined by local Air Districts in consultation with the California Air Resource Board;

(c) Residues required to be shredded and piled when possible (CARB, 2006).

---

[22] http://www.arb.ca.gov/smp/regs/regs.htm. Accessed on 12 Dec.2012.

Florida: (a) Sugarcane farmers initiated burning oversight with Florida

Department of Forestry (FLDOF) in 2004;

(b) FLDOF issues burn permits between November and March (FLDOF, 2005).

Louisiana: farmers can burn during the daytime and are required to have certified Burn Managers at the burn (LSU Ag Centre, 2000).

Oregon: (a) In 1991, House Bill 3343 established an open field burning acreage phase-down, propane flaming limitation, and residue burn permitting issued by the Oregon Department of Agriculture (ODA) for the Willamette Valley;

(b) 102,500 acres of grass seed and cereals residue can be burned per year, which is enforced through aerial and ground surveys;

(c) ODA has the right to fine growers that burn on no-burn days (ODA, 2007).

Washington: (a) Washington Department of Ecology (DOE) under the 1991 Clean Air Act of Washington issues all burning permits and determines burn days based on atmospheric conditions and U.S. Forest Service fire danger ratings;

(b) Cost of permits is $ 2.00 per acre to be paid by the farmer;

(c) DOE can fine farmers $ 10,000 for any illegal crop residue burning;

(d) DOE uses aerial photography, tip hotline, and remote sensing for enforcement (WA DOE, 2005).

Alternatives to crop residue burning in United States

Alternatives to crop residue burning include incorporating residue back into the soil. In California, the Air Resources Board recommended using crop residue for offsite use, such as “energy production, as construction materials, in paper and cardboard, as compost for mushroom growing and soil amendment as cover for erosion control and landfill (1995)”. The Air Resources Board also noted that these offsite uses were not economically viable alternatives for most farmers

except if there were future growth in energy production from crop residue, which has shown some promise in Brazil with biofuel production from sugar cane. In the state of Washington, Kentucky bluegrass seed farmers are now required to use herbicide, often referred to as “chemical burning”, as an alternative to burning residues. Seed growers in Washington have also sold their excess residue as livestock feed and bedding in the nearby and neighboring states, though this is highly dependent on the presence of drought conditions which limit natural growth of pastures.

Crop residue in China

In China 37 % of crop residues are directly combusted by farmers, 23% used as forage, 21% discarded or directly burnt in fields, 15% lost during collection, 4% for industry material and 0.5% for biogas[23]. Crop residue management is also a problem in China.

Crop residue management in some other countries

Mode of utilization	Country
Source of energy	Indonesia, Nepal, Thailand, Malaysia, Philippines, Indonesia, Nigeria
Composting	Philippines, Israel, China
Animal feed	Lebanon, Pakistan, Syria, Iraq, Israel, Tanzania, China, Africa
Mushroom cultivation	Vietnam
Burning	China, USA, Philippines, Indonesia

[23] Liu H, Jaing GM, Zhuang HY, Wang KJ, (2008) Distribution, Utilization, Structure and Potential of Biomass resources in Rural China with the special reference of crop residue. Renewable and Sustainable Energy Reviews.12:1402-1418.

In order to minimize the problems associated with the residue burning, concerted efforts have been made to explore ways and means for efficient handling the crop residues specifically for maintaining soil, human and animal health, and increasing farmer's profits. Some of the available options include; i) in-situ utilization after incorporation into the soil, burning and surface retention for later use as mulch or ii) removal from the field and its use for animal feed, bedding for animals, as a substrate for composting, biogas generation or mushroom culture or as a raw material for industry. These options are described in the following sections and details on these are also available in the reviews published elsewhere.

IN-SITU UTILIZATION OF CROP RESIDUES

Soil Incorporation

The incorporation of organic residues into fields returns the nutrients contained in straw and also helps to condition the soils. But the incorporation of crop residues with high C-to-N ratio like paddy and wheat results in microbial N immobilization and a temporary decrease in plant- available N. This initial period of several weeks of net N immobilization is however followed by a net N mineralization[24].

Paddy Straw

As stated above, low turn-around time between paddy harvest and wheat sowing can lead to net N immobilization after its incorporation. However, when paddy residue is incorporated about 10-20 days prior to establishment of the succeeding crop, 25% of it gets decomposed during the pre-wheat fallow period. Further decomposition during the wheat season leads to release of 6 to 9 kg N ha. Thus, wheat productivity was sustained when fertilizer N was applied as per

---

[24] Yadwinder Singh, Thind C.S., Bijay Singh (2005). Raise green manure crop in combine harvested wheat fields. Progressive farming 41(3): 17-18.

recommended rates. Rather the long-term incorporation of paddy residues increases the readily mineralized organic soil N indicating a potential for saving N-fertilizers for optimal rice yield. Incorporation of paddy straw did not affect on wheat yield during the initial three years and rather these improved during the 4th year compared with straw removal or it's burning.

The incorporation of paddy straw is likely to more beneficial in conditioning of heavy textured soils and improvement in their soil-water relationships and also those are irrigated with waters having residual alkalinity. In-situ paddy straw incorporation has been recommended as an alternate to burning but this practice could not gain popularity with farmers due to impediments of low turn in time at their disposal for planting wheat and also the costs and energy involved in its incorporation. The latter involves additional cost to the tune of Rs. 1000 per acre for the use of straw chopper followed by rotavator[25].

Wheat Straw

Mostly the farmers try to collect the wheat straw for its later use as cattle feed. Specialized machinery has been developed to collect wheat straw even that is left after harvesting with combines. Nevertheless, the left over anchored straw (25-30%) is still burnt since it hampers smooth transplanting of paddy. Like paddy straw, wheat straw contains considerable amount of plant nutrients representing 30-35% N, 10-15% P and 70-75% K of total nutrients removed by the crop along with several other secondary and micronutrients. Therefore, recycling of wheat straw in the combine-harvested fields can be of great help in sustaining soil health. Nevertheless, such a practice lead to reduction in rice yields by about 0.8 t ha when compared with its removal or burning. This is

---

[25] Gupta,R.K.,Yadwinder-Singh,J.K.Ladha,Bijay-Singh,Jagmohan Singh,G.Singh and H.Pathak(2007). Yield and phosphorus transformation in a rice-wheat system with crop residue and phosphorus management. Soil Science Society of America Journal71.1500-1507.

obviously due to N immobilization and release of organic acids during later decomposition. To overcome these problems, increasing the period for decomposition, enhancing its pace with additions of inorganic N and green manures (GM) or by using cellulytic bacteria have been tried.

Retention as Surface Mulch

Surface retention of crop residues as mulch is known to have multifarious effects. These conserve soil water, moderate the thermal regimes, suppress weeds and improve soil health those help in improving crop yields and may result in irrigation saving. The effectiveness of mulch to reduce soil water evaporation depends upon the soil type, rainfall pattern and evaporative demand. The evaporation reduction is more and lasts longer in fine- than coarse-textured soils, and under high evaporative demand. More favorable soil temperature and higher water content under mulched than un-mulched soil also increases mineralization of soil and applied N. This has implications for N fertilization of crops. Straw mulching of crops has been useful in both irrigated and rain-fed environments.

Machinery for Surface Retention of Paddy Straw and its Performance

Benefits of minimum and zero-till technologies are now well recognized in terms of economics, irrigation water saving and timeliness of sowing over the conventional tillage practices. Nevertheless, the problems like accumulation of loose straw along seed drill furrow openers, poor traction of seed metering drive wheel and non-uniform depth of seed placement have been the major hindrance in direct drilling of wheat into combine harvested rice fields. Thus, there was general lack of appropriate machine that could plant wheat directly in fields having heavy straw load. These problems have now been overcome and a new machine called as 'Happy Seeder' is available.

Straw Management System (SMS) for Combine Harvester:

Since uniform distribution of loose straw is pre-requisite for smooth operation of the HS, it was felt that the existing combine harvester should be

modified to achieve the same. The problem of loose straw spreading can be solved if the straw coming from the straw walker and sieves is chopped and evenly spread in the working width of combine harvester in a single pass. A straw management system (SMS) developed by PAU is attached to the rear side of combine harvester just below the straw walkers and behind the chaffer sieves. Once the straw is cut into pieces by straw manager passes through spreader, it is uniformly distributed in the already harvested field. The tentative cost of SMS unit is Rs.15,000. Use of the spreading attachment with the combine harvester enables harvesting of rice and sowing of wheat using HST on the same day in the residual soil moisture and thus saving the water to be used for pre-sowing irrigation.

The above review of literature is based on the data collected by the primary and secondary sources and the visit to various offices in the region. Importance has been given to the discussion with farmers and the experts of the field including the academicians. But the above survey is illustrative and need suggestion for further study. Chapter 3 of the study is also the part of this survey and discussed in detail entitled Existing Laws and Policies.

Chapter 3

Material and Methods

Rice and Wheat system is the major cropping of Punjab. Cultivation of high yielding verities of the rice and wheat has resulted in production of huge quantities of crop residue. At present, while more than 75% of wheat residue is collected by the farmers using straw combine after combine harvesting and fed to animals, paddy straw is considered poor feed for animals, due to its high silica contents and use of insecticide on it. Burning is the normal method of paddy straw management because residues interfere with tillage and seeding operation for the next wheat crop. Burning of residue has been doing great damage to the environment and the root cause for a series of serious environmental problems. In view of the serious environmental problems associated with the burning of paddy residue, studies were taken by PAU, Ludhiana in collaboration with ACIAR/ CSIRO Grifith/ NSW-DPI, Australia to develop sustainable methods of management of crop residue but very few steps have been taken by the policy and law makers to control and regulate the problem of crop residue burning. Here this chapter of research work is presents the existing legislation and proceeds to analyze the policies to address the pollution from crop residue burning. The chapter is important one, as it is about to the legal framework available and analysis the same and tries to find out the impact of laws on the issue. It will provide the legal ideal guidelines to control and mange the problem.

Various Laws to Control the Environmental Pollution in India

Environmental Jurisprudence in India has its roots in the Common Law principles and further developed in India by various Constitutional and unconstitutional bodies. The substantive law for the protection of environment is basically that of Common Law relating to Nuisance. In fact, the remedies under the law of tort to abate environmental pollution are the oldest legal remedy. Nuisance created by environmental pollution can also be controlled and regulated under the statutory provisions of Indian Penal Code, Criminal

Procedure Code, Civil Procedure Code and many other Central and State Laws, there are provisions to control public nuisance.

I. Common Law Remedies

The term 'Common Law' is derived from the Latin words Lex Communis. It is a body of customary law of England based upon judicial decisions. As the courts examine each new set of facts in the light of past precedent, an orderly development of common laws occurs through a slow and natural process. Thus, the basic principles underlying American jurisprudence remain fundamentally constant, evolving slowly and progressively.

The Common Law continues to be force in India under Article 372 of the Constitution in so far it is not altered, modified or repealed by statutory law. The common law actions are civil suits in which the plaintiff (the party bringing the lawsuit) seeks to remedy a violation of a right. Civil actions are distinguished from criminal proceedings. Criminal actions are those in which the state seeks to redress a breach of public or collective rights that are established in codified penal law.

The three types of common law actions most commonly encountered in the environmental field are: nuisance, trespass and negligence.

i) Nuisance

Nuisance is the most frequently pled common law action in environmental litigation. Nuisance law traditionally protected the right of a landowner to use and enjoy property.

Nuisance is defined as "that activity which arises from the unreasonable, unwarrantable or unlawful use by a person of his own property, working an obstruction or injury to the right of another or to the public, and producing such material annoyance, inconvenience, and discomfort that the law will presume resulting damage."

The general rule is that a person may use his land or personal property in any manner he sees fit. However, this rule is subject to limitation. The owner must use his property in a reasonable manner. A nuisance arises whenever a person

uses his property to cause material injury or annoyance to a reasonable neighbor. Odors, dust, smoke, other airborne pollutants, water pollutants and hazardous substances have all been held to be nuisances. Nuisance actions come in two forms: public and private. Under both private and public nuisance law, the plaintiff must prove that the defendant's activity unreasonably interfered with the use or enjoyment of a protected interest and caused the plaintiff substantial harm.

ii) Trespass

Trespass is distinguished from nuisance in that trespass is interference with the possession of property whereas nuisance is interference with the use and enjoyment of property. Trespass to land is an unlawful, forcible entry on another's realty. An injury to the realty of another or an interference with possession, above or below ground, is a trespass, regardless of the condition of the land and regardless of negligence.

Trespass to land is the type of trespass action that is generally used in pollution control cases. In an action for trespass to land, entry upon another's land need not be in person. It may be made by causing or permitting a thing to cross the boundary of the premises. The trespass may be committed by casting material upon another's land, by discharging water, soot or carbon, by allowing gas or oil to flow underground into someone else's land, but not by mere vibrations or light which are generally classed as nuisances.

The line between trespass and nuisance is sometimes difficult to determine. The distinction which is now accepted is that trespass is an invasion of the plaintiff's interest in the exclusive possession of his land, while nuisance is an interference with his use and enjoyment of it.

iii) Negligence

"Negligence" is "the omission to do something which a reasonable man, guided by those ordinary considerations which ordinarily regulate human affairs, would do, or the doing of something which a reasonable and prudent man would not do. Negligence is that part of the law of torts which deals with acts not intended to inflict injury.

The standard of care required by law is that degree which would be exercised by a person of ordinary prudence under the same circumstances. This is often defined as the “reasonable man” rule, what a reasonable person would do under all the circumstances. In order to render the defendant liable, his act must be the proximate cause of injury. Proximate cause is that which in the natural and continuous sequence, if unbroken by an efficient intervening act, produces injury and without which the result would not have happened.

II. Statutory Remedies

There are various statutory provisions in India which play a very important role in prevention and control all kinds of pollution. Constitutional Law of India, Indian Penal Code, Criminal Procedure Code and Civil Procedure Code contain specific provision to protect the environment. A brief discussion on these provisions is under the following heads:

ENVIRONMENTAL REGULATIONS AND LEGAL FRAMEWORK

i) INDIAN CONSTITUTION PRESPECTIVE

a) The State's responsibility with regard to environmental protection has been laid down under Article 48-A of our Constitution, which reads as follows:

"The State shall endeavor to protect and improve the environment and to safeguard the forests and wildlife of the country".

b) Environmental protection is a fundamental duty of every citizen of this country under Article 51-A (g) of our Constitution which reads as follows:

"It shall be the duty of every citizen of India to protect and improve the natural environment including forests, lakes, rivers and wildlife and to have compassion for living creatures."

c) Article 21 of the Constitution is a fundamental right which reads as follows:

"No person shall be deprived of his life or personal liberty except according to procedure established by law."

d) Article 48-A of the Constitution comes under Directive Principles of State Policy and Article 51 A(g) of the Constitution comes under Fundamental Duties.

e) The State's responsibility with regard to raising the level of nutrition and the standard of living and to improve public health has been laid down under Article 47 of the Constitution which reads as follows:

"The State shall regard the raising of the level of nutrition and the standard of living of its people and the improvement of public health as among its primary duties and, in particular, the State shall endeavor to bring about prohibition of the consumption except for medicinal purposes of intoxicating drinks and of drugs which are injurious to health."

h) The 42nd amendment to the Constitution was brought about in the year 1974 makes it the responsibility of the State Government to protect and improve the environment and to safeguard the forests and wildlife of the country. The latter, under Fundamental Duties, makes it the fundamental duty of every citizen to protect and improve the natural environment including forests, lakes, rivers and wildlife and to have compassion for living creatures.

The subjects related to environment in the seventh schedule of the Constitution:

State List

Entry-14 Agriculture, protection against pest and prevention of plant diseases.

Common or Concurrent List

Entries- 17A Forests

17B Protection of wild animals and birds

20 Economic and social planning

As conferred by Article 246(1), while the Union is supreme to make any law over the subjects enumerated in List I, the States, under Article 246 (3), enjoy competence to legislate on the entries contained in List II, and both the Union and the States under Article 246(2) have concurrent jurisdiction on entries contained in List III. In the event of a clash, the Union enjoys a primacy over States in that its legislation in the Union and the Concurrent List prevails over State legislations. Also, the Parliament has residuary powers to legislate on any matter not covered in the three Lists (Art. 248).

ii) **Provisions under Indian Penal Code for the Protection of Environment**

Indian Penal Code 1860 makes various acts affecting environment as offences. IPC can be used to prevent pollution of atmosphere. Thus no trade, business or manufacturing process can be carried out in residential area which produces noxious and offensive smell.

Chapter XIV of IPC containing Sections 268 to 290 deals with offences affecting the public health, safety, convenience, decency and morals. Its object is to safeguard the public health, safety and convenience by causing those acts punishable which make environment polluted or threaten the life of the people.

Section 268 & 290 of IPC defines public nuisance and provides for punishment of fine up to Rs. 200 for public nuisance respectively. Under these provisions any act or omissions of a person which caused injury to another by polluting the environment can be controlled.

Public Nuisance: a person is guilty of public nuisance who does any act or is guilty of an illegal omission which causes any common injury, danger to the people in general who dwell or occupy the property in the vicinity or cause injury, danger , obstruction to persons who use any public right.

Section 269 & 270 of IPC provides, whoever negligently or malignantly does any act which spreads the infection of disease dangerous to life, can be controlled by punishing the person responsible for such act with imprisonment upto six months to six years or with fine or both respectively.

Section 277 provides, whoever voluntarily fouls the water of any public spring or reservoir, so as to render it less fit for the purpose for which it is ordinarily used, shall be punished with imprisonment for three months or with fine of five hundred rupees or with both.

Section 278 provides, whoever voluntarily vitiates the atmosphere in any place so as to make it noxious to the health of persons dwelling or carrying on business in the neighborhoods or passing along the public way, shall be punished with fine upto Rs.500.

Section 284 provides, whoever does, with any poisonous substance, any act in a manner so rash or negligent as to endanger human life, or to be likely to cause hurt or injury to any person, shall be punished with imprisonment for a term of 6 months or with fine upto Rs.1000 or with both.

Section 285 provides, whoever does, with the fire or any combustible matter, any act rashly or negligently as to endanger human life, to be likely to cause or injury to any other person, shall be punished with imprisonment for a term of 6 months, or with fine upto Rs.10000 or with both.

Section 286 provides, whoever does, with any explosive substance, any act rashly or negligently as to endanger human life, to be likely to cause or injury to any other person, shall be punished with imprisonment for a term of 6 months, or with fine upto Rs.10000 or with both.

Under sections 426,430,432 of IPC general pollution caused by mischief can be controlled and the same is punishable.

iii) Provisions under Criminal Procedure Code for the Protection of Environment

Sec.133. (1 Whenever a District Magistrate or a Sub-divisional Magistrate or any other Executive Magistrate specially empowered in this behalf by the State Government, on receiving the report of a police officer or other information and on taking such evidence (if any) as he thinks fit, considers

(a) that any unlawful obstruction or nuisance should be removed from any public place or from any way, river or channel which is or may be lawfully used by the public; or

(b) that the conduct of any trade or occupation, or the keeping of any goods or merchandise, is injurious to the health or physical comfort of the community, and that in consequence such trade or occupation should be prohibited or regulated or such goods or merchandise should be removed or the keeping thereof regulated; or

(c) that the construction of any building, or the disposal of any substance, as is likely to occasion conflagration or explosion, should be prevented or stopped; or

(d) that any building, tent or structure, or any tree is in such a condition that it is likely to fall and thereby cause injury to persons living or carrying on business in the neighborhood or passing by, and that in consequence the removal, repair or support of such building, tent or structure, or the removal or support of such tree, is necessary; or

(e) that any tank, well or excavation adjacent to any such way or public place should be fenced in such manner as to prevent danger arising to the public; or

(f) that any dangerous animal should be destroyed, confined or otherwise disposed of,

such Magistrate may make a conditional order requiring the person causing such obstruction or nuisance, or carrying on such trade or occupation, or keeping any such goods or merchandise, or owing, possessing or controlling such building, tent, structure, substance, tank, well or excavation; or owing or possessing such animal or tree, within a time to be fixed in the order-

(i) to remove such obstruction or nuisance; or

(ii) to desist from carrying on, or to remove or regulate in such manner as may be directed, such trade or occupation, or to remove such goods or merchandise, or to regulate the keeping thereof in such manner as may be directed; or

(iii) to prevent or stop the construction of such building, or to alter the disposal of such substance; or

(iv) to remove, repair or support such building, tent or structure, or to remove or support such trees; or

(v) to fence such tank, well or excavation; or

(vi) to destroy, confine or dispose of such dangerous animal in the manner provided in the said order;

or, if he objects so to do, to appear before himself or some other Executive Magistrate subordinate to him at a time and place to be fixed by the order, and show cause, in the manner hereinafter provided, why the order should not be made absolute.

(2) No order duly made by a Magistrate under this section shall be called in question in any Civil Court.

Section 144. (1) In cases where, in the opinion of a District Magistrate, a Sub-divisional Magistrate or any other Executive Magistrate specially empowered by the State Government in this behalf, there is sufficient ground for proceeding under this section and immediate prevention or speedy remedy is desirable, such Magistrate may, by a written order stating the material facts of the case and served in the manner provided by section 134, direct any person to abstain from a certain act or to take certain order with respect to certain property in his possession or under his management, if such Magistrate considers that such direction is likely to prevent, or tends to prevent obstruction, annoyance or injury to any person lawfully employed, or danger to human life, health or safety, or a disturbance of the public tranquility, or a riot, or an affray.

(2) An order under this section may, in cases of emergency or in cases where the circumstances do not admit of the serving in due time of a notice upon the person against whom the order is directed, be passed ex parte.

(3) An order under this section may be directed to a particular individual, or to persons residing in a particular place or are, or to the public generally when frequenting or visiting a particular place or area.

(4) No order under this section shall remain in force for more than two months from the making thereof:

Provided that, if the State Government considers it necessary so to do for preventing danger to human life, health or safety or for preventing a riot or any affray, it may, by notification, direct that an order made by a Magistrate under this section shall remain in force for such further period not exceeding six months

from the date on which the order made by the Magistrate would have, but for such order, expired, as it may specify in the said notification.

(5) Any Magistrate may, either on his own motion or on the application of any person aggrieved, rescind or alter any order made under this section, by himself or any Magistrate subordinate to him or by his predecessor-in-office.

(6) The State Government may, either on its own motion or on the application of any person aggrieved, rescind or alter any order made by it under the proviso to sub-section (4).

(7) Where an application under sub-section (5) or sub-section (6) is received, the Magistrate, or the State Government, as the case may be, shall afford to the applicant an early opportunity of appearing before him or it, either in person or by pleader and showing cause against the order; and if the Magistrate or the State Government, as the case may be, rejects the application wholly or in part, he or it shall record in writing the reasons for so doing.

iii) Provisions under Civil Procedure Code for the Protection of Environment

Public nuisance derives support from section 91 of CPC that lays down the procedure for initiation of a civil suit for the offense of public nuisance. Being purely procedural, the section gives the flexibility of seeking parallel remedies in criminal jurisdiction or damages under law of torts. The marginal note of section 91 reads: public nuisance and other wrongful acts affecting the public. Inclusion of ‘other wrongful acts affecting public' besides public nuisance widens the scope of the section to incorporate various situations which although do not fall under the accepted straitjacket definitions of nuisance, yet are a cause of discomfort and inconvenience to the public. For instance, courts have read slaughtering of cattle on a public street or encroachment upon a public street by construction of buildings as legitimate cause of action for a claim for public nuisance by the virtue of it being a wrongful act against public.

Section 91 of C.P.C. states that

(1) In the case of a public nuisance the Advocate General or two or more persons having obtained the consent in writing of the Advocate General, may institute

a suit, though no special damage has been caused, for a declaration and injunction or for such other relief as may be appropriate to the circumstances of the case.

(2) Nothing in this section shall be deemed to limit or otherwise affect any right of suit which may exist independently of its provisions.

As per the General Clauses Act 1897, the definition of nuisance for the purpose of section 91, CPC has to be borrowed from section 268 IPC. The definition of nuisance excludes from its ambit the instances of legalized nuisance. Legalized nuisance are cases when the nuisance cause is statutorily approved and in the interest of greater good and social welfare. For instance, the running of railway engines and trains or establishment of the yard, despite being a legitimate cause of nuisance, is not punishable under IPC or a valid ground for invoking Section 91.

Though much hasn't been said about the inclusion of clause 1 in section 91, it is believed that inclusion of the Advocate General as the initiator of the suit for public nuisance was to act as a safety check arrangement to the expansive and broad definition of nuisance and the subjectivity of ‘wrongful acts against the public'. Later, by the 1976 amendment, the provision of two or more persons filing a suit for public nuisance with the consent of the advocate general was added to section 91. Such active involvement of the Advocate General in public nuisance suits was to ensure that suits are not initiated with malicious intentions, with the sole purpose of creating impediments for the party alleged with causing nuisance. This rule however does not extend to representative cases when a member of the community whose rights are being restricted by the act of public nuisance files the claim. In such suits, the leave of the court is not necessary. Even in cases when certain rights are provided to the entire community, but immediate damage by the nuisance occurs to an individual, leave of court is not mandatory.

Clause 2 of Section 91 permits the existence of a parallel suit for the same cause of action in criminal jurisdiction through a PIL or as a civil suit for

private claims. It also allows an individual aggravated by the nuisance to file for damages his individual suit. This is primarily so because section 91 in its entirety does not create any rights or deprive anyone of their existing rights. It merely states the procedural guidelines for instituting a civil suit when the cause of action is public nuisance. Consequently, it does not control representative suits under order I, rule 8 or modify the right of a person to sue apart from the provision of this section. This means that if a group initiates a suit for declaration of a particular right, it does not fall under the category of suit for public nuisance and hence mandates the prior approval of the advocate general. However, the existence of such right is a necessary prerequisite. For instance, a suit against a religious procession is maintainable under Section 91 only if the infringement of some right and even if the consequent damage caused is not proved. Similarly, member of the public can maintain a suit for removal of obstruction of a public highway, if his right of passage through it is obstructed, without proof of special damage.

III. Other Law to Control Pollution

The Government of India has legislated constitutional provision for protecting and improving the environment. The Indian Penal Code, Factories Act, Wild Life Protection Act, The Mines and Minerals (regulation and development) Act, Atomic Energy Act as well as laws relating to local bodies, corporation etc. contain provision to regulate and take legal action with respect to specific environmental issues. All the enactments include specific provision for environmental regulation and legal action. Over the years, pollution abatement has become an important constituent of national priority in India. These are reflected in policy decision, legislative framework and specific programmes. Important measures related to prevention and control of pollution is discussed briefly in the coming heads:

i) Air Prevention and Control of Pollution Act 1981

The Air Act was legislated in India in the year 1981 to monitor the quality of air in India and to take measures for the control, prevention and abatement of air

pollution. The 'Air Act' came into force on the 1st April 1988. As per Section (1) of the Act, the Act applies to whole of India. Section (2) of the Act defines the following terms as:

1. Air pollutant is defined as the presence of any solid, liquid or gaseous substance in such a concentration/proportion which may prove harmful to the health of human beings, animals and other living creatures and plants and environment.
2. Air pollution is defined as the presence of any air in the atmosphere.
3. 'Approved appliances' refers to the use of any equipment or gadget used for generating or consuming fume sand which is approved by the State Board for the purpose of the Act.
4. Control equipment refers to any apparatus, device or equipment or system to control the quality and manner of emission of any air pollutant and includes any device used for securing the efficient operation of any industrial plant.

As per the Section (3) of the Air Act, the Central Pollution Control Board (CPCB) shall act for the prevention and control of air pollution in India. The Central Board would have all the necessary powers to ensure the prevention, control and abatement of air pollution. Under Section (4) of the Air Act, any state which has a State Board shall act for the prevention and control of air pollution under Section (5) of the Air Act, with all the required powers to perform its functions. For those states which do not have a State Board for the prevention and control of water, but are still abiding by the Water Act of 1971, are notified to constitute a State Board for the Prevention and Control of Air Pollution. Under Section (6) of the 'Air Act' there would be no separate State Board for Union territories in India. In such cases the Central Board would act as the main board for the control and prevention of pollution. The Central Board would be responsible for informing the governments of Union territories, about the suitability of any location or premises for carrying industrial activities or other activities which are likely to emit air pollutants in the atmosphere. The Central Board has also to declare any air pollution control area under the Air Act of 1981. The CPCB has also to lay down standards for treatment of sewage and trade affluent and for emission from

automobiles, industrial plants and any other polluting source. The CPCB has also to assess the quality of ambient water and air, inspect waste-water installation, air pollution control equipment, industrial plants or manufacturing processes to evaluate their performance and to take steps for the prevention, control and abatement of pollution. For the successful implementation of the Air Act, the Board would meet at least once in every 3 month to ensure that all rules in the act are duly followed. As per Section (16) of the 'Air Act' the Central Board is assigned the following functions:

1. Advise the Central Government on any matter relating to the prevention, control and abatement of air pollution. The board is responsible for holding nation-wide programmes for the purpose of ensuring control, prevention and abatement of air pollution.
2. Coordinate with different State Boards, provide technical assistance and guidance and conduct the necessary investigations and research to ensure adequate measures are being taken for air pollution control and also to resolve any disputes that may arise within the State Boards.
3. Organizing adequate training programmes for individuals who would engage in programmes for the control, prevention and abatement of air pollution.
4. Organize nation-wide programmes for the prevention, control and abatement of air pollution.
5. Lay down standards for ambient quality of air.
6. Collect, compile and publish technical and statistical data relating to air pollution and to highlight measures for its effective prevention, control and abatement. Moreover, the Board has also to ensure that any information on pollution related matters, like air pollution level alerts, etc., are disseminated regularly to people through media or other means.
7. The Central Board has to abide by any directions in writing given to it by the Central Government.

Section (17) of the 'Air Act' defines the functions of the State Boards towards controlling air pollution as follows:

1. Apprise the state governments on all matters relating to the prevention, control and abatement of air pollution. In addition the State Boards have also to advise the state governments on the feasibility of any location or premises from the emission of air pollutants point of view, for setting up an industry.

2. Coordinate with the Central Board in disseminating pollution related information among masses. To organize training programmes in coordination with the Central Board for individuals to be involved in the control, abatement and prevention of air pollution programmes.

3. Power to inspect any time, any industrial unit, manufacturing plant to ensure that the air quality standards are met and to take steps where ever necessary for the control, abatement and prevention of air pollution.

4. Lay down standards for the emission of air pollutants into the atmosphere from industrial plants, automobiles or for the discharge of air pollutants from any other source.

5. To ensure that all the functions are being carried out in a timely manner. Furthermore to ensure that any task towards air pollution control and abatement prescribed by the Central Board, state governments from time to time is carried out satisfactorily.

6. To adhere by the directions in writing given to it by the state government or the Central Board. However, if the State Board fails or defaults in complying with the directions give to it by the Central Board and an emergency situation has arisen because of it, then the Central Government can give orders to the Central Board to perform any of the functions of the State Board in relation to such area, for such period and for such purposes.

Under sub-section (1) of Section (19) of the 'Air Act', state governments have the power to declare any area within a state as pollution sensitive area, or air pollution control area after due consultation with the State Board. If the state government after due consultation with the State Board is of the opinion that any fuel, is likely to cause air pollution in any air pollution control area, it may by notification in the official gazette prohibit the use of such fuel in such area with effect from such date as prescribed in the notification. Similarly if the state gov-

ernment after consultation with the State Board is of the opinion that the burning of any material apart from fuel is likely to cause emission of air pollutants in the air pollution control area, then it may by notification in the official gazette prohibit the burning of such material in such area. Any disputes/ inconsistencies between the Central and the State Boards in the discharge of their functions would be taken care by the Central Government.

As per section (21) of the Act, no industrial unit can set up a plant in the air pollution control area without the prior consent of the State Board. Under Section (22 A) of the Act if the State Board finds that the emission of air pollutants is in excess of the standards laid down by the State Board, the State Board may make an application to the court restraining such person or industrial unit from emitting such air pollutants. As per Section (22) of the Act, no person operating any industrial plant, in any control area shall discharge or cause or permit to be discharged the emission of any air pollutant in excess of the standards laid down by the State Board. As per Section (37) of the Act, any person who fails to comply by the provisions of Section (21) and Section (22) mentioned above, shall in respect of each failure, be punishable with imprisonment of minimum one year six month but which may extend upto 6 year and with a fine. In case the failure continues, the person would be liable to pay a fine of Rs. 50000 for every day during which the failure continues after the conviction of first such failure. In case if the failure continues beyond one year of the initial conviction, the offender shall be punishable with an imprisonment of a minimum of 2 year but which may extend to 7 year with a fine.

As per Section (24), the State Board or any member empowered by the State Board at any time can inspect the industrial unit, manufacturing plant set up in the air pollution control area for the emission of air pollutants, testing any control equipment, industrial plant, record, register, document, etc. Moreover, every person operating any control equipment or any industrial plant,

in an air pollution control area shall be bound to render all assistance to the person empowered by the State Board. If the person fails to do so the person shall be guilty of an offence under this Act. A State Board or any officer

empowered by it in this behalf, under Section (26) of the Act, have the power at all times to take samples of air or emissions from any chimney, flue or duct or any other outlet for the purpose of analysis of the air pollutants discharged. As per Section (38) of the Act, people engaged in any of the following would be liable for penalty:

1. Obstructing any person acting under the orders of the board from exercising his powers and performing his functions under this act.
2. Fails to furnish to the Board, or any officer or other employee of the Board, any information required by the Board for the purpose of the Act.
3. Fails to inform the State Board, any officer or other employee about the occurrence of the emission of air pollutants in excess of the standards laid down by the State Board or about the expectation of such occurrence.

Under Section (39) whosoever fails to comply by the provisions of the Act or any order, direction issued there shall be punishable with an imprisonment of upto 3 month or with a fine which may extend upto Rs 10000 or with both. In case of continuing contravention, with an additional fine of Rs 5000, for every day during which such contravention continues, after conviction for the first such contravention. If any company or industrial unit is found guilty for violating the provisions of the 'Air Act', then as per Section (40) of the Act, every person in charge of and responsible to the company for the conduct of business, at the time the offence was committed, shall be deemed guilty of the offence and shall be liable to be punished accordingly. Under Section (41), if any government institution is found to be violating the provisions of the 'Air Act' the head of the department would be deemed guilty of the offence and would be liable to be punished accordingly.

The Air Act just to control and regulate the pollution form all kinds of sources but the Act’s effect on agriculture pollutions always remains an untouchable stone.

ii) The Environment Protection Act 1986

The Environment (Protection) Act is umbrella legislation. It empowers the Central Government to take necessary measures for:

a) Protecting and improving the environment; and

b) For prevention, control and abatement of pollution.

Under this Act, the government is empowered to set standards for environmental quality and limits for emissions/discharges of pollutants from various specified sources. This Act empowers the government to prohibit and/or restrict certain activities, industrial or otherwise in specified areas to ensure protection of environment and it also confers enforcement agency with necessary punitive powers to restrict any activity detrimental to environment.

The Policy Statement on Abatement of Pollution, 1992 states the government's commitment to prevent further deterioration of the environment. The policy seeks to shift the emphasis from defining the objective for each problem area towards actual implementation with long term focus. To achieve these objectives, it is intended to make maximum use of mix of instrument including legislative and regularisation, fiscal incentive, voluntary agreement, education programme and information campaign.

The Environment Action Programme aims to improve environmental services in India and to facilitate the integration of environmental consideration into development programmes. The programme focuses on priority areas, which include control of industrial and related pollution with accent on reduction and/or management of waste, improving access to clean technology and tackling urban environmental issues.

The Environment (Protection) Act, 1986 and also functions within permissible standards of ambient air quality and noise levels as prescribed by national laws and international regulations.

The Environment Protection Act for the protection and improvement of environment and for matters connected therewith was enacted in the year 1986. Under Section (1) of the Act, it extends to the whole of India. This Act of Parliament got consent from the President of India on the 23rd May 1986. Under the Section (2) of the Act,

1. Environmental pollutant is defined as the presence of any solid, liquid or gaseous substance present in such concentration as may be or tend to be injurious to environment.

2. Environment pollution refers to the presence of any environmental pollutant in the atmosphere.

As per Section (3) of the Act, all the necessary powers for the purpose of protecting and improving the quality of the environment and preventing, controlling and abating environment pollution are vested with the Central Government. The following are considered to be the functions of the Central Government under the Section (3) of the Act:

1. Coordinating with various state governments, officers and other authorities under this act, or the rules made there under.
2. Organizing and planning nation-wide programmes for the prevention, control and abatement of environmental pollution.
3. Laying down standards for the quality of environment for the prevention, control and abatement of pollution. This includes laying down standards of emissions from different sources taking care of the quality or composition of the emission or discharge of environment pollutants from such sources.
4. Providing clear guidelines on areas or regions where any industrial operations cannot be carried out and if industrial operations do take place then to ensure that adequate precautions are taken for the same.
5. Laying down procedures and safeguards for the prevention of accidents which may cause environment pollution and mentioning the remedial measures for such accidents.
6. Laying down procedures and safeguards for the handling of hazardous substances.

The Central Government under sub-section (3) of Section 3 may appoint officers with such designations as it thinks fit for the purposes of this Act and may entrust to them such powers and functions under this Act as it may deem fit. The Central Government may, in the exercise of its powers under this Act, issue directions in writing to any person, officer or any other authority and such person, officer or authority shall bound to comply with such directions. The Environment Protection Act does not require the institution of the Central Board for the same.

Under Section (6) of this Act, the Central Government may make rules in respect for all or any of the following matters through notification in the Official Gazette:

1. The air, soil and water quality standards for various areas and purposes.
2. Maximum allowable limits of concentration of various environmental pollutants.
3. The procedures and safeguards for handling of hazardous substances.
4. Prohibition and restriction on the handling of hazardous substances.
5. Prohibition and restrictions on the location of industries.
6. Procedures and safeguards for the prevention of accidents which may cause environment pollution and providing remedial measures for such accidents.

Sections (7) and (8) of this Act require that:

1. No person carrying any industry, operation or process shall discharge or emit or permitted to discharge any environment pollutant in excess of such standards as may be prescribed.
2. No person shall handle or cause to be handled any hazardous substance except in accordance with such procedure and after complying with such safeguards as may be prescribed.

As per Section (9) of the Act in a situation where the discharge of any environment pollutant is in excess of the prescribed standards or is expected to occur due to any accident or other unforeseen act or event, the person responsible for such discharge and the person in charge of the place at which such discharge occurs or is apprehended to occur shall be bound to prevent or mitigate the environment pollution caused as a result of such discharge and shall also forthwith:

1. Intimate the fact of such occurrences or apprehensions of such occurrence.
2. Be bound if called upon, to render all assistance, to such authorities or agencies as may be prescribed.

On receiving such information with respect to the occurrence of any such environment pollution due to the discharge of any environment pollution in excess of the prescribed standards, either through intimation or otherwise, the authorities or agencies referred to in sub-section (1) shall, as early as practicable, because such remedial measures to be taken as are necessary to

prevent or mitigate the environment pollution. The expenses incurred on any remedial measures taken by the authorities or agencies together with interest from the date when the demand for the expenses is made until it is paid may be recovered by such authority or agency from the person concerned as arrears of land revenue or of public demand.

As per Section (10) of the Act, any person empowered by the Central Government in this behalf shall have the right to enter any place for the purpose of examining and testing any equipment, industrial plant, record, register, document or any other material object for conducting a search of any building in which he has reason to believe that any offence under this Act or the rules made there under has been or is being or is about to be committed and for seizing any such equipment, industrial plant, record, register, document that it may furnish evidence of the commission of an offence punishable under this Act or the rules made there under or that such seizure is necessary to prevent or mitigate environmental pollution. Moreover, any person carrying on any industrial operation or handling any hazardous substance is bound to render all assistance to the person empowered by the Central Government; if the person fails to do so then the person shall be guilty of the offence under this Act.

Under Section (11) of the Act, the Central Government or any of its officer empowered by it in this behalf, shall have the power to take samples of air, water, soil or any other substance from any of the factory, premises or any other place for the purpose of analysis. The person taking the sample shall specify to the person in charge of the place his intentions for taking the sample for analysis purposes. According to Section (15) of the Act, any person whosoever if fails to comply with or contravenes any of the provisions of this Act, or the rules made or orders or directions issued there under, shall, in respect of each such failure or contravention, be punishable with an imprisonment of upto 5 year or a fine of upto Rs 1 lakh or both. In case the failure, contravention continues, there would be an additional fine which may extend to Rs 5000 for every day during which such failure or contravention continues after the conviction of the first such failure or contravention, with an imprisonment of upto 7 year in case the failure extends

beyond one year. Under Section (16) of the Act, if an offence under the Act is committed by a company, then every person in the company, who at the time of the offence was committed, was directly in charge of, and was responsible to the company for the conduct of the business of the company shall be deemed to be guilty of the offence and liable to be punished accordingly.

Under Section (17) of the Act, if any Department of the Government is responsible for committing offence under the Act, the Head of the Department shall be deemed guilty of the offence and shall be liable to be punished accordingly. The State Government or any other authority or officer, under Section (20) of this Act, shall be liable to furnish any report, returns, statistics, accounts and other information to the Central Government as and when it requires. The Central Government, under Section (25) of this Act, may by notification in the Official Gazette make rules on all or any of the following matter:

1. The standards in excess of which the environmental pollutants shall not be discharged.
2. The procedure and safeguards for handling hazardous substances.
3. The authorities or agencies to which the knowledge of the occurrence or the likely occurrence of the discharge of any environment pollutant in excess of the prescribed standards shall be given. Moreover, all assistance would also be rendered accordingly-
4. The manner for taking samples of air, water and soil or other substance for the purpose of analysis shall be taken.

The objective of this Act is to provide for the prevention, control and abatement of air pollution, for the establishment, with a view to carrying out the aforesaid purposes, of Boards, for conferring on and assigning to such Boards powers and functions relating thereto and for matters connected therewith.

Decisions were taken at the United Nations Conference on the Human Environment held in Stockholm in June 1972, in which India participated, to take appropriate steps for the preservation of the natural resources of the earth which, among other things, includes the preservation of the quality of air and control of air pollution.

Therefore it is considered necessary to implement the decisions foresaid in so far as they relate to the preservation of the quality of air and control of air pollution. All the precautions had been taken in enacting the Act and an exclusive power under section 25 was added but no action was taken to frame the rules on the issue by the Central Government.

iii) The Biological Diversity Act 2002

The Ministry of Environment and Forests has enacted the Biological Diversity Act, 2002 under the United Nations Convention on Biological Diversity signed at Rio de Janeiro on the 5th day of June, 1992 of which India is also a party. This Act is to "provide for the conservation of biological diversity, sustainable use of its components, and fair and equitable sharing of the benefits arising out of the sued of biological resources, knowledge and for matters connected therewith or incidental thereto." As per the provision of act certain areas, which are rich in biodiversity and encompasses unique and representative ecosystems are identified and designated as biosphere reserve to facilitate its conservation.

The Biological Diversity Act, with the objective of conservation of biological diversity, sustainable use of its components and fair and equitable sharing of the benefits arising out of the use of biological resources, knowledge and matters connected therewith or incidental thereto was initiated in the year 2002. This Act under Section (1) of this Act is valid for whole of India. Under Section (2) of this Act:

1. Biological diversity means the variability among living organisms from all sources and ecological complexes of which they are part and includes diversity within species or between species and of ecosystems.
2. Biological resources means plants, animals and microorganisms or parts thereof. Their emetic material and byproducts (excluding value added products) with actual or potential use or value but does not include human genetic material.

The National Biodiversity Authority established by the Central Government under Section (8) of this Act, may as per Section (18) of this Act can:

1. Advise Central Government on matters relating to the conservation of biodiversity, sustainable use of its components and equitable sharing of benefits arising out of the utilization of biological resources.
2. Advise the State Governments in the selection of areas of biodiversity importance.

Under Section (22) of this Act, the various state governments can establish their respective State Biodiversity Boards. In case of the Punjab, it is the Punjab Biodiversity Board. However, there is no State Biodiversity Board for the Union territories, in which case the National Biodiversity Authority acts as the State Board. Under Section (23) of this Act, the functions of the State Biodiversity Board would be:

1. Advise the State governments, subject to any guidelines issued by the Central Government on matters relating to the conservation of biodiversity, sustainable use of its components and equitable sharing of the benefits arising out of the utilization of biological resources.

Under Section (36) of this Act, the Central Government shall develop national strategies, plans and programmes for the conservation, promotion and sustainable use of the biological diversity including measures for identification and monitoring of areas rich in biological resources, incentives for training research and public education to create awareness with respect to biodiversity. Wherever the Central Government feels that the biological diversity or biological resources are being threatened by overuse,

y. various departments/institutions in the State to control air pollution caused by the agriculture waste burning, especially that of burning of paddy and wheat straw.

Under the process of residue burning a high number of biodiversity burns and loss of it's also occurred but no efforts have been taken to make links between the issues of residue burning and loss of biodiversity.

iv) National Green Tribunal Act 2010

National Green Tribunal Act, 2010 (NGT) is a federal legislation enacted by the Parliament of India, under India's constitutional provision of Article 21, which

assures the citizens of India the right to a healthy environment. The tribunal itself is a special fast-track court to handle the expeditious disposal of the cases pertaining to environmental issues. The legislative Act of Parliament defines the National Green Tribunal Act, 2010 as follows:

"An Act to provide for the establishment of a National Green Tribunal for the effective and expeditious disposal of cases relating to environmental protection and conservation of forests and other natural resources including enforcement of any legal right relating to environment and giving relief and compensation for damages to persons and property and for matters connected therewith or incidental thereto".

The National Green Tribunal (NGT) was officially passed by the legislature on 18 October 2010. The Tribunal's dedicated jurisdictions in environmental matters are providing speedy environmental justice and help reduce the burden of litigation in the higher courts. The Tribunal is not bound by the procedure laid down under the Code of Civil Procedure, 1908, but shall be guided by principles of natural justice. The Tribunal is mandated to make and endeavor for disposal of applications or appeals finally within six months of filing of the same.

IV. Existing policies to Control Crop Residue Burning in Punjab

The Punjab Pollution Control Board (PPCB), Punjab State Council for Science and Technology (PSCST), Punjab Energy Development Agency (PEDA) is the institution that has been vested with the task of controlling pollution in Punjab. It is mainly the PPCB in coordinating with the Central Pollution Control Board (CPCB) those advices the government on pollution related matters. The roles of Department of Agriculture, Punjab Agro Food Corporation (PAFC), Punjab Energy Development Authority (PEDA), Department of Animal Husbandry, Punjab Agriculture University (PAU), Punjab State Farmers' Commission (PSFC), Department of Rural Development and Panchayat, NGOs and Legal Machinery with the help of Local administration are also important to check this problem.

Department of Agriculture

It has been increasingly felt by the Government of Punjab, to move the farmers away from the rice-wheat crop rotation into new areas, like vegetables, fruits, oil seeds, pulses, etc. The importance of crop diversification to protect the natural resources and to stabilize farm income is increasingly felt. The Government of Punjab in 2002 launched a multi crop multi-year contract farming scheme to give boost to crop diversification. The PAFC has been implementing the task and it is believed that more than 0.186 million ha area is covered under crops other than wheat and paddy, like hyola, winter maize, sunflower, durum wheat, moong, etc., with around 0.1 million farmers under this programme (Punjab Agro Food Corporation, 2005). Government of Punjab is promoting 'zero tillage technique' since 2001-02 in areas of state where wheat is sown after harvesting of rice. Zero till system refers to planting crops with minimum of soil disturbance. 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. The area under zero tillage in Punjab has increased from 6.83 thousand ha in 2001-02 to 41 2.69 thousand ha in 2005-06. As per the information provided by PAU, zero tillage sowing of wheat on 412 thousand ha in the state during rabi 2005-06 has reduced the consumption of diesel by 20.6 to 24.7 million L and also reduced the emission of $C0_2$ to the tune of 53.6 to 64.2 million kg in the environment on the basis of conversion factor of 2.6 kg of CO_2/L of diesel burnt[26].

During the year 2008-09, a total number of 5117 farmers training camps at

---

[26] Singh, R.P. ,(2008). Economic assessment of the happy seeder for rice-wheat system in Punjab. AARES 52nd Conference. ACT, Australia.

district, block and village level were organized by Department of Agriculture to make the farmers aware about the benefits of reincorporation of the crop residues. Besides this, the Department was organizing frontline demonstrations to encourage farmers to adopt zero-till-drills, Happy Seeders, Rotavators and distribution of new agricultural implements on subsidy. During 2007-08 and 2008-09, 760 and 1290 frontline demonstrations were organized at farmers' fields, respectively. As a result of these demonstrations and supply of these equipments on subsidy, these techniques were adopted by the farmers of the state in 5.92 lakh and 7.21 lakh ha area, respectively during the sowing of wheat crop in 2007-08 and 2008-09. To promote the use of equipments which help in checking the burning of crop residues, rotavators, happy seeders, zero-till-drills and straw reapers were distributed to the farmers on subsidy. During the year 2007-08 in all, 2659 rotavators, 1383 zero-till-drills, 2 happy seeders and 448 straw reapers were distributed to the farmers on subsidy. Further, the Department is promoting diversification of cropping pattern in Punjab under which area under Basmati rice had been increased from 1.5 lakh ha to 3.5 lakh ha in the past 5 year whereby straw of basmati rice can be used as a fodder[27].

Punjab Energy Development Agency (PEDA)

PEDA has been facilitating the setting up of 29 power projects with total installed capacity of 330 Mw on BOO basis to private developers. These projects are being set up by the private developers with state-of-art technologies, such as biomethanation, combustion, etc. The plants are designed to receive mixed waste, such as paddy straw, cotton stalks and other agro residues available in the state. Out of these, one project of 8 MW had been commissioned in March 2009 and another of 14.5 MW in September 2009. At present only five bio-mass based power plants are operational in Punjab. Present quantity of crop residue has the potential to generate 3000 MW of electricity in Punjab.

---

[27] Source: Statistical Abstracts of Punjab, Punjab Agriculture University.

Department of Animal Husbandry

Department organized 478 demonstrations at various locations in the state for protein enrichment of paddy/wheat straw through urea treatment upto October 2008. Awareness camps for providing information about straw as animal bedding was also organized by the Department.

Punjab Agricultural University (PAU)

PAU had been according priority towards developing efficient agro-technologies for crop residue recycling in machine harvested areas as an alternative to burning. The major equipments developed by PAU are: (i) Happy seeder machine for planting in standing paddy stubbles; (ii) tractor operated paddy straw chopper; (iii) straw collector and baler; (iv) residue incorporation in soil; (v) compositing techniques using paddy straw.

Happy seeder machine for planting in standing paddy stubbles: This technology, developed by PAU, has already been adopted by the government of Punjab and is being popularized by Department of Agriculture. Wheat was successfully sown in 200 acre area using happy seeder during 2007-08 producing 5-10 % more yield (with 50-60 % less operational costs) compared to conventionally sown wheat. Financial analysis by PAU indicated that this machine is more profitable than other conventional alternatives, like full stubble incorporation through direct drilling or rotary seeding.

Tractor operated paddy straw chopper: For incorporation of paddy straw into soil, the University has also developed a tractor operated straw chopping-cum-spreading machine. The machine, in a single operation, harvests the left over paddy stubble after combining, chops it into pieces and spreads it on to the field. The chopped and spread stubble then can easily be incorporated in the soil after light irrigation by using a rotavator or disc harrow and is allowed to decay.

Straw collector and baler: Baler is also another promising technology developed by PAU for collecting paddy straw. Balers make rectangular or round bales by collecting the loose straw from the ground. One operation of stubble shaver in a

combine harvested paddy field, created favorable conditions for operating a baler, which in turn, results in smooth sowing of the next crop.

Residue incorporation in soil: In situ incorporation of rice straw before sowing wheat, did not adversely affect the wheat crop. Rather the incorporation of the residues had a favorable effect on soil physical, chemical and biological properties.

Composting techniques using paddy straw:

PAU has also been working on use of rice straw as bedding material for animals and thereafter going in for its composting. A special machine has been acquired for the turnover of composting materials and its watering for a rapid generation of high value compost.

Punjab State Farmers' Commission

In order to reduce area under paddy without decreasing the income of the farmers, the commission has initiated the following programmes:

1. Commercial dairy farming and increasing the area under fodder.
2. Production of vegetables under net house technology.
3. Encouraging cultivation of hybrid maize in Kharif season.
4. Introduction of new high value crops, such as banana cultivation in the State.
5. Subsidy for agricultural machinery like happy seeder, rotavator, etc.

Department of Rural Development and Panchayats

The Department is popularizing technologies proposed by Department of Agriculture and PEDA and is facilitating provision of panchayati land for setting up of biomass based power plants in the state. It had already facilitated 33 year lease of panchayati land of 5 villages for setting up such units.

In addition to the efforts of various institutions mentioned above there have been various technological responses undertaken for conservation of environment affected by agriculture. Keeping in view the increasing problems associated with crop stubble burning, many initiatives have been taken to

manage agricultural waste including paddy and wheat straw, cotton sticks, bagasse and animal waste. Various district administrations in the state in the past imposed ban on the burning of rice straw in the fields after its harvesting, the problem still persists. As a result various departments and institutions are promoting alternative uses of straw instead of burning. These include:

Use of rice residue as fodder for animals:

The rice residue as fodder for animals is not a very popular practice among farmers. This is mainly because of the high silica content in the rice residue. It is believed that almost 40 % of the wheat straw produced in the state is used as dry fodder for animals. However, to encourage the use of rice residue as fodder for animals, a pilot project was 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 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 propagated the technology in the state.

Use of crop residue in biothermal power plants : Another use of rice residue, that is being encouraged by various institutions and departments is the use of rice residue for generation of electricity.

Use of rice residue 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, under 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 crop residue for mushroom cultivation: Paddy straw can be used for the cultivation of Agaricus bisporus, Volveriella volvacea and Pleurotus spp. One kg of paddy straw yields 300 gm, 120-150 gm and 600 gm of these mushrooms, respectively. At present, about 20,000 MT of straw is being used for cultivation of mushrooms in the state.

Use of rice residue in paper production: The rice straw is also being used in conjunction with wheat straw in 40:60 ratios 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 rice residue 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 proposed to be set up at Ladhowal on pilot basis on land provided by PAU. The new technology will generate 300 m^3 of biogas from one tonne of paddy straw.

V. Other measures

For agricultural diversification, the new strategy lays emphasis on production of fruits and vegetables under controlled conditions, using modern practices, like net houses, plastic tunnels and green houses. For achieving the same objective, half a million acre of land has been brought under crops, other than wheat and paddy, through contract farming. Yet another step towards diversification of

agriculture, taken by the state government, is the establishment of a new University of Animal Sciences. This is likely to impart desired impetus to dairy and livestock development. Besides, an agriculture diversification, research and development fund, with an initial corpus of Rs 20 crore have also been created. However, there is a need for creating a Venture Capital Fund at the National level for promoting agri-businesses. The Government of Punjab demanded a sum of Rs.5000 crore from the Centre Government for its diversification plan but only Rs.224 crore were sanctioned by the Centre Government, which is a very small amount as compared the gravity of the problem.

Some of the figures and evidences covered by media and other agencies are telling about the a very few number of cases registered in the concerned police stations, therefore, how the tribunals and courts can works in the direction to control the problem. A few numbers of evidences in this regard are covered under chapter 4 of the work. All the state agencies are busy in performing their duties and results are coming but the next chapter is indicating about the Impact of the existing laws and policies on the problem.

Chapter 4

Results

This chapter of the shows the impact of laws and government policies, level of awareness and the status of local participation regarding the serious environmental and agricultural issue of crop residue burning in the state of Punjab.

In Punjab, more than 60% of the population live in the paddy growing areas and is exposed to air pollution due to burning of stubbles. It is estimated that burning 1t of straw releases 3 kg particulate matter, 60 kg CO, 1460 kg CO2, 199 kg ash and 2 kg SO2[28] (Gupta and Sahai 2005). Inhaling the fine particulate matter present in the atmosphere leads to serious problem of human health, especially among children, old age people, pregnant woman and people with acute asthematic and cardio vascular problems. Inhaling fine particulate matter also causes lung disease, coughing and shortness of breath, decreasing lung functioning. Air pollution leads to respiratory diseases like eye irritation, bronchitis, asthma, etc. increasing individuals' disease mitigation expenses and also effects ones working capacity. Open burning in the fields affects life of animals, birds and other insects below and above the earth. Burning also causes poor visibility and increases the incidences of road accidents. It is roughly estimated that total annual welfare loss in terms of health damages due to air pollution caused by the burning of paddy straw in rural Punjab amounts to Rs 76 millions. If one also accounts for expenses on averting activities, productivity loss due to illness, monetary value of discomfort and utility and additional fertilizer, pesticides and irrigation, the losses would be much higher[29].

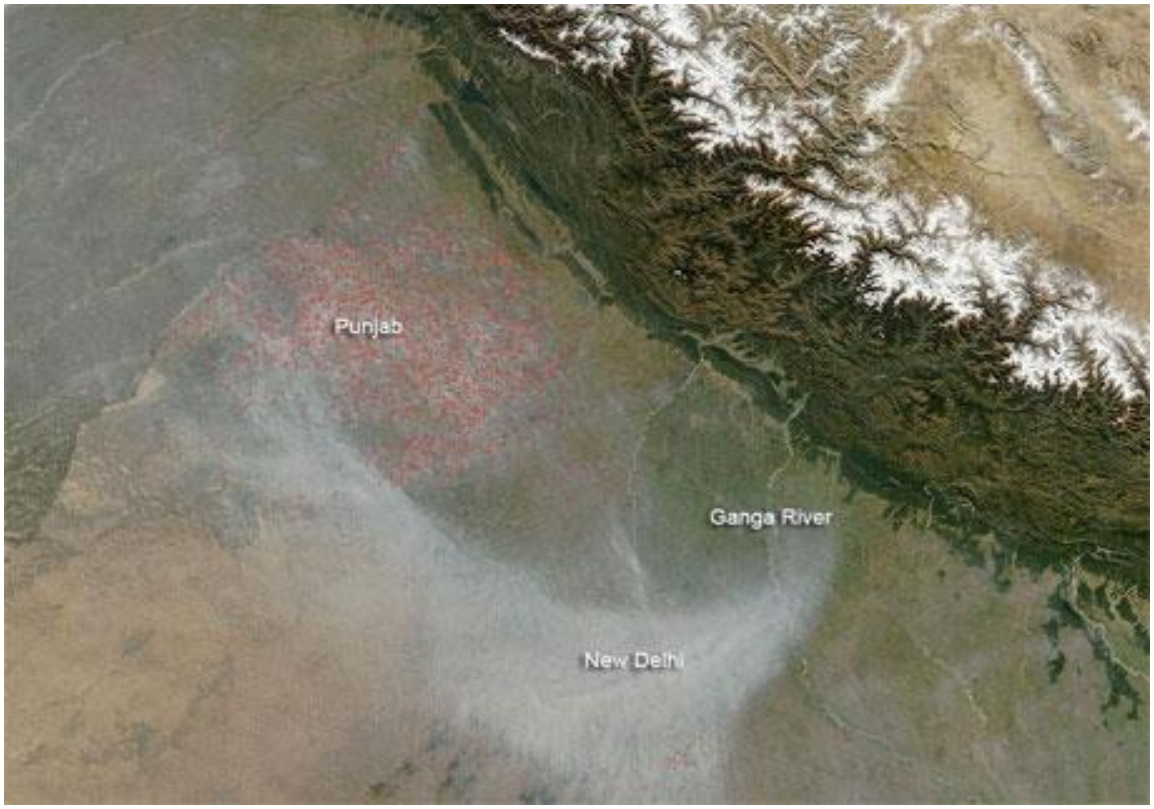
---

[28] Gupta, P.K. and S. Sahai. 2005. Residues open Burning in rice-wheat cropping system in India: An agenda for conservation of environment and agriculture.

[29] Kumar. P.and Kumar. S. Valuing the Health Effects of Air Pollution from Agricultural Residue Burning.

NASA draws attention to the fires in Pujab fields

The practice of burning post harvest crop stubble in the agricultural fields of Punjab has received international attention with the NASA releasing a satellite image that resembles those taken during forest fire. The Aqua satellite images captured by NASA shows large number of fires over millions of hectares of agriculture fields of Punjab (Pic. 4.1)[30].



Pic. 4.1 Source: NASA

"The fires could very well be agriculture fires. Smoke from hundreds of fires (the red dots seen in the image) obscure most of Punjab region of India," said NASA while releasing the image on October 31 2012.

---

[30] Source URL: http://www.downtoearth.org.in/content/nasa-draws-attention-fires-punjab-fields. Accessed on 25 Nov. 1012

A Burning Cause: Paddy Straw

Putting paddy residue to flames damages both the environment and soil, yet farmers carry on with the practice because the alternatives are not convenient, and the government is not acting tough (pic. 4.2)[31].

(pic. 4.2)

The draft of Punjab Prohibition of Burning of Crop Residue Act, was drafted and submitted to the government by an IAS officer, Kahan Singh Pannu, who also served as Chairman PPCB a few years ago. He had argued that by not burning the residue, the government and farmers could claim carbon credits from the adaption fund set up under the Kyoto Protocol, being managed by the Union Government for India. Ha had also proposed a penalty of Rs.4000 per care for violators, besides disconnecting the electric supply to the tubewells.

Eminent academician and scientist Prof. (Dr.) Jai Rup Singh, Vice Chancellor of Central University of Punjab, Bathinda, has written to the Chief Secretary to give serious thought to Pannu's proposal, while Dr. G.S. Kalkat, Chairman of the Punjab Farmers Commission and Baba Sewa Singh and Baba Balbir Singh Seechewal, both environmentalists, have also urged the government to frame a law. The draft was discussed at the level of Deputy Chief Minister and Chief Secretary but the matter rests there.

The Planning Commission has now proposed to make the performance of states on the environmental front one of the parameters to allocate grants from the national pool. The last study conducted in this connection had put Punjab at the bottom of the list.

Burning crop residue exposes farmers to cancer-causing chemicals: Study

A team of researchers from Indian Institute of Science, Education and Research (IISER), Mohali, reported that burning crop residue exposes farmers to smoke containing cancer-causing chemicals which farmers and villagers ignorantly inhale as these chemicals stay in the air for few days. The researchers measured the level of these chemicals known as benzenoids in the air near Chandigarh in October and November 2012, to compare the level of these chemicals before and after paddy crop residue was burnt. Compared to October, there is 300% increase in benzenoid level in November. Such high level of benzenoids for 1-2 months in a year aggravates smog and can enhance cancer risk in northwestern India[32]. This study is published in June 25 issue of Current Science.

 (pic. 4.3)

---

[31] The Trubune, Bathinda,"A Burning cause: Paddy Straw", November 15, 2012.

[32] Source: http;//www.deccanherald.com/content/341453/burning-crop-residue-exposes-farmers.html. Accesed on 13th August 2013

Archives of Environmentalist: Enact law to ban straw burning

Pressure has started building on the state government to enact a law banning the burning of crop residue, a major health and environmental hazard, in the state. Baba Sewa Singh, an environmentalist, who awarded Padma Shri owing to his contribution to promote sapling plantation, today urged the Chief Minister Parkash Singh Badal to pass the legislation. Some factions of the Bharti Kisan Union have also supported the enacting of the law. G.S. Kalkat has also laid emphasis on the framing of law. Pannu, justifying the framing of a law in this regard, has stated that vital nutrients worth Rs.200 crore were burnt along with the paddy and wheat straw. Moreover, the burning of residue causes huge damage to sapling plantation along the roads, in fields and elsewhere. Moreover, it is a big health hazard and causes lot of hardships to people suffering from respiratory problems and allergies[33] (pic. 4.4).

Pic. 4.4

---

[33] The Tribune, "Enact law to ban straw burning", 06th Sept.2010

Supreme Court: Punjab, Haryana told to check paddy straw burning

The Hon'ble Supreme Court of India directed the states of Punjab and Haryana to ensure complete ban on the environmentally hazardous practice of burning paddy straw within two years. Punjab has been asked to immediately issue a notification making agriculture residue burning an offence in the state. Officials from the two states, along with their counterparts from Uttar Pradesh and Delhi, attended the meeting convened by the Supreme Court appointed Environment Pollution Control Authority (EPCA) to discuss smog that engulfed the NCR region for nine days at a stretch in November 2012. Punjab and Haryana were told to promote alternative uses of paddy straw and execute plans for power generation and bio-methanation in the next two years. However, Punjab said that there was no scientific evidence to hold it responsible. Punjab and Haryana also asked the centre to chip in and consider their proposal to provide 50 percent subsidy on price of new agricultural equipments which help in recycling the straw[34]. Centre for Science and Environment, director Sunita Narian, who is a member of the EPCA, said Punjab was specifically asked to issue a notification prohibiting burning of leftover straw after harvesting of crops in the entire state with immediate effect under section 19 (5) of the Air (Prevention and Control of Pollution) Act, 1981. The EPCA would monitor progress on compliance of these directions every six months.

pic.4.5

---

[34] The Indian Express, New Delhi,"Smog: Punjab, Haryana told to check paddy straw burning", 12th Nov. 2012.

Lack of political will fuels stubble burning menace

Every six months, when Punjab harvests either paddy or wheat in cyclic pattern, newspapers carrying government advertisements- with photographs of Chief Minister Parkash Singh Badal and Deputy CM Sukbir Badal, appealing to farmers not to burn stubble and every season, deputy commissioners across the state have a busy time issuing orders under Section 144 Cr.P.C. banning burning of stubble. And, every season, these orders go up in smoke, literally, with nobody paying heed[35].

In the last paddy season, Punjab produces more than three crore tones of paddy straw, having the potential to generate 3000 MW power, which is one third of the total power demand of the state but almost all of it is burnt down in the fields. Despite the state issuing the massive advertisements in newspaper urging the farmers not to burn paddy straw, besides polluting the air, it mars the soil fertility, the practice goes on. Ironically, for a state like Punjab, which perennially faces power shortage, the stubble can come as a boon and fuel the bio-mass based power plants. Five bio-mass based power plants are operational in the state but more are needed.

Sources in Punjab Agriculture Department and Punjab Energy Development Agency (PEDA) claim that as per a survey conducted by a private company dealing in bio-mass power plants, three crore tones of paddy straw can generate 3000 MW power. During peak summer, Punjab requires nearly 9500 MW power while it gets only 7100 to 7200 MW to meet the demand. Dr. Naresh Gulati, Deputy Director, Agriculture Technological Management Agency (ATMA) said that by burning the paddy straw state farmers loose crores of rupees. The straw can be sold to plants as bio-mass fuel to generate power, or to sugar and paper mills. He said that most of the nitrogen, phosphorus and other micro nutrients in

---

[35] The Times of India, 06th Nov. 2012.

the soil get damaged in the fire and then the farmers have to spend money on chemicals to boost the fertility of the soil. Dr. M.S. Sandhu, Director Agriculture, Punjab said that to keep to keep the state's soil and environment healthy, a straw Management Machine has been introduced which can collect the paddy stubble from one acre farm in 45 minutes[36].

Plumes of smoke and pollutants rising from the burning fields of north India can spread through the air to places as much as 1000 km away, cause persistent fog over the region and could even be playing a part in depressing rice yields, various scientific studies on the phenomenon have found. A 2009 study by K.V.S. Badarinath of Indian Remote Sensing Centre and others reported that aerosols and trace gases from crop burning in north India had been found over Hyderabad and Arabian Sea. Prof. S.N. Tripathi of IIT Kanpur's chemical engineering department said that particles from these fires can travel upto 1000 km[37].

National Green Tribunal: Response to crop residue

A case has been filed by Uttar Pradesh based environmentalist Vikrant Tongad before the National Green Tribunal (NGT), who alleged that burning of agricultural residue, in states of Punjab, Haryana and Uttar Pradesh is causing air pollution not only in these states but also in the National Capital Region of Delhi. A bench headed by NGT chairperson Justice Swatanter Kumar issued notice and sought responses of the Environment Pollution (Prevention and Control) Authority (EPCA) and the pollution control boards of these states[38].

---

[36] The Indian Express, "3 crore tone paddy straw that Punjab burns can generate 3,000 MW"', 13th Nov. 2012.

[37] The times of India, 'smoke from fields travel 1,000Km:Study", 13th Nov. 2012.

[38] http://www.articles.economictimes.indiatimes.com/2013-05-13/news/39228623-1-residue-air-pollution-biomass. Accessed on 13th May 2013.

'Energy Harvest' to end open field burning

A new renewable energy technology that has the potential to eradicate the problem of open field burning has been unveiled at both the Indian Institute of Technology, Ropar and the British Council, New Delhi. The pyroformer container has been developed by scientists at the European Bio-energy Research Institute (EBRI) at Aston University, UK in collaboration with IIT, Ropar[39]. Working in Punjab, this project titled "Energy Harvest" takes agriculture waste and the Pyroformer heats it in controlled conditions. The process generates oil, gas and biochar. Each one of these product is useful and means that harvest waste now has a value as it is put to use rather than simply being burnt. The oil produced can be mixed with diesel and used in engines, the gas can be used for power generation, while the biochar can be used as a fertilizer to increase crop growth. Funding from the Oglesby Charitable Trust enabled Aston University to work closely with IIT, Ropar to make this innovative technology available as a pilot phase in three villages of Ropar district: Khuaspura, Hussainpur and Ladal. The Pyroformer is housed in a container unit that can be transported between rural locations by tractor and is operated by the villagers themselves.

Prof. M.K. Surappa, Director, IIT, Ropar said that "Open field burning is an enormous problem for India and I hope this project will provide a socially and economically viable solution for farming communities." Prof. Dame Julia King, Vice Chancellor of Aston University, said "Energy Harvest is an excellent example of the importance of UK and Indian universities working together to solve real life problems." Prof. Robert Berry, Executive Dean, School of Engineering and Applied Sciences at Aston University said that the technology has the potential to provide a cost effective, reliable and sustainable form of decentralize power generation to address the local needs of heat and energy. This technology may become a valuable tool to control the problem.

---

[39] Daily Post, Chandigarh, 03rd July 2013.

Various Reasons of Crop Residue Burning

During the literature survey I find the various relevant reasons of crop residue burning in the area of my study. And present circumstances encouraged me to continue with the study. Brief overviews of the reasons of crop residue burning are as follows:

Monoculture cropping pattern, increased mechanization, particularly use of combine, declining number of livestock, long period required for compositing, shortage of labour, paddy residue not used as fodder due to high silica content as well as excess use of pesticides etc., limited time gap between two crops and no economically viable alternate use of residue are some of the reasons for residues being burnt in fields. The major reasons for increase in use of combine are labour shortage, high wages during harvesting season, ease of harvesting and thrashing and uncertainty of weather. With combine harvesting, however, about 80% of the residues are left in the fields as loose straw that finally end up being burnt.

Other reasons for intentional burning include clearing of fields, fertility enhancement, and pest and pasture management. Burning traditionally provides a fast way to clear the agricultural field from residual biomass and facilitate further land preparation and planting. It also provides a fast way of controlling weeds, insects and diseases, both by eliminating them directly or by altering their natural habitat. The time gap between paddy harvesting and wheat sowing is 15-20 days. In this short duration farmers prefer burning the rice stubble in the fields. Burning is also perceived to boost soil fertility, although burning actually has a differential impact on soil fertility. It increases the short term availability of some nutrients like P and K and reduces soil acidity, but leads to a loss of other nutrients like N and S and organic carbon. Farmers have their own limitations to stop this practice and only collective efforts by all the stakeholders can solve this problem.

Problems and Limitations of alternatives to crop residue burning

Crop Diversification

Presently the area under paddy cultivation in Punjab is 28.0 lakh ha although; paddy is not the traditional crop of the state. Diversification of land from wheat-paddy rotation to some other crops is a very effective step to reduce the serious problem of crop residue burning. Paddy cultivation is putting too much stress on the available natural resources of the state such as over-exploitation of ground water, consumption of electricity, loss of soil fertility, problem of residue management, etc. There is no growth in the output of paddy since many years but the cost of inputs increases every year. The net income of the paddy cultivators is decreasing. Realizing the gravity of the problem of wheat-paddy 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 wheat and paddy increased steadily, mainly due to assured remunerative prices offered for these crops.

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 lead to overexploitation of groundwater 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 a replacement of 1 million hectare area under paddy-wheat rotation with other crops like seeds and pulses, which have less

water requirement and are ecologically and soil friendly. According to the recommendation of the report a subsidy of Rs. 12,500 per ha should be given to the 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 the report, it should not be difficult for the Central Government as it will make a saving of Rs. 50 billion by not procuring paddy and wheat produced from 1 million hectare 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.

The latest Draft Agriculture Policy for Punjab prepared by Committee for Formulation of Agriculture Policy for Punjab State, submitted to Government of Punjab on March 2013 recommended reducing the area under paddy cultivation in Punjab from 28 lakh ha to 16 lakh ha. But diversification from wheat-paddy rotation is very difficult in the present circumstance without the active monetary and policy support from the Central Government.

Incorporation of paddy straw in the soil

This is also a good alternative to crop residue burning but this requires new costly implements, training and awareness among the farmers with requires a major policy change.

Crop residue for power generation

Punjab is having the huge potential to generate power from crop residues. It is estimated that 3000 MW of power can be generated from crop residue in bio-mass based power plants. PEDA is engaged in this process and decided to establish 29 small bio-mass based power plants in the state. There are five biomass plants operational under private sector in Punjab having agreement with PEDA:

1. Malwa Power Limited, Village Gulabewala, District Sri Muktsar Sahib.

2. Deep Development Limited, Village Gadda Dob, District Ferozpur.
3. Universal Biomass Energy Private Limited, Village Channu, District Sri Muktsar Sahib.
4. Punjab Biomass Power Private Limited, Village Bhagora, District Patiala.
5. Green Plant Energy Private Limited, Village, Binjon, District Hoshiarpur.

The PPCB has given the contact number of these biomass plants mentioning that the plant owners would themselves carry the stubble from the fields after purchasing it from the farmers. But a majority of them not does the same. Despite the appeal to the farmers by the state government to sell the paddy stubble to the bio-mass plant rather than burning in the open fields, the offer has so far failed to yield the desired results due to the indifference of the authorities of the bio-mass plants. In its campaign, the Punjab Pollution Control Board (PPCB) has given the contact numbers of five bio-mass plants set up across the state mentioning that the plant owners would themselves carry the stubble from the fields after purchasing it from the farmers. But a majority of them do not even attend the phone calls being made by the farmers. The officials of the bio-mass plants said that there were no arrangements to bring the stubble from the fields. The stubble would have to be brought at the plant by the farmers itself. Transportation of stubble is a major hurdle as only five bio-mass based power plants are operational in the state and there capacity to consume the crop residue available is very low. There is no bio-mass based power plant in Bathinda district.

Punjab has empowered district magistrates to invoke Section 144 Criminal Procedure Code, with cases against farmers setting their fields on fire. Once booked for violating Section 144, the Air (Prevention and Control of Pollution) Act, 1981 is slapped on the offenders. Experts say it would have been more effective to invoke the Act directly. The seriousness of these efforts can be

gauged from the fact that while fires have been burning in most fields across the state, just 200 people have been booked for burning stubble in the year 2012. In 2011 180 cases were registered. P.S. Rangi, consultant to Punjab State Farmers' Commission, said that the new implement called the "Happy Seeder", developed by Punjab Agriculture University with support from the Australian government, is a viable solution. Happy Seeder, introduced two years ago, has been successful. But it is in excruciatingly short supply. It is a tractor powered machine that cuts and lifts the rice straw, sow seeds and deposits the straw over the sown area as mulch. It combines stubble-mulching as well as seed and fertilizer drilling operations in a single pass. Punjab has failed in promoting this new technique that is promising a solution to the acute environmental problem. Till last year, there were less than 50 Happy Seeders in Punjab, which have increased to nearly 200 in the year 2012. Punjab needs atleast 40,000 Happy Seeders to tackle paddy burning for its over 12,000 villages[40].

The impact of laws and policies of state government on this serious environmental and agricultural issue is not very encouraging. There are various legislations on air pollution but no specific legislation on this problem. Government is making efforts to educate the people but lot more is required. Local participation of the stakeholders is also less.

---

[40] The Times of India,"Delhi chokes on Punjab Smoke", 07th Nov. 2012.

Chapter 5

Discussion and Suggestions

The study has been an attempt to understand the serious problem of 'crop residue burning' and the impact of laws, level of awareness and local participation in prevention and control of crop residue burning in Punjab. The problem of crop residue is not a state specific problem or national problem rather it is a worldwide problem. Many developed and developing nations are facing the problem of crop residue management. United States of America, the most developed nation of the world is also facing the problem of crop residue management. A general perception is that only farmers are responsible for this problem but the reality is that the modern system of agriculture is widely responsible for it. The mono-culture pattern of cropping of wheat-paddy rotation created this problem in the state. This mono-culture pattern of cropping is not adopted by the farmers on its own rather it is the result of the priorities of the government and its policies. In the past, such kind of policies is formulated by the government which forced the farmers to adopt wheat-paddy cropping rotation such as fixation of MSP in favor of these two crops. The study argued that there is a lack of impact of laws, awareness among various stakeholders and local participation on the issue.

The problem that has been discussed under chapter 1 of the study is serious and has direct and indirect effects on human health, soil, air, biodiversity and to the overall environment of the state. In this chapter, I tried to collect the evidences to show the seriousness of the problem. I started this study with a view to find out the real obstacles and followed with some objectives. I also tried to make participation of all the concerned parties. In this study a mixed approach has been followed, keeping in of the unavoidable circumstances. It is reflected in the study that the majority of the farmers wants to avoid this practice but they are helpless due to lack of practical and economic viable alternatives available with them at this stage and hence the policies of both State and Union government is in question.

A good volume of literature is available on the issue of crop residue burning as it is a universal problem but very limited research is available on the issue of role of laws involved with this issue. There is also need to study the laws regarding this issue other countries but as field situation varies from one country to another those laws cannot be adopted in a straight jacket way but certainly they can provide some guidance. That's why this study also discussed about legislations in the United States regarding the issue of crop residue burning.

Laws and government policies plays a very vital role in the framing of things. The problem of pollution caused by crop residue burning has not received much attention by the policy makers and the various pollution control authorities till recently. This could be partially due to the fact that rice stubble burning takes place only during selected months of October and November and the pollution is mainly restricted only during these two months. Even during these two months there is considerable loss of human health and environmental degradation. Punjab Government is publishes regarding the ill effects of crop residue burning in newspapers. The government through its various Departments and other institutes like PAU, PSFC, PEDA, PPCB, etc. are all making efforts to develop some alternate economic use of crop residue.

Among the all available alternatives, Happy Seeder, seems to be the only practical and economically viable alternate to reduce the problem of crop residue burning. There is urgent need to develop this technology further for the benefit of farmers. It seems unlikely that more than 10% of the total paddy straw produced in the state can be put to alternative uses other than on-farm recycling using Happy Seeder. Therefore, all out efforts are needed in the near future by the government and extension agencies for popularizing the large scale adoption of Happy Seeder technology. It is the responsibility of the government to make available this machinery to the farmers at a reasonable price. The study shows that impact of laws on this issue is very negligible and there are serious problems in the implementation of government policies and programmes at the grass root level.

Suggestions

Legal

1. There is urgent need to bring a specific law regarding this issue like Punjab Preservation of Subsoil Water Act 2009.
2. A nodal agency for the proper enforcement of that Act.
3. Compulsory use of 'Straw Management System' machine with combine harvesters.
4. Fix responsibility of the bio-mass based power plant to collect crop residue within specified area.
5. Registration and permit system in case of crop residue burning.

Policies

1. Crop Diversification from paddy to other crops.
2. More observatories to measure pollution level, especially in rural areas.
3. Promotion of happy seeder technology
4. Incentives to farmers, those are adopting alternative uses of crop residue in place of burning.
5. Participation of all the stakeholders in decision making process on the issue.
6. More focus on public awareness regarding the issue.

Bibliography

Books

Wiikman,Anders., Rockstorm. Johan. Bankrupting Nature. New York: Routledge.2012. Print.

Barr, Steward. Environment and Society. London: Ashgate, 2008. Print.

Soltav, Friedrich. Fairness in International Climate Change Law and Policy. New York: Cambridge, 2009. Print.

Nandimath, O.V. handbook of Environmental Decision Making in India. New Delhi: Oxford, 2010. Print.

Sadeleer, Nicolas. Environmental Principles. New York: Oxford, 2002. Print.

Radkav, Joachim. Nature and Power. New York: Cambridge. 2008. Print.

Plumwood, Val. Environmental Culture. New York: Routledge. 2002. Print.

Larkin, Amy. Environmental debt. London: Palgrave Macmillan. 2011. Print.

Boylan, Michael. Environmental Ethics. New Jersey: Prentice Hall. 2010. Print.

Braver, Jurgen. War and Nature. United Kingdom: Alta Mira Press. 2009. Print.

Edited Books

Caitlin, Wilson.”Educating for Sustainability.” Environmental Political Philosophy. Ed. Loukola, olli and Gasparski, Wajciech W. New Jersey: 2012. 311-325. Print.

Singh, Sukhpal.”Globalisation and Sustainability Issue in Agriculture in Asia: A Case of India.” Economic and Environmental Sustainability of the Asian Region. Ed. Gill, Sucha Singh, Singh, Lakhwinder. And Marwah, Reena. New Delhi: Routledge. 2010. Print.

Reports

Government of Punjab. Diversification of Punjab Agriculture, Punjab. Chandigarh: Committee on Diversification of Punjab Agriculture, 1985.

Government of Punjab. Agriculture Policy and Restructuring, Punjab, Chandigarh: Advisory Committee on Agriculture Policy and Restructuring, 2002.

Government of Punjab. Statistical Abstracts of Punjab, Punjab, Chandigarh: Government of Punjab, 2012.

International Food Policy Research Institute (IFPRI). Withering Punjab Agriculture: Can it regain its leadership: IFPRI 2006.

Punjab State Council for Science and Technology (PSCST). State of Environment Punjab, Chandigarh: PSCST 2007.