A STUDY ON IMPACT OF URBAN GROWTH ON ARABLE LAND

A study by

The Auditor General of Pakistan

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PREFACE

Pakistan can neither ignore a compelling urge for urbanization as a corollary to industrialization, rural urban migration and population explosion, nor afford to lose its repositories of prime agricultural land. Punjab province, a land of five rivers, enriching its plains with alluvial deposits, irrigated with flows of glacial melt and monsoon run off, is a bread basket of the country, but still challenge of feeding the people is so daunting that the country can hardly afford to feel complacent about its food security, catered for by increasingly scarce and shrinking prime agriculture land.

The ranking of the country as worst hit by climate change as borne on Global Climate Risk index is precariously placed as a hot spot amongst 10 worst hit countries in the world. Food security of the country having been imperiled, there is a direly needed urgency of compelling nature for ensuring a controlled and planned urbanization. In addition, thereto, Land Use Land Conversion (LULC) changes on ground represent transformation of rural settlements into agro polis, further expanding into urban agglomerations.

The findings of this study report are likely to help firming up of a range of recommendations to synergize an integrated inter and intra-agency response mechanism, beneficial to those who are likely to suffer the most in the event of reduced agricultural productivity, influx of rural urban migration and big boom of housing societies with compromised ecosystem services, propelling an unwieldy urban sprawl.

The study indicates specific actions that, if taken, will help the management realize the desired objectives of fending for conservation of depleting prime crop lands.

Dated:
Islamabad

(Muhammad Ajmal Gondal)
Auditor General of Pakistan

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ABBREVIATIONS & ACRONYMS

µg/L	Means Micrograms per Liter
ALA	Agricultural Land Abandonment
B	Boron
Bq/kg	Becquerel per Kilogram
Ca	Calcium
CCPF	Carbon-Cycle-Positive-Feedback
CCS	Carbon Capture Storage
Cl	Chlorine
CO	Carbon monoxide
CO2	Carbon dioxide
COPD	Chronic Obstructive Pulmonary Disease
CPEC	China Pakistan Economic Corridor
CSA	Climate Smart Agriculture
DC	Deputy Commissioner
DFO	District Forest Officer
DG	Director General
EDB	Electronic Data Bank
EPD	Environmental Protection Department
ES	Ecosystem Services
FAO	Food and Agriculture Organization
FATA	Federally Administrative Tribal Areas
GDA	Gujranwala Development Authority
GDP	Gross Domestic Product
GHGs	Greenhouse Gases
GIS	Geographic Information System
GLOFS	Glacial Lake Outburst Floods
GT	Grand Trunk
IARC	International Agency for Research on Cancer
IBIS	Indus Basin Irrigation System

IFAD	International Fund for Agricultural Development
IPCC	Intergovernmental Panel on Climate Change
IWMI	International Water Management Institute
K	Potassium
KG	Kilo Gram
KM	Kilo Meters
KPK	Khyber Pakhtun Khawa
LBDC	Lower Bari Doab Canal
LG&CD	Local Government and Community Development
LMQ	Lahore Multan Quetta
LST	Land Surface Temperature
LULC	Land Use Land Conversion
MDA	Multan Development Authority
Mg	Magnesium
Mn	Manganese
Mo	Molybdenum
MPI	Multidimensional Poverty Index
MSW	Municipal Solid Waste
MW	Mega Watt
N	Nitrogen
Na	Sodium
NEQS	National Environment Quality Standards
NH3	Ammonia
NO	Nitrogen Oxide
NOx	Nitrogen Oxides
NWC	National Water Council
O3	Ozone
OEM	Original Equipment Manufacturer
P	Phosphorus
P & D	Planning & Development
PCRWR	Pakistan Council of Research in Water Resources

PHATA	Punjab Housing and Town Planning Agency
PM	Particulate Matter
PMU	Project Management Unit
RDF	Refuse Derived Fuel
RS	Remote Sensing
S	Sulfur
SC	Steering Committee
SCCS	Supercritical Carbon Capture Storage
SDG	Sustainable Development Goal
Se	Selenium
SOPs	Standard Operating Procedures
SOx	Sulfur Oxides
SPS	Sanitary and Phyto-sanitary
SRS	Satellite Remote Sensing
SWM	Solid Waste Management
TDS	Total Dissolved Solids
TMA	Town Municipal Administration
UNICEF,	United Nations International Children's Emergency Fund
UNSCEAR	United Nations Scientific Committee on the Effects of Atomic Radiation
VOCs	Volatile Organic Compounds
WFP	World Food Program
WHO	World Health Organization
WMO	World Meteorological Organization
Zn	Zinc

EXECUTIVE SUMMARY

Pakistan has gained fastest pace in urbanization in South Asian region and the Province of Punjab is no exception in this regard. According to the most recent Population Census data, overall urban population share in Pakistan has increased from 28.3 percent in 1981 to 36.38 in 2017.

This population increase in urban areas has concurrently been unfolding incidence of Urban Sprawl, coupled with mushrooming growth of agro polis and Land Use Land Conversion (LULC) changes. These LULC changes are exerting pressure on the rural landscape because of new housing schemes and built up structures, land acquisitions and mercurial rise in the influx of brick kilns in the heart of erstwhile cropped areas. Equally astounding and daunting is the dearth of infrastructural development in the vicinity of urban fringes in need of futuristic master plans. Albeit, the process of urbanization is rapidly changing the socio-economic conditions in peri-urban surroundings of expanding cities, urgency for the conservation of arable land in Punjab, indeed cannot be brushed aside.

Evidently, availability of fresh water and that of arable land is limited. Punjab Growth Strategy 2018 envisions the Provincial urban growth that favors establishing new urban settlements and using urbanization as a means for economic growth. This urban transition is occurring due to urban-rural migration concurrent with a shift in sectoral priorities tilting towards a manufacturing and service based economy, associated with expanding urbanization.

The Province’s urban population is likely to increase to 52 million by 2025 and 59 million by 2030, which is equal to 1 million additional urban residents every year. If current trends continue, the outcome will be slum and squatter settlements, sheltering millions more with compromised

sustainable living, degrading the already dilapidated ecosystem services, not only for those who reside in urban fringe but also for those who continue to dwell in agriculture and protected zones and fall out of this chain of events is likely to jeopardize ecological balance, biodiversity conservation, aquifer recharge, watershed management.

Punjab's experience with urbanization has been characterized by lack of clear urban policy, leaving unaddressed the exponential growth of urban sprawl while public infrastructure and expected service delivery for eco-system services and civic amenities are struggling to keep pace with each other. The government is yet to finalize master plans of more than 150 urban local governments/cities of Punjab, despite urgency to do so because of increasing migration of the people from small towns to big cities.

Agriculture, together with agro-based products contributes more than 80 percent in the country's exports, and accommodates bulk of the labor force participation in the Province. Accordingly, Punjab province needs a thriving agriculture to support growing food requirements of its ever increasing population. Conversely, urbanization as a result of population explosion, migration to cities, displaced population due to super floods, IDP crisis, climate refugee waves and industrial and infrastructure development is putting more pressure on arable lands which are depleting at a relatively fast rate.

Punjab is ironically also categorized as a water-scarce province because the yearly water availability is less than 1,000 cubic meters per **person**. The country crossed this level in 2005. If per capita availability of water reduces further and reaches 500 cubic meters, it will become a region that is absolutely scarce of water by 2025. Quite a few districts consist of arid regions dependent upon rain fed agricultural outputs with unpredictable yields, rendering the conservation of irrigated lands in

central Punjab, particularly situated in study areas such as Sahiwal and Kamoke far more vital because of paucity and dearth thereof.

In order to evaluate the impact of urbanization on availability of arable land, a sample study of two regions i.e. district Sahiwal and tehsil Kamoke has been carried out. Kamoke is located in Rachna Doab that lies between Rivers Chanab and Ravi. On the other hand, Sahiwal is located between Rivers Ravi and Satluj called Bari Doab. Both of the regions represent the areas which are irrigated through surface water sources of canals and distributaries. The thrust of urban sprawl and agricultural land abandonment coincides here and due to Land Use Land Conversion (LULC) tendencies and consequent usurping of arable lands, coverage of crop area sown is receding and incidence of urban sprawl is on the rise.

Key Audit findings of the study are summed up as follows:

i. Housing Schemes have a mushrooming growth in the heart of arable lands. There are 39 Housing Schemes in Kamoke, 52 Housing schemes in Sahiwal in breach of classification of peri urban and agricultural zoning.

ii. 11 Mouzas are under consolidation in District Sahiwal since 2001-2003 and the process to finalize consolidation is dormant and as such agricultural lands in these Mauzas are ripe for illegal subdivision of agriculture holdings.

iii. List of illegal subdivisions of agricultural land include area spanning over 328 Acres in Gujranwala including Kamoke, which factor alone is indicative of governance failure.

iv. Vegetation cover is being lost due to depletion of forest land vital for watershed management, soil conservation and carbon sequestration as 2079.70 Acres of Forest Land is now turned into a built up area in Chichawatni Forest. Valuation of encroached upon land is not less than

Rs. 6239.1 Millions, according to averaged estimates based on valuation tables of the neighboring Mouzas.

v. Comparing the Revenue Record for notified Forest Land in the same area, whereabouts of a declared tract of Forest land measuring 60 Acres are not traceable either.

vi. In the surrounding localities, Depalpur Forest has 115 Acre of built up Area for rest house and colony, and 387.8 Acre has been depicted occupied by other Departments whereas Pirowal Forest satellite image depicts sizeable chunks lost to other Departments.

vii. Government Land Acquisitions are a major source of shrinkage of arable land, 759 Acre, 3 Kanal, 11 Marla acquired in Kamoke alone since 2018 for Road construction. Same is the case with acquisition of arable land for Coal Fired Power Plant, landfill site, and waste water treatment facilities at Sahiwal.

viii. 429 Brick Klins in Sahiwal, are another major source of depletion of arable land. The situation at Komoke is alike.

ix. Urban fringe in proximity to Kamoke has witnessed drastic decrease in consumption of vegetable seeds, making it evident that cultivable lands in peri urban surroundings have lost the recognition of their status as arable lands.

x. 100 acres of agricultural land had been eaten up by strong river currents in the wake of changes in river course at Miyana Thatta village, Moza Molanza, Miran Shah village, Dad Baloch and Longa Wali villages, occasioned by erosion due to river Ravi changing its course.

xi. Sahiwal is also suffering from irrigation of agriculture fields from urban untreated, sewage, adding environmental and health hazards for consumers of vegetables and fodder

grown on fields, so irrigated with uptake of non-biodegradable heavy metals.

xii. Notified spatial plans, master plans, zoning, land use plans, including classification and reclassification of land, urban design, urban renewal are non-existent and hence represent neglect of authorities.

xiii. Inaction and in-attention was evidenced in following cases

a. Action plan for integrated system of water reservoirs, water sources, treatment plants, drainage of effluents according to NEQS are lacking efficacy with respect to liquid and solid waste disposal, sanitation and other municipal services;

b. Undertaken urban design and urban renewal programs are far from adequate; the need was found to integrate the existing land uses and priorities pegged to sustainable urbanism

c. Outline Development Plans for Sahiwal and Kamoke have expired and also stand breached;

d. Climate Change is taking its toll. Precipitation trends show impending drought. Land Surface Temperature is rising impairing the

xiv. Coal Fired Power Plant at Sahiwal consumes 16667/tons of coal per day and is dependent on irrigated water through outlets from Lower Bari Doab Canal (LBDC) canal, depriving one entire Mauza of access to canal water.

xv. The lower riparian of LBDC needing irrigated water for farming face shortage of water required for irrigation purposes.

xvi. Disposal of leachate from the Coal fired plant has the tendency to adversely affect the agricultural outputs, once it

is drained out though an outfall drain cascading through agricultural fields.

xvii. Coal-fired power plants ought to be subject to environmental monitoring which is presently, lackadaisical and thus keynote parameters to be embedded in lab test reports are unduly ignored.

xviii. The poisonous fumes and particulate matter emitted from the coal power plant and also remain unmonitored by EPD (Environment Protection Department).

xix. There has been a tangible impact of groundwater abstraction and the rising arsenic levels in Sahiwal, including nearby villages, because of the coal-fired power plant. The groundwater table has decreased by up to 15 feet over the last three to four years, owing to over-pumping of groundwater for utilization by the coal power plant, given the context that during the winter season, canal water is not sufficiently available from January to March.

xx. From Secondary Source analysis of the samples, it is revealed that drinking water sources in study area were found unsafe due to bacteriological as well as the chemical contamination of arsenic, nitrate and TDS above the World Health Organization's safe limits in drinking water.

xxi. Results of Environmental samples from primary source are held up with unreported results on the part of EPD, as no response materialized for sharing results of environmental monitoring samples.

xxii. Data generation discrepancies attributable to Government entities were astounding to the extent of alarming proportions:

a. 38000 hectares of uncultivated land was shown decreased in one year in 2015

b. Crop Reporting Services show 461000 Hectares cropped Area more than Punjab Bureau of Statistics Report in 2019-20 and 195 Acre less net sown area in year 2018-19. In Kamoke there was a dip of cropped Area Kharif 2017-18, reduced from 132537 to 12736 hectare with other columns of cultivation, and culturable waste remaining constant.

c. Similarly, there was inexplicable depiction of decrease in culturable waste area of Chichawatni for 838 Hectares in 2019-20

d. Tehsildar Kamoke reported that cropped Area was 807 acres less than that of Punjab Bureau of Statistics Report.

xxiii. An area measuring 23,119 acres of arable land was converted into urbanized land in Sahiwal District and Tehsil Kamoke over a time span of twenty two years.

xxiv. An expected shortfall of agricultural produce is likely to be confronted because of urbanization of arable land in the study area.

Generic audit findings, supplementing core issues highlighted, are enumerated at (Annexure-1). In view of appraisal of problem analysis at macro level, an overview at a glance is summarized at (Annexure-2), and the corresponding remedial measures to take stock of the deteriorating situation are also enlisted while concluding the study.

Audit endorses a set of action plans proposed at (Annexure-3), which must be considered for execution by the relevant governing entities for doing away with deficiencies which have since been discernible. These

actions include planning the peri-urban growth, enhancing the forest coverage to fight climate change and seeking conservation of soil from degradation, improving the agriculture across peri-urban landscape. Concurrently, priority needs to be accorded to ensure recharging of underground water, usage of technology for enhanced agricultural output, taking recourse to treatment of effluents before drainage into water bodies and mixing of the same with irrigation system, improving the solid waste management system, relocating dumping sites of solid waste to appropriate locations, and above all devising master plans for urban centers etc. In these action plans, brief description of additional resources to be mobilized, time span planned, budget to be allocated, human resource needed to be engaged and the departments involved are also embedded for a pragmatic roll out of a holistic reform agenda.

1. INTRODUCTION

Agricultural land conversion into urban use, particularly, in District Sahiwal and Tehsil Kamoki is best depicted through digital imagery from 1990 to 2022, leading to meaningful analysis of the expansion rate of these cities and urban clusters. More so, LULC remote sensing satellite imagery data also captures establishment of number of industries within the parameters of peri-urban and agricultural land.

Due to shrinking farm size, agriculture as an avocation has begun to yield under-sustenance with smaller land holdings also confronted with forced changes in dynamics for farming, triggering rural urban migration. Most often, it cannot be relied upon as a solitary means of gainful employment. Evidently, land around urban and semi-urban clusters of population is increasingly compromised. The development of housing societies around urban fringe and road networks is one of the main factors for converted agriculture land into housing units or plots. Agricultural Land Abandonment (ALA) is being preferred in lieu of allurements on offer, by property developers and speculators.

Urban sprawl goes on unchecked. The people generally purchase land in the peri-urban areas on comparatively cheaper rates, hoping that they can sell it on high prices. If urbanization and land conversion continue without adequate enforcement of laws to protect agricultural lands in the districts, an increase in food insecurity could occur. Urbanization in Punjab has changed the landscape and the demography of the study areas in the wake of profound fundamental modifications in the dynamics and composition of the fragile rural/urban balance.

Urban expansion is contributing towards a range of environmental problems in urban areas as well as the adjoining country side. The land use changes from agricultural to urban purposes considerably affects the sustainability of the soil and water resources, ecosystem functioning and

biodiversity, also unfolding low farm output, besides land degradation. Horizontal urban expansion was observed with residential development as the dominant expression of this expansion, which characterizes detection of the range of urban intrusion on agricultural lands. Moreover, enhancing agriculture yield is essential for minimizing hunger (SDG 2), alleviating poverty (SDG 1), ensuring land (SDG 15) and food security.

Feeding the increasing human population, with increasingly limited arable land and water resources has become a major challenge for humanity. There is some concern that the resources of the planet could soon restrict the ability of human beings to keep up with the increasing food demand required by people. Urbanization and changes in human diets have increased pressures on agro ecosystems and worsened food insecurity.

Urbanization denominates the change or shift from a rural setting to an urban setting, and the increase in the proportion of people living in the urban areas and how they adapt to this change pushes and displacing farmers in peri-urban areas out from good agricultural lands because of high demand for housing and certain social amenities. Agricultural land losses often occur in peri-urban areas where there are high-quality farmlands. It is important that the government fulfills its obligations to strengthen urban land-use planning systems so that there is increased stakeholder participation in land use planning while encouraging vertical-type building construction for commercial and residential purposes.

2. OBJECTIVES OF THE STUDY

The study focuses upon the following areas having significant impact on agricultural output, environment and socio-economic challenges:

i. Appraisal of trend analysis of utilization of land for last twenty years because of population change in area.

ii. Diagnosis as to how agricultural land has been affected through urban settlements.

iii. Evaluation of short, medium and long-term food insecurity issues for the residents of the selected area of the case study due to diminishing arable land.

iv. Assessment of arable land reduction and dwindling yield including food requirements for the human population as well as production of fodder for animals with reducing pattern of land percentage for natural eco-system

v. Review of policies on construction of houses in the area.

vi. Recommendations facilitating management for improving overall Urban Planning in the wider context of food security, law and order situation, polarization of society and preservation of ecosystem.

vii. Recommendations on raising a sustainable model keeping in view the increasing population and decreasing arable areas.

3. STATEMENT OF THE PROBLEM

Agricultural land abandonment occasioned by an unwieldy urban sprawl is a widespread Land Use Land Conversion process in Punjab Province. Spatial-temporal shrinkage of arable land concurrent with intensified densification within the built-up area as well as peripheral urban growth are persistently on the rise, transforming the rural urban interface, that too haphazardly which has invariably resulted in mushrooming entrenchment of slums or undesirable residential areas with lack of services and amenities, unfolding chaotic intermix of conforming and non-conforming land uses, thereby accentuating wastage of cultivable areas. SDG goals as part of the 2030 agenda thus remain a distant dream.

Unplanned urban sprawl at the expense of reduction in arable land and sub optimal mitigation measures to promote climate resilient agriculture, water conservation, also conniving at arresting environmental degradation is resulting in reduced agricultural productivity from the left over prime land which can turn ominous for food security and poverty reduction, Loss of agricultural land, rural livelihood, land use and land cover changes, land policy draw backs and environmental degradation are not attracting remedial action in a concerted manner. Annual Development plan spending on Agriculture, Urban development, Climate Resilience and infrastructure Development are unable to yield tangible results.

The key research question, the study took up for resolving was as to whether the current state of affairs was to perpetuate unabated or a holistic and structured reform agenda could be firmed up with a multi-pronged remedial measures, supplemented with a road map based actionable interventions.

4. LITERATURE REVIEW

The spatial-temporal analysis of LULC changes call for improvised strategies for coveted resilience so as to capitalize upon land and environmental resources (Arif et al. 2018)[1].Concurrently, urban growth is not without exhibiting significant effects[2] on energy flow, biogeochemical cycles, and biodiversity at local and regional levels [3]. Additionally, urban growth involves a significant decrease in arable land, habitat loss, species extinction, lowered net primary productivity[4] coupled with landscape degradation[5] through environmental hazards[6]. Although urban expansion is considered amongst some of the very important indicators of socioeconomic development, it is at the cost of loss of agricultural land[7] which results in land use land cover changes[8] within and outside the urban centers (Badlani et al., 2017)[9].

1 Arif, G. M., and Shahnaz Hamid. "Urbanization, city growth and quality of life in Pakistan." European Journal of Social Sciences 10, no. 2 (2009): 196-215. Malik, Naveed, Fahad Asmi, Madad Ali, and Md Mashiur Rahman. "Major factors leading rapid urbanization in China and Pakistan: A comparative study." Journal of Social Science Studies 5, no. 1 (2017): 148-168.

2 Khurshid, Mareena, and Safdar Ali Shirazi. "Applications of Geospatial Techniques to Identify Landscape Changes and Urban Expansion of Dera Ghazi Khan City, South Punjab-Pakistan." International Journal of Economic and Environmental Geology 12, no. 3 (2021): 40-43.

3 Manonmani, R., and G. Suganya. "Remote sensing and GIS application in change detection study in urban zone using multi temporal satellite." International journal of Geomatics and Geosciences 1, no. 1 (2010): 60-65.

4 Liu, Ting, and Xiaojun Yang. "Monitoring land changes in an urban area using satellite imagery, GIS and landscape metrics." Applied Geography 56 (2015): 42-54.

5 Bhatta, Basudeb. Analysis of urban growth and sprawl from remote sensing data. Springer Science & Business Media, 2010.

6 Nedd, Ryan, Katie Light, Marcia Owens, Neil James, Elijah Johnson, and Aavudai Anandhi. "A synthesis of land use/land cover studies: Definitions, classification systems, meta-studies, challenges and knowledge gaps on a global landscape." Land 10, no. 9 (2021): 994.

7 Xian, George Z. Remote sensing applications for the urban environment. Vol. 12. CRC Press, 2015.

8 Singh, Raj Mohan. "Assessment and prediction of LULCC dynamics in a part of Indo-Gangetic Alluvial Plain (IGAP) using geospatial techniques on multi-temporal Landsat imageries." Arabian Journal of Geosciences 15, no. 11 (2022): 1-19.

9 Badlani, Bhavika, Ajay N. Patel, Krunal Patel, and Manik H. Kalubarme. "Urban growth monitoring using remote sensing and geo-informatics: case study of Gandhinagar, Gujarat state (India)." International journal of geosciences 8, no. 4 (2017): 563-576.

Land use land cover (LULC) are two distinct terms[10] that are used interchangeably especially concerning urban expansion/urbanization[11]. The land cover indicates the biophysical features of the earth's surface, for example, vegetation, soil, water, and urban infrastructure[12] whereas, land use is linked with how human beings use the land with an emphasis on the role of land in furtherance of economic activities (Arsanjani, 2011)[13]which cannot ignore climate risk adaptation, seeking to reduce vulnerability and enhance coping capacity[14]. These definitions may imply that adaptation and mitigation are compartmentalized. However, it is argued that the ultimate goal of both is to minimize the undesirable consequences of climate change (Ayers and Huq, 2009)[15]. To this end, mitigation mainly focuses on the long-run reduction of risks, while adaptation is aimed at reducing the current risks that exist due to historical emissions and/or because of failure to achieve mitigation targets [16]. Therefore, it can be said that adaptation and mitigation are not mutually independent, as more mitigation can reduce adaptation needs in the long run and more adaptation can lower the mitigation costs through improving coping and adaptive capacities[17]. In other words, mitigation is needed for successful

10 Mundhe, Nitin N., and Ravindra G. Jaybhaye. "Impact of urbanization on land use/land covers change using Geo-spatial techniques." International journal of geomatics and geosciences 5, no. 1 (2014): 50-60.

11 Singh, Raj Mohan. "Assessment and prediction of LULCC dynamics in a part of Indo-Gangetic Alluvial Plain (IGAP) using geospatial techniques on multi-temporal Landsat imageries." Arabian Journal of Geosciences 15, no. 11 (2022): 1-19.

12 Zaman, Haq M., Z. Saqib, Atif S. Bokhari, N. Akhtar, and S. Amir. "The Dynamics Of Urbanizations And Concomitant Land Use Land Cover Transformations In Planned And Quasi-Planned Urban Settlements Of Pakistan." Geography, Environment, Sustainability 13, no. 4 (2020): 107-120.

13 Arsanjani, Jamal Jokar. Dynamic land use/cover change modelling: Geosimulation and multiagent-based modelling. Springer Science & Business Media, 2011.

14 Demuzere, Matthias, Kati Orru, Oliver Heidrich, Eduardo Olazabal, Davide Geneletti, Hans Orru, Ajaye Gajanan Bhave, Neha Mittal, Efrén Feliú, and Maija Faehnle. "Mitigating and adapting to climate change: Multi-functional and multi-scale assessment of green urban infrastructure." Journal of environmental management 146 (2014): 107-115.

15 Ayers, Jessica M., and Saleemul Huq. "The value of linking mitigation and adaptation: a case study of Bangladesh." Environmental Management 43, no. 5 (2009): 753-764.

16 Sathaye, Jayant, Adil Najam, Chris Cocklin, Thomas Heller, Franck Lecocq, Juan Llanes-Regueiro, Jiahua Pan et al. "Sustainable development and mitigation." In Climate change 2007: Mitigation of climate change, pp. 691-743. Cambridge University Press, 2007.

17 Sharifi, Ayyoob. "Co-benefits and synergies between urban climate change mitigation and adaptation measures: A literature review." Science of the total environment 750 (2021): 141642.

adaptation and vice versa. This is increasingly recognized in global policy frameworks. For instance, the need for developing action plans that include both mitigation and adaptation mechanisms is underscored in the Paris Agreement[18] and the New Urban Agenda[19]. Similarly, the United Nations Sustainable Development Goals (particularly SDG 11 and SDG 13) recommend adopting integrated plans and policies towards mitigation and adaptation[20]. Such integrated approaches also contribute to achieving the targets of the Sendai Framework for Disaster Risk Reduction[21].

Pakistan is on the brink of a lengthy and severe groundwater crisis[22]. The supply of safe, usable groundwater is diminishing as a result of pollution, over-extraction, poor management of canal water, and inappropriate irrigation practices. Despite decades of national and international experts predicting the burgeoning crisis and identifying key requirements to address these challenges, little attention has been given to them. As a result, depletion is curtailing feasible access to groundwater in Punjab, and waterlogging and salinity continue to threaten water and soil quality[23].The Indus basin is the heartland of irrigated agriculture in Pakistan, supported by the largest contiguous irrigation network in the world, and accounts for 96 percent of the country's total renewable water

18 Dimitrov, Radoslav S. "The Paris agreement on climate change: Behind closed doors." Global environmental politics 16, no. 3 (2016): 1-11.

19 Caprotti, Federico, Robert Cowley, Ayona Datta, Vanesa Castán Broto, Eleanor Gao, Lucien Georgeson, Clare Herrick, Nancy Odendaal, and Simon Joss. "The New Urban Agenda: key opportunities and challenges for policy and practice." Urban research & practice 10, no. 3 (2017): 367-378. Las Casas, Giuseppe, Francesco Scorza, and Beniamino Murgante. "New urban agenda and open challenges for urban and regional planning." In International Symposium on New Metropolitan Perspectives, pp. 282-288. Springer, Cham, 2018.

20 Kaika, Maria. "'Don't call me resilient again!': the New Urban Agenda as immunology or what happens when communities refuse to be vaccinated with 'smart cities' and indicators." Environment and Urbanization 29, no. 1 (2017): 89-102.

21 Wahlström, Margareta. "New Sendai framework strengthens focus on reducing disaster risk." International Journal of Disaster Risk Science 6, no. 2 (2015): 200-201.

22 Lytton, Lucy, Akthar Ali, Bill Garthwaite, Jehangir F. Punthakey, and Basharat Saeed. "Groundwater in Pakistan's Indus Basin." (2021).

23 Prof. Dr. Muqarrab Akbar , Shoaib Ali Khan, Shumaila Dilawar, Dr. Muhammad Tahir Hassan. 2021. "WATER CRISIS IN PAKISTAN: PROSPECTS AND IMPLICATIONS". PalArch's Journal of Archaeology of Egypt /Egyptology 18 (1):4884-92. https://archives.palarch.nl/index.php/jae/article/view/8948.

resource. The Indus basin irrigation system (IBIS) consists of a network of dams, barrages, and canals built in stages from the early 1900s. An unintended outcome of this vast surface water delivery system is that a significant volume of seepage water has been introduced into the underlying groundwater system, which now represents the largest reservoir of freshwater in the country and constitutes a transboundary resource of major importance. Conservatively estimated at 1,250 billion cubic meters, the fresh groundwater in storage in this aquifer represents less than 13 percent of the total 10,000 billion cubic meters stored in the aquifer, the remainder being brackish or saline, which, for most purposes, is not usable without treatment. Before the development of the irrigation network, groundwater in the Indus basin is considered to have been relatively deep and saline, except for narrow zones adjacent to the rivers that cross the Indus plain. Seepage from the expanding canal network became the major source of groundwater recharge.

Most of this domestic water in both rural and urban Pakistan falls short of basic health standards, especially for drinking purposes, and many parameters are not routinely measured. This compromised water quality has significant public health outcomes, inevitably having a disproportionate effect on the most vulnerable households[24]. These households have no choice but to continue to pump groundwater for their domestic use, despite its poor quality, because they lack access to piped water and cannot afford alternative forms of water supply. The SDG targets aim for universal access to drinking water, sanitation and hygiene and call for enhanced monitoring to ensure that no one is left behind. This report considers the implications of target 6.1, “by 2030, achieve universal and equitable access to safe and affordable drinking water for all,”[25]

24 World Health Organization. "Safely managed drinking water: thematic report on drinking water 2017." (2017).

25 Tortajada, Cecilia, and Asit K. Biswas. "Achieving universal access to clean water and sanitation in an era of water scarcity: strengthening contributions from academia." Current opinion in environmental

Change in climate is mainly attributed to the unabated increase in greenhouse gases, including fluorinated gases, carbon dioxide, methane, and nitrous oxide, which bring changes in rain pattern, temperature, and negative effects on water and land resources, floods, and droughts.[26] Crops are potentially vulnerable to climate change[27]. A 1.5 C warming would reduce crop net revenues by 13% per year. A 3 C warming would reduce net revenues by 28% per year[28].

Food security with receding production of wheat is imperiled. The sowing period for wheat is winter and this low temperature is conducive for the growth of wheat, while high temperature can cause a delay in seedling growth. Similarly, rainfall pattern causes damage to the production of wheat at harvesting time, ultimately leading to a situation of food insecurity in the country [29]. A decrease of 1.9% was observed in wheat production[30]. The main reasons for the decreased production were irregular rainfall. Asian agriculture nonetheless is likely to succumb to future global warming[31]Spring temperatures have a hill shaped relationship with net revenue with a maximum at 6 C. Given the warm spring temperatures in Asia, this implies spring has a negative marginal

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sustainability 34 (2018): 21-25. World Health Organization. "Progress on household drinking water, sanitation and hygiene 2000-2020: five years into the SDGs." (2021).

26 Ali, Sajjad, Ying Liu, Muhammad Ishaq, Tariq Shah, Aasir Ilyas, and Izhar Ud Din. "Climate change and its impact on the yield of major food crops: Evidence from Pakistan." Foods 6, no. 6 (2017): 39.

27 Change, IPCC Climate. "The physical science basis: Working group I contribution to the fifth assessment report of the Intergovernmental Panel on Climate Change." K., Tignor, M., Allen, SK, Boschung, J., Nauels, A., Xia, Y., Bex, V., Midgley, PM, Eds (2013): 1535.

28 Mendelsohn, Robert. "The impact of climate change on agriculture in Asia." Journal of Integrative Agriculture 13, no. 4 (2014): 660-665.

29 `Janjua, Pervez Zamurrad, Ghulam Samad, Nazakat Ullah Khan, and Muhammad Nasir. "Impact of climate change on wheat production: A case study of Pakistan [with comments]." The Pakistan Development Review (2010): 799-822.

30 Ali, Sajjad, Ying Liu, Muhammad Ishaq, Tariq Shah, Aasir Ilyas, and Izhar Ud Din. "Climate change and its impact on the yield of major food crops: Evidence from Pakistan." Foods 6, no. 6 (2017): 39.

31 Caballero-Anthony, Mely, and Margareth Sembiring. "Cases and implications of environmental insecurity in Southeast Asia." In Handbook of Security and the Environment, pp. 149-161. Edward Elgar Publishing, 2021.

impact[32] on net revenue. Summer and winter temperatures have U-shaped relationships with net revenue with a minimum at 19 and 10°C, respectively. Climate model simulations clearly indicate that average annual temperatures are likely to increase across the region by approximately 1 C through 2030[33], and they will keep increasing through the remainder of the 21st century.

Pakistan is on the road to urbanization at a tremendous speed endangering the sustainability of the succeeding generations by converting its fertile agricultural land into housing colonies and commercial enterprises. Most of the ongoing urbanization is unplanned and irregular and it entirely depends on the will of the real estate developers.[34]

The urban expansion involves the conversion of rural land into commercial and residential areas at the boundary of the urban fringe[35]. While some scholars, including Peerzado et al. (2019), recommend government policies to protect agricultural land[36], others recognize that urban expansion is irreversible and call for integrated interventions that simultaneously address the challenges of supplying food to an increasingly urbanized population as well as coping with agricultural risk and

32 Hanif, Uzma, Shabib Haider Syed, Rafique Ahmad, Kauser Abdullah Malik, and Muhammad Nasir. "Economic impact of climate change on the agricultural sector of Punjab [with comments]." The Pakistan Development Review (2010): 771-798.

33 Akbar, Haseeb, and Shabbir H. Gheewala. "Effect of climate change on cash crops yield in Pakistan." Arabian Journal of Geosciences 13, no. 11 (2020): 1-15. Ahmed, Kamal, Shamsuddin Shahid, and Nadeem Nawaz. "Impacts of climate variability and change on seasonal drought characteristics of Pakistan." Atmospheric research 214 (2018): 364-374.

34 Ahmed, Shabbir, Wu Huifang, Saira Akhtar, Shakeel Imran, Gulfam Hassan, and Chunyu Wang. "An analysis of urban sprawl in Pakistan: consequences, challenges, and the way forward." International Journal of Agricultural Extension 8, no. 3 (2021): 257-278.

35 Zaman, Haq M., Z. Saqib, Atif S. Bokhari, N. Akhtar, and S. Amir. "The Dynamics Of Urbanizations And Concomitant Land Use Land Cover Transformations In Planned And Quasi-Planned Urban Settlements Of Pakistan." Geography, Environment, Sustainability 13, no. 4 (2020): 107-120.

36 Peerzado, Moula Bux, Habibullah Magsi, and Muhammad Javed Sheikh. "Land use conflicts and urban sprawl: Conversion of agriculture lands into urbanization in Hyderabad, Pakistan." Journal of the Saudi Society of Agricultural Sciences 18, no. 4 (2019): 423-428.

production shortfalls associated with climate change[37]. Sustainable intensification of food production through the adoption of climate-smart agricultural practices is considered as a promising option[38].

Therefore, unplanned urban growth is associated with several negative effects on the urban environment[39]. For example, urban growth involves social changes and is linked with various environmental risks such as deterioration of air and water quality, loss of agricultural land, and forest as well as proliferation of economic inequalities[40]

Urban growth also exhibits significant effects on energy flow, biogeochemical cycles, and biodiversity at local and regional levels[41] . Additionally, urban growth involves a significant decrease in arable land, habitat loss, species extinction, lowered net primary productivity coupled with landscape degradation through environmental change[42].

The major contributing factors of urbanization in Pakistan are internal migration[43], real estate business without any approval from the concerned urban development authorities, conversion of fertile agricultural

37 Bayulken, B. and Huisingh, D., 2015. A literature review of historical trends and emerging theoretical approaches for developing sustainable cities (part 1). Journal of Cleaner Production, 109, pp.11-24.

38 Rahman, MD Mashiur, Sreejith Aravindakshan, Muhammad Arshadul Hoque, Mohammad Arifur Rahman, Md Ashrafuzzaman Gulandaz, Jubaidur Rahman, and Md Tariqul Islam. "Conservation tillage (CT) for climate-smart sustainable intensification: Assessing the impact of CT on soil organic carbon accumulation, greenhouse gas emission and water footprint of wheat cultivation in Bangladesh." Environmental and Sustainability Indicators 10 (2021): 100106.

39 Hobbie, Sarah E., and Nancy B. Grimm. "Nature-based approaches to managing climate change impacts in cities." Philosophical Transactions of the Royal Society B 375, no. 1794 (2020): 20190124.

40 Ul Din, Shaker, and Hugo Wai Leung Mak. "Retrieval of Land-Use/Land Cover Change (LUCC) Maps and Urban Expansion Dynamics of Hyderabad, Pakistan via Landsat Datasets and Support Vector Machine Framework." Remote Sensing 13, no. 16 (2021): 3337.

41 Liaqut, A., Younes, I., Sadaf, R. and Zafar, H., 2019. Impact of urbanization growth on land surface temperature using remote sensing and GIS: a case study of Gujranwala City, Punjab, Pakistan. International Journal of Economic and Environmental Geology, pp.44-49.

42 Khurshid, Mareena, and Safdar Ali Shirazi. "Applications of Geospatial Techniques to Identify Landscape Changes and Urban Expansion of Dera Ghazi Khan City, South Punjab-Pakistan." International Journal of Economic and Environmental Geology 12, no. 3 (2021): 40-43.

43 Ishfaq, Sadia, Vaqar Ahmed, and Danish Hassan. "Internal migration and labour mobility in Pakistan." In South Asia Migration Report 2017, pp. 339-360. Routledge India, 2016.

land to build housing colonies, motorways, and commercial enterprises[44]. The rapid urbanization has affected the agricultural sector of Pakistan to a great extent. The fertile agricultural land conversion has startled the agriculture sector because the arable land is declining rapidly, and the country may face the problems of food security soon[45]. The swift urban sprawl is also a challenge for the urban development authorities and the agricultural extension department to convince the real estate developers about the implications of urbanization for agricultural sustainability and food security of the country[46]. Conservation of fertile agricultural land is of vital importance for the sustainability of the diminishing agriculture sector which remains the backbone of the economy of the country[47].To encourage the diversification of agriculture a multi-prone strategy needs to be designed. The principle of 5-Is is expected to meet the objectives in a competitive environment. These 5-I's are:

1) Incentives;
2) Innovations;
3) Inputs;
4) Institutions; and
5) Infrastructure[48].

44 Anwar, Nausheen H., Gulnaz Anjum, Kanza Rizvi, Arsam Saleem, and Muhammed Toheed. "Land, Governance & the Gendered Politics of Displacement in Urban Pakistan." (2021).

45 Ahmed, Shabbir, Wu Huifang, Saira Akhtar, Shakeel Imran, Gulfam Hassan, and Chunyu Wang. "An analysis of urban sprawl in Pakistan: consequences, challenges, and the way forward." International Journal of Agricultural Extension 8, no. 3 (2021): 257-278.

46 Farah, Naveed, Izhar Ahmad Khan, Adeela Manzoor, and Baber Shahbaz. "Changing Land Ownership Patterns and Agricultural Activities in the Context of Urban Expansion in Faisalabad, Pakistan." Pakistan Journal of Life & Social Sciences 14, no. 3 (2016).

47 Al-Rashid, Muhammad Ahmad, Muhammad Nadeem, Adel Shaheen Aldosary, Yong Adilah Shamsul Harumain, and Hafiz Syed Hamid Arshad. "An integrated approach to analysing the urban growth patterns: The case of Sialkot, Punjab, Pakistan." International Review for Spatial Planning and Sustainable Development 9, no. 4 (2021): 116-138.

48 Joshi, Pramod K. "Diversification of agriculture in more competitive environment." Agricultural Diversification and International Competitiveness. Tokyo: Asian Productivity Organization (2004).

The first ‘I’ refers to the policy environment that is favorable to those commodities which augment income and generate employment without degrading resources. [49].The second ‘I’ concerns technologies. Without economically viable, socially acceptable, and environment-friendly technologies for the crops to be used for diversification, the prospects of diversification would be bleak. [50]The third ‘I’ refers to the availability of inputs required for cultivation and/or production of diversified crops or enterprises. Non-availability of inputs at appropriate time would hinder the prospects of diversification. The fourth ‘I’ involves the development of appropriate institutions for new crops or new enterprises. For example, a strong seed sector, credit and insurance institutions, etc. must exist. If the diversification of enterprises calls for collective action, appropriate institutions are needed to support cooperatives[51]. The fifth and last ‘I’ refers to the presence of required infrastructure. For example, marketing, processing and transportation facilities are important elements in case of vertical diversification[52]. A well-knitted strategy encompassing the 5-Is would go a long way in enlarging the scope of agricultural diversification.[53]

Conversion of agriculture land into non-agriculture or urban land is more intense in Punjab compared to other provinces of the country. From the pro ruralists’ point of view, land conversion has some disadvantages which include loss of agriculture output, loss of prime agriculture land, socio-economic issues related to uncontrolled urbanization etc. Ultimately,

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49 Joshi, Pramod K. "Diversification of agriculture in more competitive environment." Agricultural Diversification and International Competitiveness. Tokyo: Asian Productivity Organization (2004).

50 Pingali, Prabhu. "Agricultural diversification in Asia: opportunities and constraints." Copyright International Rice Research Institute 2005 (2005): 420.

51 Pingali, Prabhu L., and Mark W. Rosegrant. "20 Intensive Food Systems in Asia: Can the Degradation Problems be Reversed?." TRADEOFFS OR SYNERGIES? AGRICULTURAL INTENSIFICATION, ECONOMIC DEVELOPMENT (2001): 383.

52 Kader, Adel A. "Increasing food availability by reducing postharvest losses of fresh produce." In V International Postharvest Symposium 682, pp. 2169-2176. 2004.

53 Haque, Tajamul. "Small farm diversification: problems and prospects." (1996).

the direct impact is on the agricultural production, food security and on the lives of the people[54]. So, pro-ruralists believe that agricultural land should be protected with utmost planned efforts to maintain agricultural outputs. Pro-ruralists, conclude that agricultural land should be reserved to maintain food production. On the other-hand, the pro-urbanites argue that land conversion is a logical outcome of urban growth. The decrease of agricultural production, they suggest, can be resolved by intensification and technological development. Hence, land conversion is not thought as a threat in their view. In their view, the conversion of land is an unavoidable phenomenon due to increasing population growth, economic development etc. However, they emphasized more on the controlled growth of urbanization to ward-off the negative impacts of urbanization and to protect the agricultural outputs[55]. Lichtenberg emphasized that the solution lies in trying to conserve agricultural land to be converted for other purposes as done by China, USA, Japan which deliberately made efforts to conserve agricultural land. [56]

Han, Sun Sheng He, and Chun Zing[57] observed that the real estate industry normally operates in the outskirts of major cities and they are the primary reason for loss of agricultural lands. The biggest predicament with real estate industry is that not only the productive agriculture land is lost but for many years to come majority of such lands remains unoccupied as they are in the peripheries of the main urban centers and devoid of basic amenities of life necessary for inhabitation. Therefore, a large chunk of land remains empty for a long period of time without contributing any

54 Malik, Rabia, and Maisam Ali. "The Impact of Urbanization on Agriculture Sector: A Case Study of Peshawar, Pakistan." Journal of Resources Development and Management 8 (2015).

55 Tan, Rong and Beckmann, Volker and van den Berg, Leo and Qu, Futian. "Governing farmland conversion: Comparing China with the Netherlands and Germany." Land use policy (Elsevier) 26, no. 4 (2009): 961-974.

56 Ho, Samuel PS Lin, and George CS. "Non-agricultural land use in post-reform China." The China Quarterly (Cambridge University Press) 179 (2004): 758-781.

57 Han, Sun Sheng He, and Chun Zing. "Diminishing farmland and urban development in China: 1993--1996." GeoJournal (Springer) 49, no. 3 (1999): 257-267.

production in real terms. This industrialization caused a lot of conversion of agricultural land into urban cluster. The same phenomenon can be observed around the major cities in Asia which have experienced major economic growth. Such mushroom growth requires infrastructural support such as road network, sanitation and drainage system which results in even more loss of agricultural land. China has faced similar pattern in the last three decades.

Lutz, Scherbov Warren, and Sergei [58] present their views and claim that the world population would grow upto 10 to 14 billion by the year 2100 AD. The projection for the year 2050 is around 8.8 billion population. Gerlagh, Keyzer Reyer, and Michiel A [59]postulate that Annual Global consumption is expected to rise at a pace of 3 percent over the next many years. Hence, in the long run with increased population and consumption demand, the need for agriculture production and ultimately the availability of arable land would be a necessity that would require protection from urbanization and other conversions. Harris, M Kennedy Jonathan, and Scott [60] has cautioned that in the long run, growth rates in production from agriculture will slow down. This indicates the rising importance to conserve the agricultural land.

58 Lutz, Scherbov Warren, and Sergei. "The end of world population growth." n.d.

59 Gerlagh, Keyzer Reyer, and Michiel A. "Sustainability and the intergenerational distribution of natural resource entitlements." Journal of Public Economics (Elsevier) 79, no. 2 (2001): 315-341.

60 Harris, M Kennedy Jonathan, and Scott. "Carrying capacity in agriculture: global and regional issues." Ecological Economics (Elsevier) 29, no. 3 (1999): 443-461.

5. SIGNIFICANCE OF THE FINDINGS

Availability of land-use change statistics aids in the decision-making process for environmental planning and management (Prenzel 2004; Fan, Weng, and Wang 2007)[61].

Land cover conversion modifies surface-albedo, which in turn increases energy exchanges between atmosphere and surface thus introducing an impact on local climate (Sagan, Toon, and Pollack 1979)[62].

Metropolises with diverse physical surfaces than the surrounding rural areas show impact on their microclimate[63]. The diffusion of urban development results in higher emissions of global warming gases[64], especially carbon dioxide, because urban sprawl results in higher energy use in transportation and the heating and cooling of spacious homes on the urban periphery.[65]

The study thus explores as to how a paradigm shift in investments in urban management infrastructure and services across clusters of cities in Punjab could materialize with a focus pivoted around making cities more efficient also conserving arable lands. Simultaneously, equally important is the urge for prevention of biodiversity losses of natural habitat including forest cover. alarming are the ancillary adverse implications relatable to

61 Björn Prenzel, Remote sensing-based quantification of land-cover and land-use change for planning, Progress in Planning, Volume 61, Issue 4, 2004, Pages 281-299, ISSN 0305-9006, https://doi.org/10.1016/S0305-9006(03)00065-5.
(https://www.sciencedirect.com/science/article/pii/S0305900603000655). Fan, Fenglei, Qihao Weng, and Yunpeng Wang. 2007. "Land Use and Land Cover Change in Guangzhou, China, from 1998 to 2003, Based on Landsat TM /ETM+ Imagery" Sensors 7, no. 7: 1323-1342. https://doi.org/10.3390/s7071323 https://www.mdpi.com/1424-8220/7/7/1323#cite

62 Sagan, C., O. B. Toon, and J. B. Pollack. 1979. “Anthropogenic Albedo Changes and the Earth’s Climate.” Science (80-) 206: 1363–1368. . Crossref. PubMed

63 Chen, Haoyuan, Qinli Deng, Zeng Zhou, Zhigang Ren, and Xiaofang Shan. "Influence of land cover change on spatio-temporal distribution of urban heat island—a case in Wuhan main urban area." Sustainable Cities and Society 79 (2022): 103715.

64 Mills, Gerald. "Urban climatology: History, status and prospects." Urban climate 10 (2014): 479-489.

65 Mahtta, Richa, Anjali Mahendra, and Karen C. Seto. "Building up or spreading out? Typologies of urban growth across 478 cities of 1 million+." Environmental Research Letters 14, no. 12 (2019): 124077.

watershed management and carbon sequestration making it all the more urgent to turn eco system services more sustainable without compromising agricultural productivity, by recourse to preservation of agricultural and forestry zoning.

The World Planners Congress in Vancouver in 2006 suggested that urban planners should address urban sustainability putting human livelihoods in the core of urban planning. Because of the increasing trend of urbanization along with potential environmental consequences, urban growth modeling should have a protagonist role in urban planning to provide appropriate decisions for sustainable urban development. Urbanization involves an increase in residential population and extension of non-farm activities.

The study dwells upon as to whether the government entities have been able to add value to the prevailing policy regime also chalking out rectification and remediation of the administrative drawbacks and governance gaps, notified spatial plans, master plans, zoning, land use plans, including classification and reclassification of land, urban design and urban renewal.

6. RESEARCH METHODOLOGY

A very significant decision in research design process is the choice to be made regarding research approach since it determines how relevant information for a study will be obtained; however, the research design process involves many interrelated decisions.[66] This study employed blended methods opting for well-structured questionnaires and semi-structured interviews with key stakeholders. This research pursued both qualitative and quantitative methods and combination of primary and secondary sources. The qualitative data supports the quantitative data analysis and results. A survey research design was employed with three types of interviewing duly triangulated;[67]

I. Close-ended questions in a structured interview;
II. Open-ended questions embedded in the interview;
III. Follow-up conversational interviews employing open-ended questions.

This combined-methods approach enabled meaningful assessment in relation to elaboration of answers, interpretation and context, discovery in the field, enriching it with divergence.[68] Focus group discussion being "cost effective" turns out to be a "promising alternative" offering a divergent paradigm or world view.[69] The result obtained is triangulated

66 Tesfaye Boru, "Chapter Five Research Design And Methodology 5.1", Introduction Citation: Lelissa TB (2018); Research Methodology; University of South Africa, PHD Thesis. 10.13140/RG.2.2.21467.62242,

67 Ingrid Connidis, "Integrating qualitative and quantitative methods in survey research on aging: An assessment", Qual Sociol, 334–352 (1983), https://link.springer.com/article/10.1007/BF00986684.

68 ibid.

69 Evan G. Guba and Yvonna S. Lincoln, "Competing paradigms in qualitative research", Thousand Oaks, CA: Sage Publications Inc., 1994, https://psycnet.apa.org/record/1994-98625-005.

since the researcher utilized the qualitative and quantitative data types in the data analysis.[70]

The research methodology compatible with home grown recipe of reform for poverty ridden countries of third world have relevant research model for replication as also elaborated by Roleun, who is of the view that "Value of mixed methods research is now widely established. Experiences from research in developed and developing country contexts reveal how efficaciously mixed methods approaches can contribute to make research more credible, usable and responsive to complexity".[71]

Different streams of data are available to proceed with research. But available data does not provide complete picture of the problem, therefore, primary data by interviewing relevant persons has been adopted in continuation of secondary data. Descriptive approach is used in analysis of research question and developing the theme of research.

In addition, thereto, the techniques involved to monitor Urban Sprawl, are change detection from Remote Sensing data, besides applying GIS tools in order to study spatial extensions of land cover. This research also displays how satellite imagery can be taken into account to manipulate and analyze digital techniques in popular image processing software program. As technology evolved over the years, Remote Sensing (RS) and GIS techniques have offered multiple options to deal with spatial features for monitoring, assessment also mapping out sprawl pattern. Urban planners and geographer have drawn fruitful information out of it for the measurement of future sprawl direction as well as magnitude precisely rather than using typical approaches.

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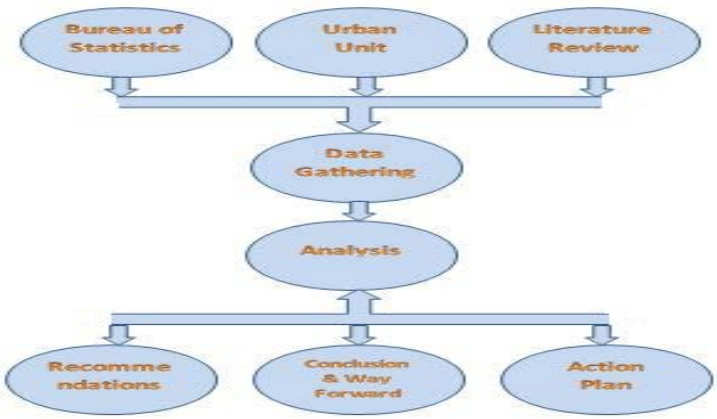
70 JW. Creswell and V.L. Piano Clark, "Designing and Conducting Mixed Methods Research," 2nd edn. Sage, Los Angeles, 2011, https://books.google.com.pk/books?hl=en&lr=&id=6tYNo0UpEqkC&oi=fnd&pg=PR1&ots=lZPav3JiT_&sig=Mg-qB_r5GKpANf2FVwyuClwrqjc&redir_esc=y#v=onepage&q&f=false. (accessed on 13 December, 2020).

71 Keetie Roleun,"Mixed Methods Research in Poverty and Vulnerability", https://www.kobo.com/gr/en/ebooks. (accessed on 08 December, 2020).

Technique to measure urban spatial growth includes time-series Satellite Remote Sensing (SRS) data, was found to be a best practice. Initial process involved to scrutinize the quality of data, received through multiple preselected standards likely to eradicate geometric errors. To extract maximum land cover/land use classes, image enhancement techniques were applied for better visual interpretation. After making all these preliminary measures, imagery was set under supervised classification process. Ultimate purpose of the classification of the imagery is to assign each pixel to its respective category as on ground representing theme in final output.

These classes/themes were later on assigned respective categories based on visual interpretation made before applying classifier algorithm to dataset. To measure the difference in spatial distribution of urban area, post-classification and cross-tabulation techniques were implemented.

To detect spatial changes, post classification is an authentic technique which demands comparison of two or more independent classified image to draw out results. Hence this technique lessens the possible errors produced internally and externally. “Cross-tabulation analysis was carried out to study the spatial distribution and area of urban sprawl on different soil types. This analysis had clearly shown the trends and future prospects for predicting sprawl locations and directions.



1) Use of GIS imagery /data obtained from urban unit regarding urbanization sprawl, agricultural land, peri-urban sprawl from 1990 to 2022.
2) Agriculture produce of major crops of the area has been obtained from 2015 to 2020 obtained from Bureau of Statistics, P&D Board, Government of the Punjab.
3) Land utilization status of cultivated and uncultivated area has been obtained from Bureau of Statistics.
4) Average yield based on last three years i.e from 2018-2020 of major crops grown in the region is obtained by analyzing the figures printed in Punjab Development Statistics 2020, Government of the Punjab.

The study findings can help the local authorities to implement urban planning regulations for public awareness and policy makers for a sustainable planning and management in forthcoming years. The LULC change studies provide useful information for a better understanding of previous practices, current LULC patterns, and future LULC trajectory.

The built-up area growth within the circumference of total land area during past 22 years is indicative of the fact that LULC have noticeable influences on LST with a negative correlation between vegetation cover and LST.

7. SCOPE OF THE STUDY

Key aims behind this study are to monitor urban sprawl over last few decades and to gauge a nexus between influx of rapid urbanization and the consequential environmental degradation converging into one monstrous menace eating up arable land, causing ALA and spurring LULC. Moreover, the study would further point out its peripheral influences, which have tangibly crept into natural ecosystem. This study would further explore;

I. To find relation among the urban growth, its climate and environmentally degrading factors.

II. To propose solutions to eliminate the possibilities of irregular city expansion and environmental hazards elements.

III. To undertake a drill down of several associated factors like construction activities, sewage system, deforestation, water supply and industrial activities. These factors are linked with urban expansion and the environment as new housing colonies, residential societies and industries are constructed. Reduction in the vegetated/open area associated to outer extent of the city gives rise to deforestation and conversion of cultivated area into commercial area.

IV. To sort out darker side of urban expansion like slum dwellings and squatter settlements.

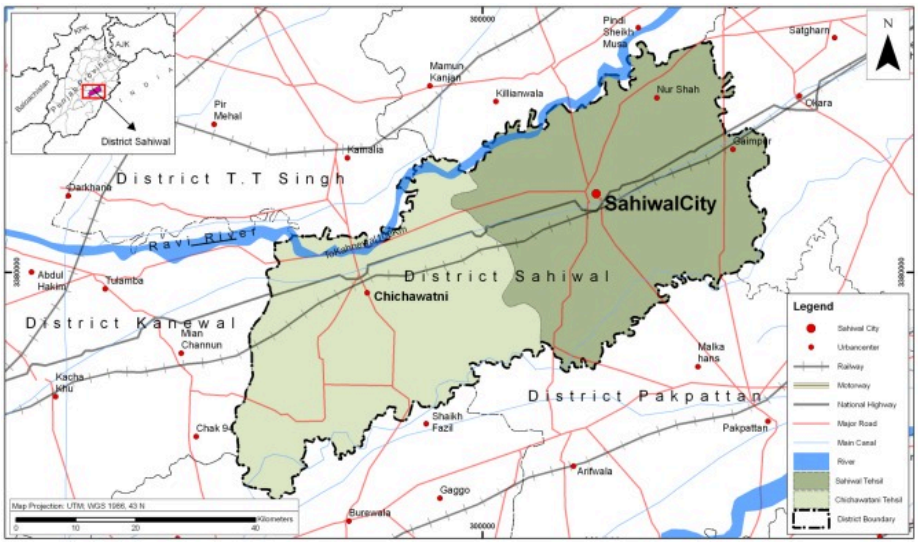
V. To set forth and prescribe a number of policy making interventions and suggestions with a pragmatic way forward.

8. LIMITATIONS ACKNOWLEDGED

1. Major crop production for Tehsil/district under study has been obtained from both irrigated and un-irrigated lands. However, differentiation of production data between irrigated and un-irrigated is not worked out.
2. Satellite imageries before 1990 and in most of cases data prior to 1990 was not available. Hence, the study spans from 1990 to 2022.

9. Case Study 1: Urban Growth Across Sahiwal

Sahiwal city as a District and Divisional Headquarter is situated at a distance of about 18 miles from the left bank of the river Ravi, 187 KM west of Lahore and 200 KM east of Multan. The lower Bari Doab Canal separates the town into two parts. Its approximate height above sea level is 500 feet. The map of district Sahiwal along with its surrounding is depicted hereunder:



Sahiwal's topography is that of a flat semi-arid plain. Its fertility is by virtue of an extensive canal irrigation. The Lower Bari Doab canal is the main source of irrigation in the area and it is fed by a link from the Chanab River. From the topographical point of view, the semi-arid plain is remarkably homogeneous. Generally, the natural slope is North-East to South-West. The average natural gradient is about 1/2474. On the whole, it is flat area.

The commercial and trade centers of Sahiwal are primarily concentrated around the old city, surrounded by High Street, Railway

Road, Hall Road, Masood Shaheed Road, Depalpur Bazar, Sori Galli, Sua Bazar and further extended up to Jinnah Chowk. The main industrial units are located on Sahiwal-Pakpattan Road, Arifwala Road and across the Lahore-Multan Road, with the exception of a few, scattered in the city as well. The Main Industrial Area constitutes the industries located along Sahiwal-Pakppatan and Sahiwal Arifwala Road. The major industries in this area include Biscuit, Confectionary, Sugar Mill, Cotton Ginning, Dairy Products, Drug and Pharmaceuticals, Flour Mills, Food Industries, Textile Weaving, Tobbaco, Woolen Textile Spinning/Weaving, Seed Producing Units, and Pesticides Packing and Distribution Units.

The Mixed Industrial Area is bounded by the Lower Bari Doab Canal (L.B.D.C), Railway Line and the L.M.Q. road. The area contains the industrial units like Oil Processing Units, Animals Skin Processing Units, Tanneries, Iron/Steel Remolding Units and Carpets Weaving Centers. The Residential Areas include old city along Jinnah Road and Railway Road and planned colonies along Farid Road and Pakpattan Road and Sahiwal by pass. It is further divided into old city and Planned Colonies. The Old City constitutes mainly the areas in the heart of the Sahiwal city from Jinnah Road to Noor Shah Road, Ghalla Mandi, Vegetable Market and Railway Road. These settlements are quite haphazard with narrow streets, open drainage and devoid of most of the civic amenities. The zone of planned colonies comprises the area of the Satellite Town, known as “Farid Town”, and Tariq Bin Ziad Colony. The Land Use Character in these colonies is very distinct and different from the rest of the city. The residential density is very low as compared to the old city. Beyond Farid Town, there can also be witnessed a haphazard growth and new slums being created. New settlements are being developed by the private sector in South of Lower Bari Doab Canal, between Pakpattan Road and Lahore –Multan By-pass Road. These are planned colonies having their own water, sewerage and sanitation systems but these systems neither possess any treatment plant nor connected with

any public service system. The sewerage water is simply drained out without any treatment in the fields for the agriculture purposes. Such colonies are also under development along Noor Shah and Faisalabad Road.

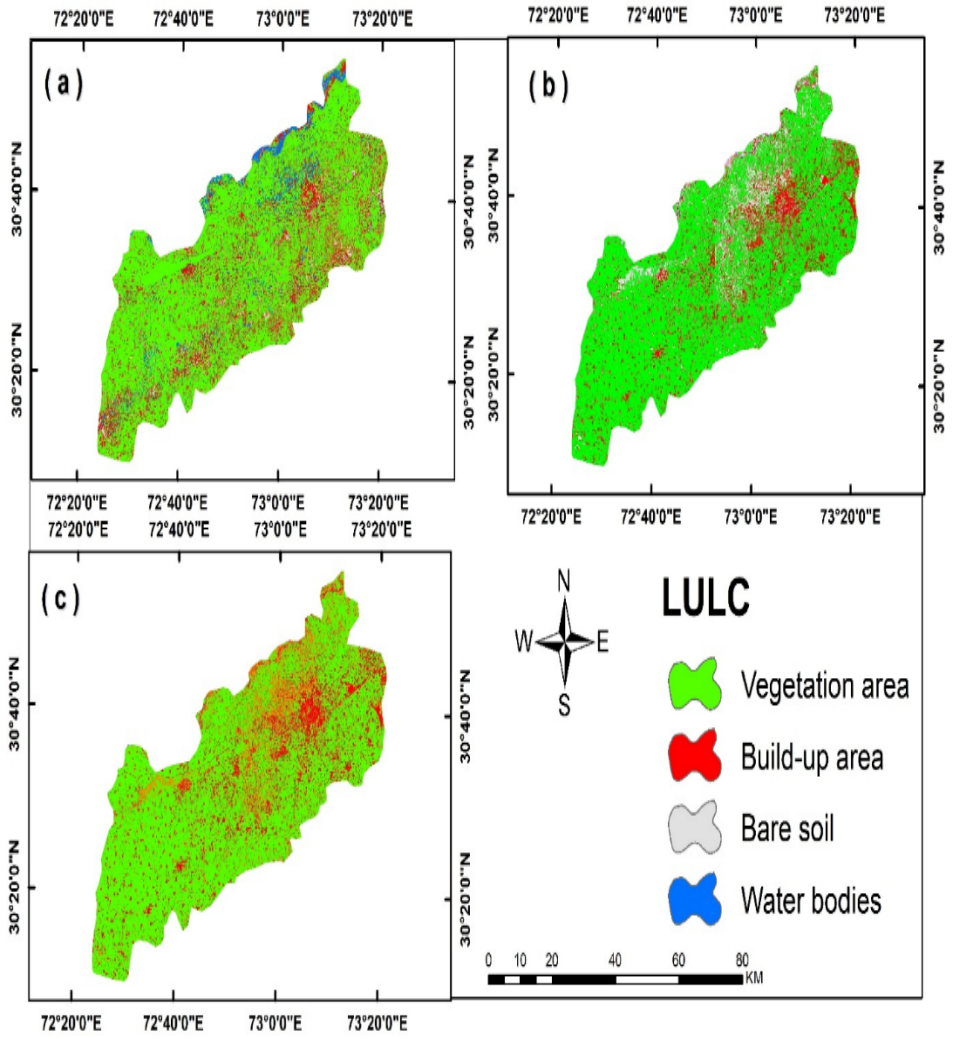
The land of Sahiwal District is used for agriculture purpose. The main crops include Wheat, Maize, Rice, Cotton and Sugar Cane. In addition, all types of vegetable are grown with domination of Potato grown areas exceeding all other vegetable products. The Orchards are common throughout the area and cover about 10% of the agriculture land. The Rural Settlement/Villages/Dwellings include those areas that are populated in between the agriculture land around the city and the suburbs. These areas are generally having a low profile of facilities and civic amenities. But at the same time they represent a better hygienic atmosphere because of open spaces and lack of traffic congestion

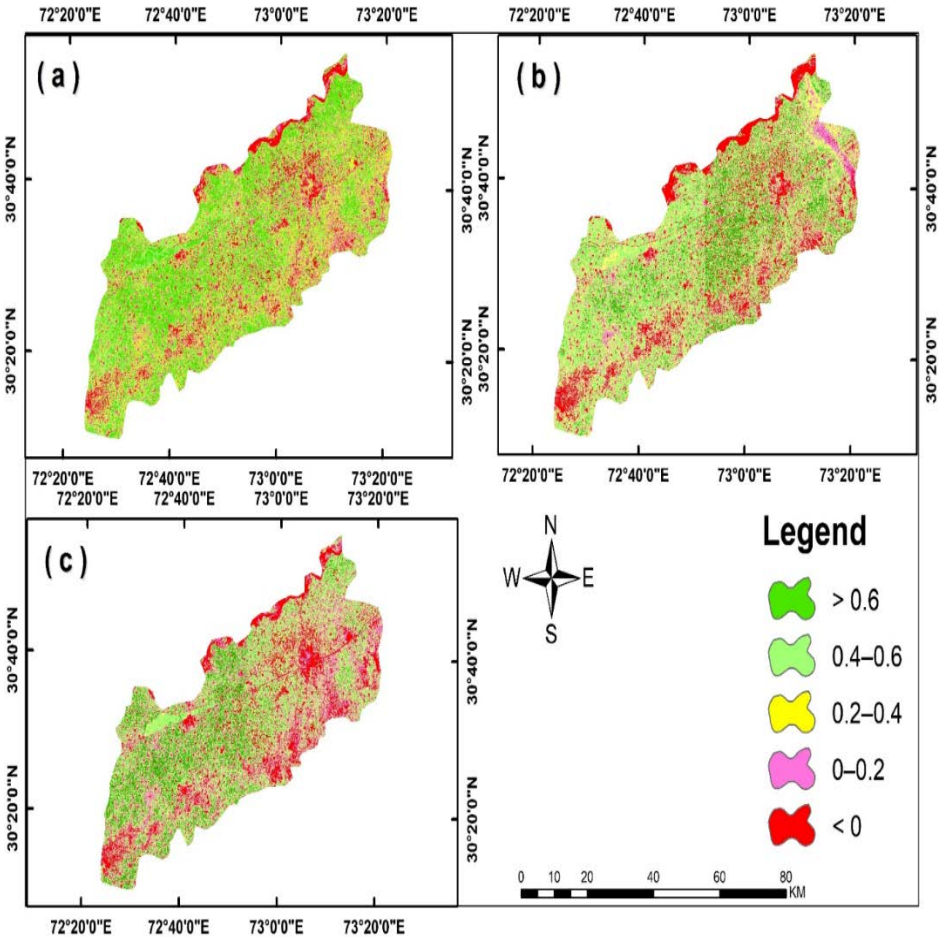
As the city has grown, prime agricultural lands surrounding it in the periphery also gradually transformed into non-agricultural uses. Urbanization and population pressure have both been contributory to appreciation in land values. The satellite images of the GIS indicate that the urban sprawl of the district has increased over the years signifying that Sahiwal city is growing farther than the available utilities and civic amenities.

According to a secondary source of time series data selecting the Sahiwal District as a study area for using Multispectral Remote Sensing Data", the build-up area stood increased from 7203.76 ha (2.25%) to 31,081.3 ha (9.70%), while the vegetation area decreased by 14,427.1 ha (4.5%) from 1981 to 2021[72]. The study obtained response to a questionnaire from farming community. Almost 78% of farmers stated

72 Hussain, Sajjad, Linlin Lu, Muhammad Mubeen, Wajid Nasim, Shankar Karuppannan, Shah Fahad, Aqil Tariq, B. G. Mousa, Faisal Mumtaz, and Muhammad Aslam. 2022. "Spatiotemporal Variation in Land Use Land Cover in the Response to Local Climate Change Using Multispectral Remote Sensing Data" Land 11, no. 5: 595. https://doi.org/10.3390/land11050595

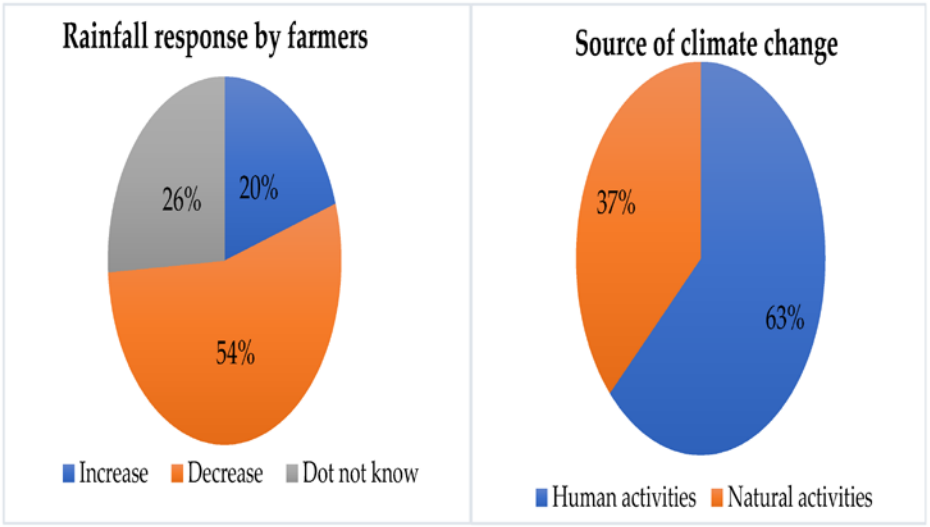
that the climate had been changing during the last few years, 72% of farmers stated that climate change had affected agriculture, and 53% of farmers thought that rainfall intensity had also decreased. The images show built up area expanding so as to eclipse vegetation area as shown here under:





Source: Using Multispectral Remote Sensing Data : https://doi.org/10.3390/land11050595

Both the Land Surface Temperature and precipitation tendencies have contributed to the stress on agricultural productivity also being impacted by serious challenges such as deterioration of ground water quality for the water extracted. Moreover, water use efficiency for surface water irrigation is also adversely impacted by virtue of LST and precipitation variation.



Spectral analysis of Sentinel-2 images integrated by Sentinel-1 time series [73] implies that land use also involves the management and modification of natural environment or wilderness into built up environment.

Placing reliance upon another publication of European Academic Research Vol. II, Issue 9, in terms of research article titled as Land Use in Sahiwal District, Pakistan authored by Muhammad Irshad Hussan, about 35% of the total built up area is used for residential purpose. The second largest use includes the transportation system that occupies about 17% of the total built up area. The other uses include industry 5%, open spaces 10%, commerce and trade 3% and health 2%. Other minor uses are canals, distributaries and Government Buildings which occupy 10%, 8% and 10% of the built up area respectively.

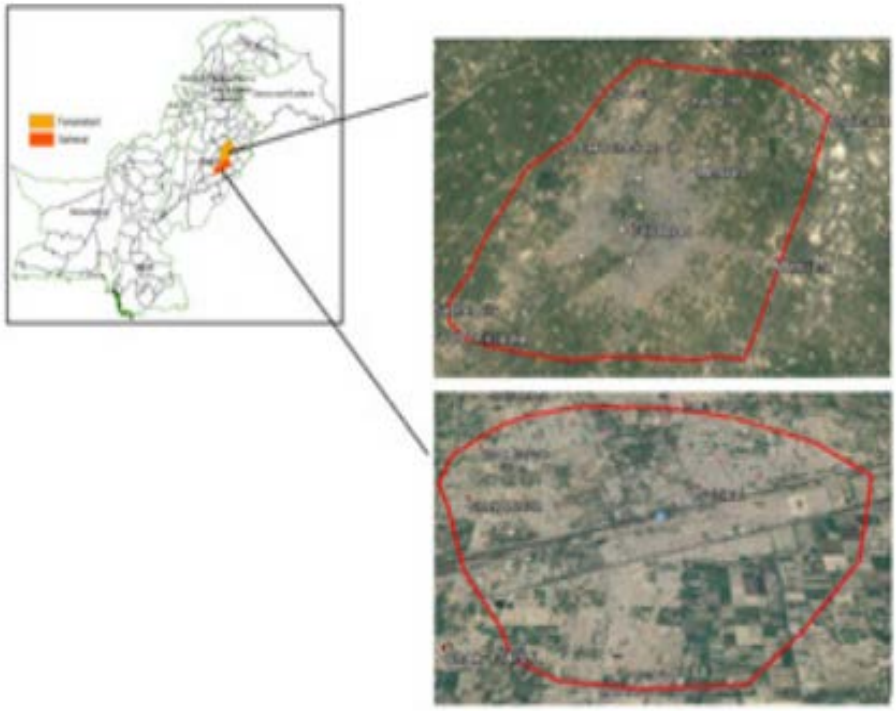
73 Liu, Y.; Gong, W.; Hu, X.; Gong, J. Forest type identification with random forest using Sentinel-1A, Sentinel-2A, multi-temporal Landsat-8 and DEM data. Remote Sens. 2018, 10, 946. [Google Scholar] [CrossRef] Waser, L.T.; Rüetschi, M.; Psomas, A.; Small, D.; Rehush, N. Mapping dominant leaf type based on combined Sentinel-1/-2 data—Challenges for mountainous countries. ISPRS J. Photogramm. Remote Sens. 2021, 180, 209–226. [Google Scholar] [CrossRef]

Increased food per unit area is an indispensable factor to tackle food security. Therefore, a research survey was carried out to evaluate the salinity and fertility status of district Sahiwal to explore how to gain maximum output from different crops of this area. According to another secondary source, a total of 14490 soil samples were collected from two tehsils of Sahiwal (Tehsil Chichawatni and Tehsil Sahiwal) and analyzed for physico-chemical properties in Soil and Water Testing Laboratory, Sahiwal. About 81% soils had EC values (≤ 4.0 dSm-1) which were non-saline in nature and 74% of total soil samples exhibited normal pH value < 8.5. Organic matter status of 90% soil samples was deficient < 1%. The available phosphorus in 45% samples were poor (i.e., ≤7.0 mg kg-1), Potassium contents of most (70%) of the soils were satisfactory having 80-180 mg K kg-1 soil[74]. The results of this study indicated that the most of soils of district Sahiwal are good for agricultural crops production but with low fertility status[75].

Through the 2nd study- the soil of different sites in the surroundings of Harrappa at Sahiwal district was collected to investigate it for pH, electrical conductivity, organic matter, micronutrients and macronutrients. The soil turned out to be saline sodic. pH was found to be in the range of 7.62-8.27 which is slightly neutral to basic. Electrical conductivity was in the range 8.9-12.0 mS/ cm while percentage of organic matter was 0.276-1.035. The elements like Na, K, Ca, Mg, Zn, Ni, Cu, Mn, Mo, Se, B, P, N, S, Cl were found in the range.

74 Jamil, Muhammad, Naseem Akhtar, Muhammad Mazhar Iqbal, Muhammad Umar Hayat Khan, Nafeesa Muslim, and Muhammad Akram Qazi. "Indexing of physico-chemical variables and fertility status of district Sahiwal soils, Punjab, Pakistan." Soil & Environment 40, no. 1 (2021).

75 Ibid.



In terms of comparative analysis through another secondary source, a total of six peri-urban communities/ villages were selected purposively at a distance of 12 km from city center of Sahiwal. The total number of farming household in the selected communities constituted a sample of 416 farming households. 20 % of total farming households from the villages at rural-urban interface was selected via a well-designed interview schedule containing close ended and open ended questions. comprising purposively selected farmers who sold their agricultural land to different urban developers[76]. The aim of the focus group discussion was to get information about the push and pull dynamics of agricultural land

76 Farah, Naveed, Izhar Ahmad Khan, Asif Ali Abro, Jehanzeb Masood Cheema, and Muhammad Luqman. "The nexus of land use changes and livelihood transformation of farmers at rural-urban interface of Pakistan." Sarhad Journal of Agriculture 38, no. 1 (2022): 46-59.

conversion to test the relationship/association between predictor and response variables[77]. It was ascertained that the land was abandoned to various uses irrespective of its suitability for the particular use. As a consequence, the present day city is a mixture of various quite often incompatible uses, except for the new planned colony. The Land Use of the urban area as a whole can be described as developed out of sprawl without any preconceived plan. Urban areas may be cities, towns or conurbations[78], but the term is not commonly extended to rural settlements such as villages[79].

In comparative terms Sahiwal is not having as good a profile as that of other intermediate cities of the Province.

City	Economic				Technical				Financial			Management	
	Connectivity	Population 2010	Population 2020	Economic Activity	Service Delivery (Coverage)				Collection Against Demand	Meets O&M Cost	Investment in Services	TMA Management Filled	TMA Staff Filled
					Transport	Sewerage	Waste	Water					
Chiniot	Good	304,917	357,722	Fair	Yes	50%	Poor	75%	Good	Yes	Poor	80%	88%
Kasur	Good	404,550	495,082	Good	Yes	1%	Fair	70%	Fair	No	Poor	93%	70%
Sheikhupura	Good	503,817	623,852	Good	No	30%	Poor	40%	-	-	Poor	83%	100%
Okara	Fair	447,779	519,319	Fair	No	55%	Fair	70%	Poor	-	Poor	92%	82%
Sahiwal	Fair	406,681	482,775	Good	Yes	90%	Poor	90%	Good	No	Poor	95%	87%
Rahim Yar Khan	Fair	468,431	581,173	Good	Yes	85%	Poor	40%	Good	Yes	Fair	85%	76%
Bahawalpur	Fair	644,872	822,276	Good	Yes	82%	Poor	3%	Good	No	Fair	48%	90%
Sargodha	Good	692,250	862,227	Good	Yes	85%	Poor	70%	-	-	-	73%	94%
Gujrat	Good	421,211	500,515	Fair	Yes	50%	Poor	70%	-	-	-	96%	96%
Dera Ghazi Khan	Fair	421,308	539,310	Fair	No	60%	Poor	80%	Poor	No	-	54%	92%
Jhang	Fair	466,121	551,707	Fair	Yes	80%	Poor	25%	Poor	No	Poor	68%	52%
Sialkot	Good	809,588	1,007,390	Good	Yes	20%	Poor	35%	Good	No	Good	83%	92%

Source: GHK analysis based on data collected for developing city profiles

Good
Fair
Poor

77 Farah, Naveed, Izhar Ahmad Khan, Asif Ali Abro, Jehanzeb Masood Cheema, and Muhammad Luqman. "The nexus of land use changes and livelihood transformation of farmers at rural-urban interface of Pakistan." Sarhad Journal of Agriculture 38, no. 1 (2022): 46-59.

78 Batty, Michael. "Cities in a completely urbanised world." Environment and Planning B: Planning and Design 42, no. 3 (2015): 381-383.

79 Clout, Hugh D. "Rural space." In Regional Development in Western Europe, pp. 81-99. Routledge, 2017.

In August 1972, the Punjab Housing and Physical Planning Department started a land use study of Sahiwal city and completed in September 1972. No other overall urban plan can be found in the available documentation. Lower Bari Doab Canal was constructed in 1913. Later, the Depalpur and Pakpattan Canals brought almost the entire district under the command of Irrigation system. Sahiwal in the decade of 1911-1921, and 1921 -1931, attracted the highest ever percentage of people. Population growth rate during these decades was 79.7% and 79.3% respectively. During pre-1900, period the area of the Town was 307 acres only. The Central Jail and the Municipality were constructed during this period. Later on certain areas like Civil Line, Canal Colony, Area around Fateh Sher Road, gymkhana club and certain parts of the west of the oval were constructed and its boundaries extended almost 3 times and about 979 acres under its occupation. But after the independence, Farid Town, New Abadi, Jahaz Ground, District Head Quarter Hospital and the area between railway line and G.T Road were added, because the population grew very rapidly due to influx of refugees and industrialization and this was the time when most of the haphazard development has taken place. The total areas increased from 979 to 1971 acres. During the post 1960 period, the Town started eating up indiscriminately almost all the vacant parcels and the area increased to 2,464 acres.

On the average, the total rainfall during the year is about 11.20". Generally, the rainy season lasts from July to September. Sahiwal is situated in South-West Punjab and is influenced by monsoon wind through the year. In winter season, its direction is northeast and in Summer South-West. But in winter this direction is usually disturbed by Westerlies Disturbances. Due to this, temperature becomes low and winds begin to move towards low pressure. This situation prevails in autumn.

Groundwater is the sole source of potable water exploited in Sahiwal. The water table averages about 40-50 feet below ground level

and upper levels produce limited quantities on mineralized water. At the depth of 450-500 feet greater quantities of good quality groundwater are available. The water table in recent years has been falling at a rate of one foot per year due to abstraction and decreased rainfall and department recharge. There are currently six regular sewerage disposal works in the city. These comprise, a prescreening chamber and collection tanks into which the trunk sewage is discharged and from which sewage is pumped in pressurized pipe work to discharge at ground level into open channels (up to agricultural lands). The only treatment applied is prior to discharge into collection tanks. Municipal waste water is being used for irrigation purposes as demand by the farmers and the remaining waste water is disposed of into river through drain and nallahs with an uptake of excessive trace metals.

The project for commissioning effluent treatment facility has remained confined to acquisition of land i.e.

Capacity = 24.6 MGD
Treatment Technology = Waste Stabilization Ponds (WSP)
Area Requirement = 201 Acres, 03 Kanals & 12 Marlas

Sr.No	Name of Mauza	Locality	No. of Land Owners
1	Muhammad Pura	1099-kanals & 12 Marlas (137- Acres, 03-Kanals & 12-Marlas)	114
2	Chak No. 66/G.D	512 Kanals (64-Acres)	33
	Total	**201 Acres, 03 Kanals & 12 Marlas**	**147**

This additional encumbrance upon vegetation cover is to the entail of the following land use land conversion implications:

Sr. No.	Acquisition	Area
1	Coal Fired Power Plant	1700 Acre
2	Landfill Site Tibbi Litigation despite paying acquisition cost	50 Acre
3	Effluent Treatment Facility	201 Acre
4	Livestock semen Station With dismal cultivation produce	1000 Acre

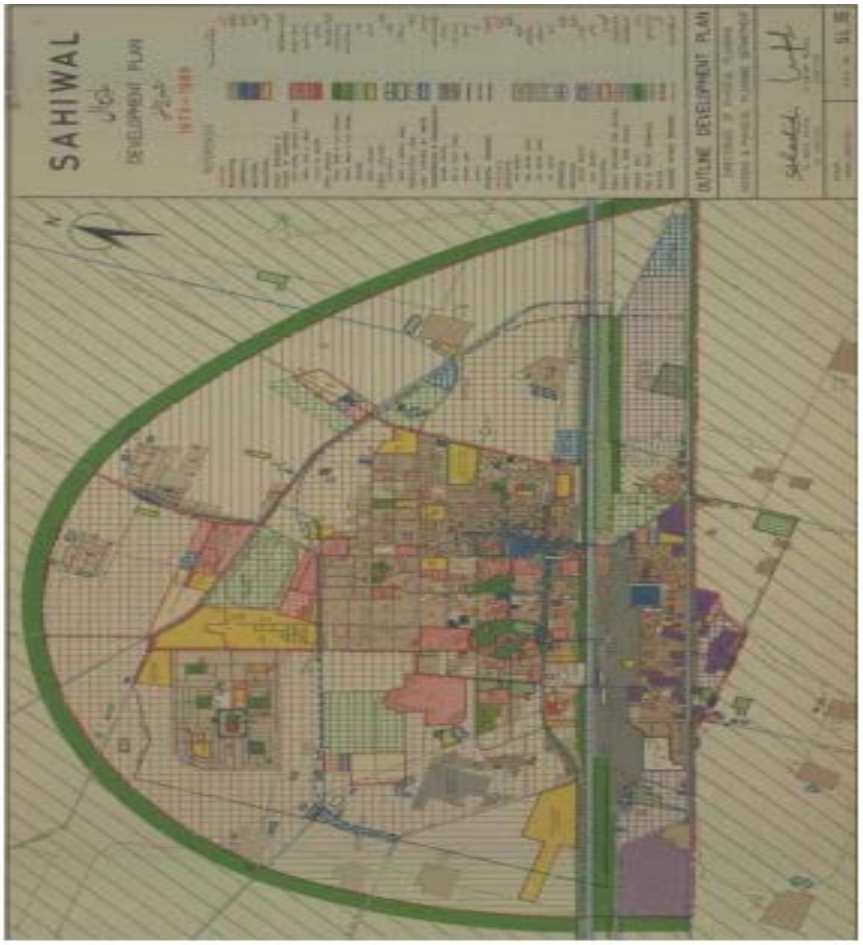
Further loss of vegetation cover is attributable to the encroachment upon forest land in Tehsil Chichawatni where more than 2000 Acre of Forest Land is lost as per report received from respective DFO.

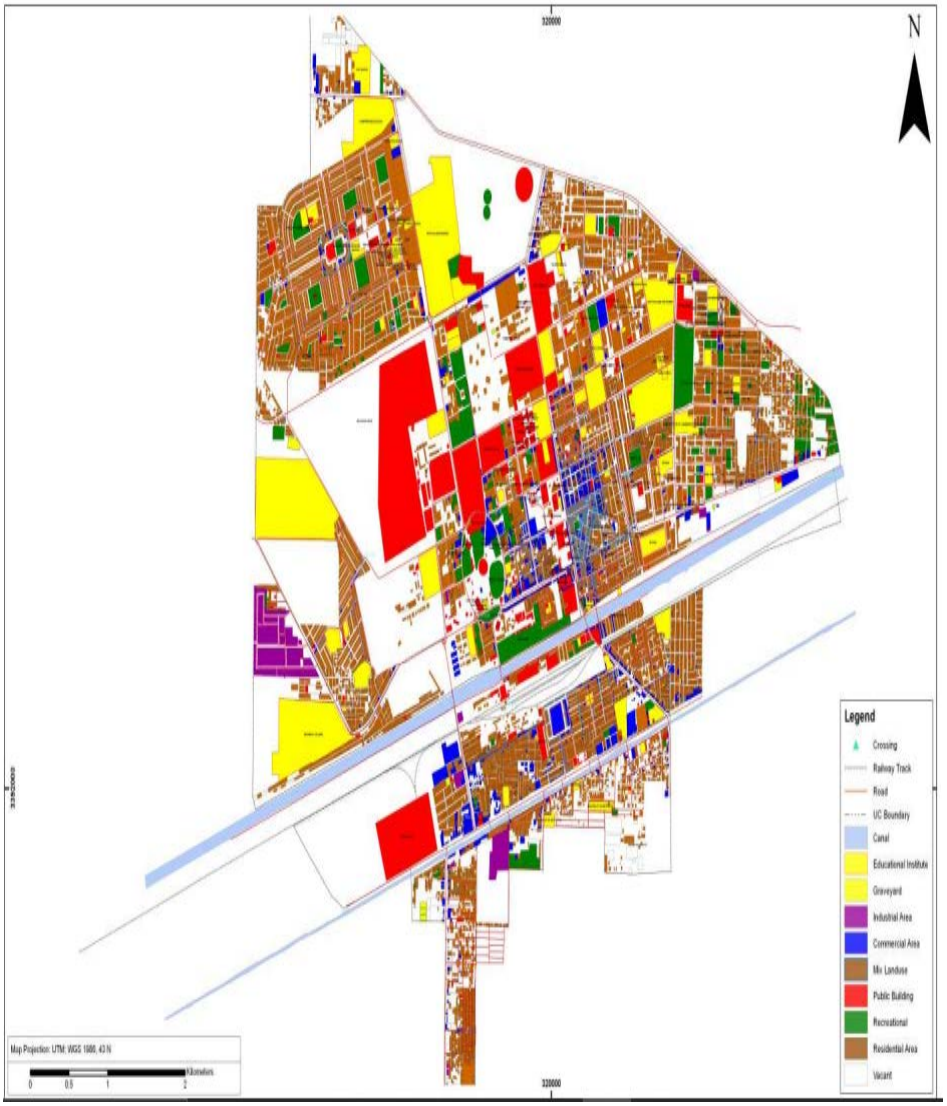
Deputy Commissioners and Assistant Commissioners were not able to respond to the queries for sharing master plan of the District as well as deliberations of the Spatial and Planning Committee. The value addition to be contributed by provincial Special Planning Strategy steered from Urban Unit of Punjab under the ambit of Foreign Aided Project is also negligible.

Sahiwal was originally designed as a planned colony town, covering only 307 acres. However, following independence, Sahiwal emerged as a major administrative and commercial town without a comprehensive zonal and spatial plan. As a consequence, mixed land use is prevalent. In August, 1972, Punjab Housing and physical planning department started land use study of Sahiwal city and completed in September 1972. The Outline Development plan of the City shows that out of the total area surveyed, the largest portion is of the undeveloped area. It accounts for 41.70% of the total area surveyed. It is found in scattered pockets within the built up areas and in open strips between various built up belts which ultimately join the agricultural land around the city.

Since no comprehensive plan was available, land in the town was given to various uses irrespective of its suitability for any particular use.

Except for the new planned colony, there has been intensive mixing up of land use, particularly small scale cotton factories etc. This area is of ribbon type of development along the major bazaars. To sum up, the land use of the city as a whole can be described as developed out of sprawl without any preconceived plan. The result is the prevalence of chaos and unpleasant living conditions.





There are three industrial sites in city area. There is also small industrial estate developed by the Punjab small industrial Corporation. The industrial estate is built on about 52 Acre land which have 188 plots. About 99.5 work has been completed.

Unregulated housing schemes are also not few and far between.

Sr. No.	Name	Type	Area
1	Marsal town 91/9-L	Private Housing Scheme	Information with TMA is not available
2	Nazim town 135-A/9		
3	Barkat town nai wala bangla		
4	Jivan city 87-A/6-R		
5	Shalimar town harapa station		
6	Rehman town 135-9-L		
7	Gulshan habib 135/9-L		
8	Hafiz garden 93/6-R scheme no 3		
9	Makah town 91/9-L by pass		
10	Al haseeb town 91/9-L arif wala road		
11	Al hamad block 86/6-R		
12	Al rehman town check no93/9-L		
13	Apna gar 91/9-L		
14	Sagal block89/6R Muhammad pura		
15	Bismillah block 93/9-L		
16	Millat block 90/9-L		
17	Al zak homes midhali road		
18	Hassan block 82/6-R		
19	Al ghani town check no 93/6-R		
20	Javen city phase27/6-R midhali road		
21	Nazir ahmad hosing scheme arif road		
22	Model town 1/10-L		
23	Shadab town		
24	Canal view hosing scheme		
25	Model city hosing scheeme		
26	Baba farid park arif road		
27	Gulshan nor		
28	Irshad town		
29	Safdar block		
30	Baba farid park		
31	Dobi garden		
32	Shadab colony		
33	Shaju town		
34	Ahmad park		
35	Nooor park		
36	Green town		
37	Garden town		
38	Model town		
39	Movakal colony		
40	Hameed ullah colony		
41	Model city jall road		
42	Muslim bin taseel colony		
43	Gulstan colony		
44	Farid town	Govt. Housing Scheme	
45	Tariq bin zayad colony (low income housing scheme no1		
46	Low income housing scheme no2		
47	Low income housing scheme no3		
48	Three marla hosing scheme		
49	Labour colony		
50	Fathe sheer colony		
51	Bilal colony		
52	Officer colony		

Source: TO P&C TMA Sahiwal Records

There is a dire need of updated master planning or peri-urban structure planning of the city to avoid chocking the system of utility and service provision to the citizens and to fend for the haphazard conversion of the precious fertile land into urbanized buildings. The degradation of eco system is not prevented even by the regularized housing schemes which have compromised civic amenities such as truncated trunk sewerage discharges of untreated effluents into open drains as is the case with the following settlements:

Sr. No.	Name	Type	Area
1	Sharif colony	Recognised	50-14-01
2	People's colony		126-2-7
3	Bhutto nagar		189-19-01
4	Jehaz ground		547-14-03
5	Mohallah farid ganj		41-02-03
6	Imamia colony		32-15-01
7	Fateh sher colony		12-03-02
8	Christain colony ,karbala road		32-07-01
9	Amato colony		50-15-08
10	Christian colony gujjar ahata		16-04-01
11	Christian colony nor shah road		16-08-03
12	Islam nagar		12-17-07
13	Gau shalla ghalla mandi		10-04-08
14	Behind general bus stand		05-13-00
15	Mohallah new farid gunj		13-07-08
16	Inyat elahi colony		112-05-00
17	Dosehra ground		08-19-00
18	Ghallah mandi w		132-06-00
19	Ghallah mandi e		87-14-06
20	Ghallah mandi s		70-10-05
21	Ghallah mandi		31-14-04
22	Dastagir colony amjad park		07-05-04
23	Ahata badian		42-04-01
24	Juneio colony		07-03-00
25	Khilji colony		No information available
26	Oad colony		No information available
27	Wapda colony		No information available
28	Ghausia colony		No information available

Source: TO P&C TMA Sahiwal Records

The roads taking part in the linear development of the city are, Bahawalpur Road, Surajkund Road, Vehari Road, and Khanewal Road. A total increase of 23.05 Sq. Km area has been witnessed along the edges of these roads in terms of the individual measurements of the increment of built up along these roads. The spread of cooperative housing societies has also shown mixed results in terms of half-baked ventures e.g.

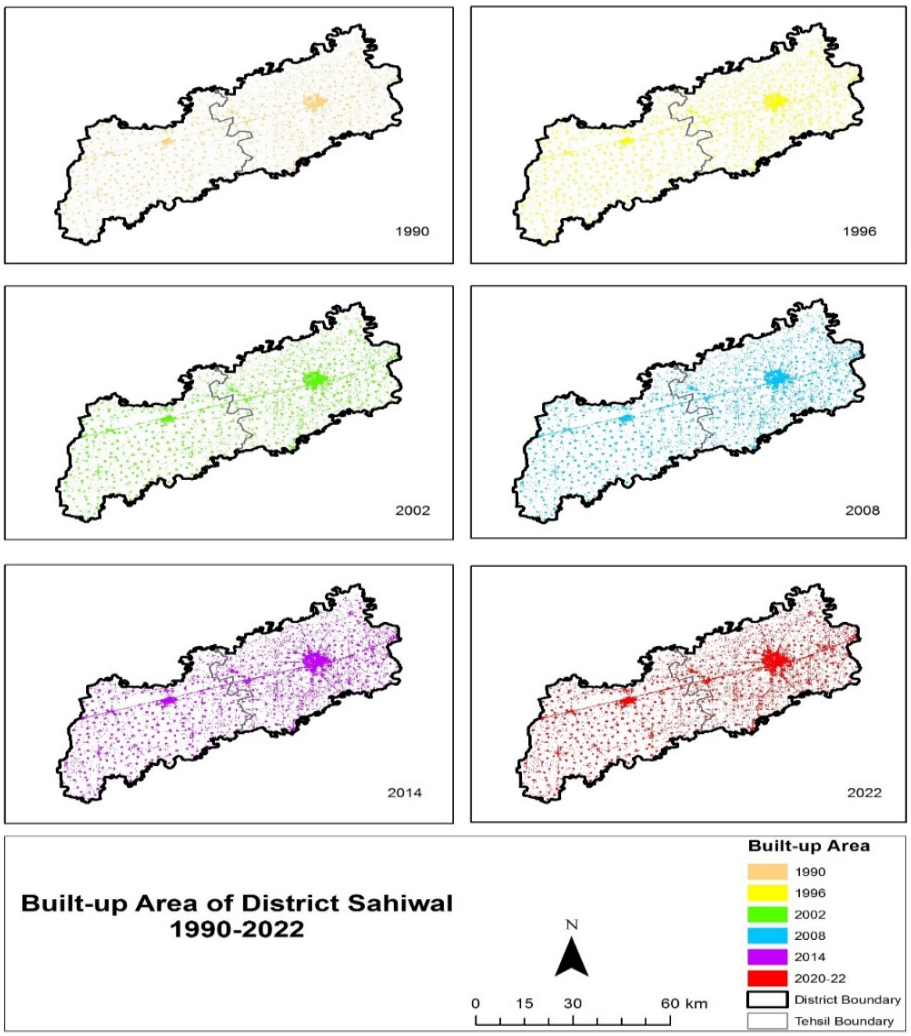
DISTRICT SAHIWAL		
FUNCTIONAL COOPERATIVE HOUSING SOCIETIES		
243.	Municipal Employees Cooperative Housing Society Ltd. Sahiwal.	Functional
244.	Sahiwal Lawyers Cooperative Housing Society Ltd. Sahiwal.	Functional
NON-FUNCTIONAL COOPERATIVE HOUSING SOCIETIES		
245.	Government Servants Cooperative Housing Society Ltd. Sahiwal.	Non Functional
246.	Muhammadpur Cooperative Housing Society Ltd. Sahiwal.	Non Functional
247.	Punjab Govt. Employees Cooperative Housing Society Ltd. Sahiwal.	Non Functional

The overall built-up area has been increased by 38 sq. Km. This directly demonstrates a tendency of a rapid increase in urbanization in the coming years that would eventually lead to even further loss of fertile agriculture land.

Buildup of urban sprawl in District Sahiwal

To evaluate the urbanization of District Sahiwal, GIS images were obtained from GIS system of Urban Unit, Lahore. Images were available only from 1990 and hence with a gap of six years i.e from 1990, 1996, 2002, 2008, 2014 and 2022 corresponding to coverage area data for urbanization were analyzed. It indicates that the urbanized land of the district has increased from 22552 in 1990 to 41762 acres in 2022 resulting

in conversion of 19210 acres of agricultural land to urban land[80]. This reduced availability of land has a direct impact on the production of agricultural crop. The images of the GIS obtained are as under:



80 GIS image was obtained from PMU, Urban Unit Lahore.

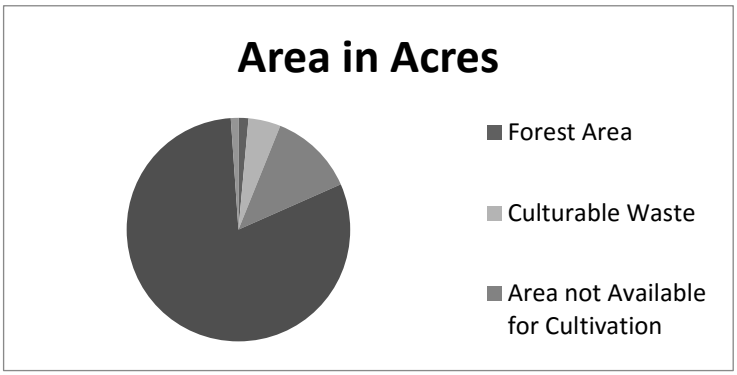
9.1 Agronomy of Sahiwal

Economy of Sahiwal is largely dependent on agriculture. Sahiwal is mainly irrigated through a canal. However, with the expansion in population and main city cluster, a variety of industry has also emerged. New housing societies are also emerging in the city raising pace of urbanization.

9.1.1 Agriculture

Major crops in the district are wheat, barley, gram, cotton, sugarcane, jawar and maize etc. As per data obtained from Bureau of Statistics Government of the Punjab, average Forest area, Culturable waste, not under cultivation, net sown, current fallow and total is given as under[81]:

Description	Area in Acres	Percentage
Forest Area	11353.52	1.437403465
Culturable Waste	36832.71	4.663176264
Area not Available for Cultivation	96809.52	12.2564931
Net Sown	636219	80.54800583
Current Fallow	8648.38	1.094921344
Total	**789863.13**	**100**

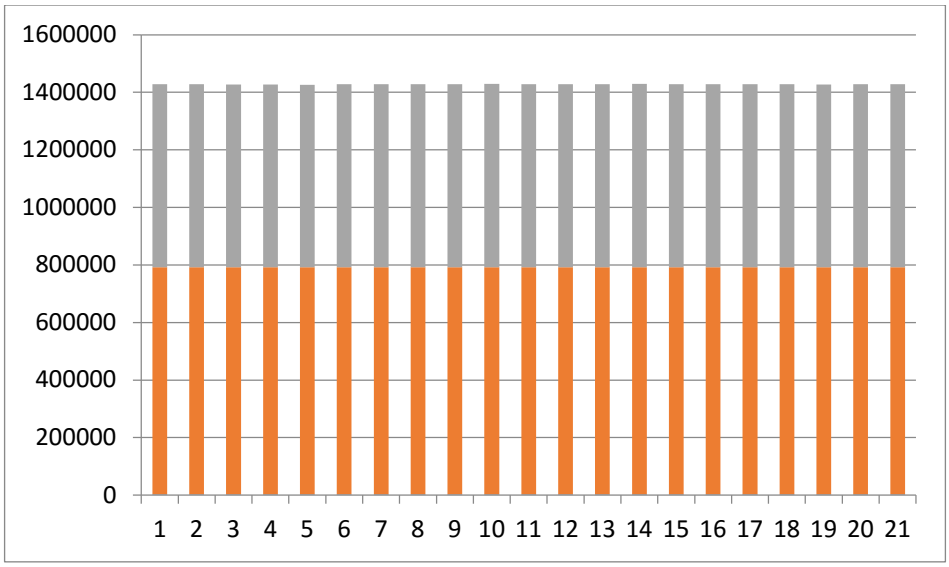


81 Data obtained from Bureau of Statistic, Government of the Punjab through Query Analyzer

Above mentioned data indicates that a predominant i.e 82 percent area is used for agriculture out of total area. There still remains ample land i.e culturable waste which is 4.66 percent that can be utilized for agriculture but currently remained uncultivated.

9.1.1.1 Net Sown Area

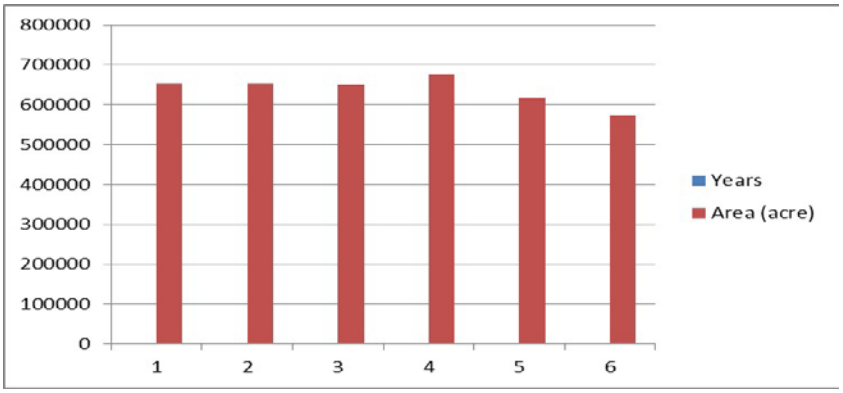
The above depiction is an average obtained since 2000 to 2021. However, over the years net sown area of the district has remained consistent and remained around 80 percent i.e. out of total 789856 acres of district land, around 80 percent remained under utilization and sown for different crops as detailed under:



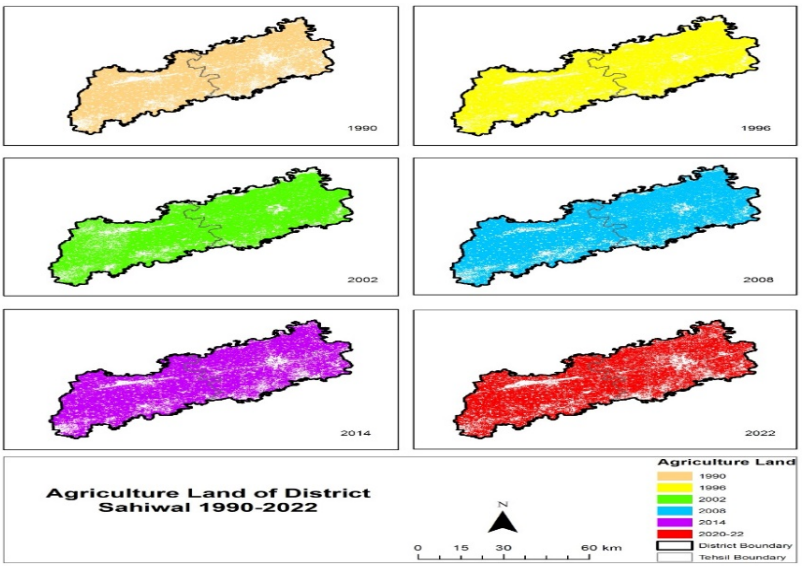
9.1.1.2 Reduced Availability of Agricultural Land

To assess the available land for agriculture, again data related to the availability of land in the district is obtained through GIS from Urban Unit Lahore. GIS imagery and data from years 1990, 1996, 2002, 2008, 2014 & 2022 was gathered and it showed an overall downward trend.

Total available land for agriculture in 1990 was 652529 acres while in 2022, a total land of 573682 remained available for agriculture, as depicted by the diagram given below:



This loss of land mainly can be attributed to the factor of urbanization. This is evident from the satellite imageries of agricultural land obtained through GIS. The image shows a consistent growth in main cluster of urbanization as shown below:



It can be safely concluded from above mentioned data that although the net sown area generally remained consistent but the availability of agricultural land is reduced to some extent and mainly because of urbanization and related infrastructure development. It is clearly indicative of the fact that net sown area could have been enhanced, had the area not been lost due to urbanization.

9.1.1.3 Impact of Urbanization on availability of Land for Agriculture:

Urbanization definitely has reduced the available land for agricultural activities. The combination of data received from GIS system of urban unit reveals the facts as delineated hereunder:

Year	Urbanized Land (Acres)	Remaining Land (Acres)	Net Sown Area (Acres)	Loss of area due to Urbanization (Acres)
1990	22552	767304	-	0
1996	27286	762570	-	4734
2002	29409	760447	635687	2123
2008	32850	757006	636842	3441
2014	39142	750714	636691	6292
2022	41762	745094	636404	2620
Total Area lost from 1990 to 2022				**19240**

Aforementioned data clearly indicates that although, the total sown area of the district remained quite consistent but the arable land lost at the cost of urbanization is not less than 19240 acres since 1990 to date.

9.1.1.4 Calculating the Volume of Impact of Urbanization on the Economy

Major crops of the district are sown in Rabi and kharif seasons. Major five crops for the Rabi season are wheat, barley, gram, rape sarson and linseed crops and major five crops for the Karif season are rice, sugarcane, cotton, jawar and bajra etc. These major five crops are selected for evaluation of the economic impact of the land lost due to urbanization.

Their selection is justified because their data of last six years as obtained from the Bureau of Statistics[82] reveals that they cover around 80 and 62 percent of the total area under cultivation in Rabi and Kharif respectively during the last six years. Moreover, the trend indicates that their percentage is continuously increasing in the overall share of the total crops sown as detailed below:

(Acres)

Year	Total sown area for Rabi	Total sown area for Kharif	5 Major Rabi crops and Sown area/Percentage	5 Major Kharif crops and Sown area/Percentage
2015	543814	475730	387470 (71.25)	258971 (54.44)
2016	518533	494375	340520 (65.67)	272303 (55.08)
2017	547499	483160	426517 (77.90)	274072 (56.72)
2018	545185	489808	436636 (80.08)	301299 (61.51)
2019	532506	479247	438065 (82.26)	267604 (55.84)
2020	568387	532773	480693 (84.57)	350066 (65.71)

In 32 years, a total 19420 acres of land has been urbanized evidently by converting the agricultural land. To evaluate the economic impact, this land has been distributed for both seasons as per proportion of their cultivated area in last 6 years as detailed under:

(Acres)

Crops	Season	2015	2016	2017	2018	2019	2020	Total	% of land used
Wheat	Rabi	471499	429287	426605	414361	338353	384210	2464315	98.18
Barley		564	618	690	512	0	138	2522	0.10
Gram		495	608	613	588	120	0	2424	0.10
Rape Sarson		8007	7416	8646	11022	2040	3065	40196	1.60
Linseed		128	136	82	34	7	57	444	0.02
Total Rabi Season Land Usage over the last 6 years								**2509901**	
Rice	Kharif	87599	91643	100889	93310	102783	162660	638884	37.05
Sugarcane		34157	28715	29779	27514	24494	28791	173450	10.06
Cotton		213177	138694	161731	141608	131370	60095	846675	49.10
Jawar		1341	519	433	751	1409	582	5035	0.29
Bajra		13792	8049	8467	10889	12247	6843	60287	3.50
Total Kharif Season Land Usage over the last 6 years								**1724331**	

82 From the printed book of Bureau of Statistics, Government of Pakistan 2022

The economic impact is calculated as follows:

Crops	Season	Percentage of land (extrapolated)	Distribution of 19240 acres amongst major crops	Average yield per acre (As per last 3 years production)	Rates per 40kg as per 2022 (Rs.)	Value (Rs.)
Wheat	Rabi	100	19240	1.3891/40 kg	2,200	58,797,825
Rice	Kharif	38.51	7410	0.8753/40kg	10,000	64,859,730
Sugarcane	Kharif	10.45	2011	47.7529/40kg	9,000	864,279,737
Cotton	Kharif	51.03	9819	1.2868 Bales/ 7.5063 maunds	5,000/ maund	368,521,799
Total Economic Loss per year of crops due to urbanized land from 1990 to 2022						**1,356,459,091**

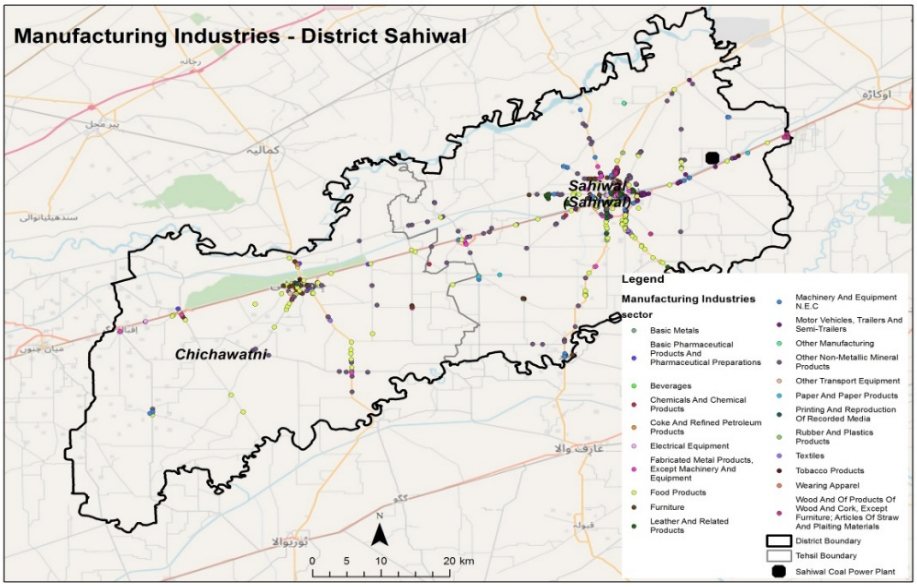
Total loss calculated above represents the economic loss per year and with ever increasing rate of urbanization, this loss would keep on increasing steadily over the coming years.

9.1.2 Industrialization in Sahiwal

In Sahiwal, in recent past, industry has been thriving fast. The latest available survey in 2017 by the PMU, Urban Unit indicates substantial existence of small, medium and large scale industries as detailed under:

Industry	No. of Industries	Area Occupied (Acre)
Small	960	482.545
Medium	52	341.375
Large	6	178
Total	**1018**	**1001.92**

Industrialization is important for developing countries to grow economically and to achieve higher growth. Industry's share in Pakistan's GDP is around 23% as per economic survey of Pakistan for the financial year 2021-22. These industries mainly consist of Beverages, Pharmaceuticals, metals, chemicals, electric equipment etc. as depicted by their respective locations in the following diagram:



Total area occupied by these industries is around 1,000 acres. Industry wise area occupied is reflected hereunder:

Industry Type	Number of Units	Total area Occupied (Acres)
Food Products	184	410.218
Other Non-Metallic Mineral Products	119	387.213
Furniture, Leather and Machinery & Equipment	233	27.517
Paper, Printing, Plastic & wood Products	284	64.78
Chemicals And Chemical Products	19	50.444
Others	179	61.749
Total	**1018**	**1001.921**

The direct economic impact of this commercial activity is associated with the pace of urbanization and its economic impact has already been evaluated. As evident from the data, the land occupied by the industries is not much. Hence the impact of land occupation and resultant impact on agriculture produce and value is minimum. However, there are associated socio-economic impacts related to these industries.

9.1.2.1 Sewerage and drainage

The sewerage and drainage system covers 90% of the total area of Sahiwal through a 40 KM sewerage network (Punjab Cities Improvement program /executive summary of Sahiwal city profile). This study also indicates that waste water is disposed of in a nearby sewer system, which pollutes the surrounding environment and causes water borne diseases. In the main urban cluster of Sahiwal city, the residential areas are rapidly expanding to the north side of the town, and also gradually expanding towards the East, thus, reducing the coverage of the facility to approximately 20 to 30% area only which is aggravating service delivery denial of coverage for sewerage disposal. As per information obtained from TMA, so far, no sanitation plan is developed.

Major issues of sewerage & drainage are:

- Mushroom growth, of housing colonies and societies with any master planning and proper approval of designated forum.
- Sewerage is laid down quite often by other agencies and no proper map/records are available with TMA.
- Encroachments
- Plastic Bags
- Open drains
- Cattle dung
- Damaged sewerage lines
- Poor maintenance and supervision.

9.1.2.2 Solid Waste Management

A dumping site has been allocated for the disposal of waste of city. Collected waste is dumped at designated dump sites at Ratti Tibbi, without any environmental safeguards, such as segregating infections hazardous

waste produced by tanneries, slaughter houses, manufacturing industries and hospitals. Currently, only part of solid waste is being collected and disposed of. Moreover, the google imagery indicates that the dumping site is located in proximity with the canal bank. Following concerns have been observed:

- Jungle on left and right is disturbed and forest vegetation is absent which is very clear from the image.
- The dumping site is at the bank of main irrigation canal causing water of the canal to get polluted.

Some of the solid waste is dumped on roadside, vacant plots, storm water drains and open drains. Situation is even worse in peri-urban areas and rural areas remain unserved by TMAs and no proper waste collection and disposal mechanism exists. A project document of Sahiwal waste management company prepared in July 2015 by Local Government and Community Development Department Government of the Punjab indicates that open dumping, burning and un-engineered sanitary landfills are not only usual but contributing to environmental hazards, as

contaminants deposited result in direct chemical and physical contamination of surface water. Many heavy metals from waste and effluents of above mentioned industries are trapped in the soils beneath dump sites, resulting in risk of further long term environmental contravention.

Uncontrolled and open burning of solid waste (particularly certain types of plastics) releases smoke and gaseous contaminants into the air. The smoke commonly contains particulates, carbon monoxide and other contaminating gases including low level of dioxins, all of which evidently are hazardous to health. In some cases, directly hazardous chemicals are generated from disposal of certain types of waste like hydrogen sulphide.

The existing Solid Waste Management (SWM) system of Sahiwal is in a state of disarray. Waste generated is disposed of into the designated dump site at Ratti Tibbi without making any arrangements for environmental safeguards. By adopting the 0.35 kg/person/day generation rate, the present waste generated in Sahiwal aggregate to 120 tons/day which requires an area of 24-28 acres approximately for landfill facility. Of the 120 tons/day of municipal solid waste generated, only 40-50% enters the municipal waste system, leaving rest of waste uncollected. Presently, the district has lack of adequate waste collection and disposal system. Most of the generated municipal waste is either dumped or burnt illicitly on vacant non-engineered landfill sites which are eventually not only deteriorating environment of the area but also pose adverse impacts on human health.

To cope with the current situation, Local Government and Community Development (LG & CD) Department has sought “Establishment of Segregation, Treatment & Disposal Facility” in district Sahiwal. This facility is anticipated to provide clean environment through reduction of municipal solid waste, diurnal collection of waste, onsite segregation of recyclables and recovered materials and further sound

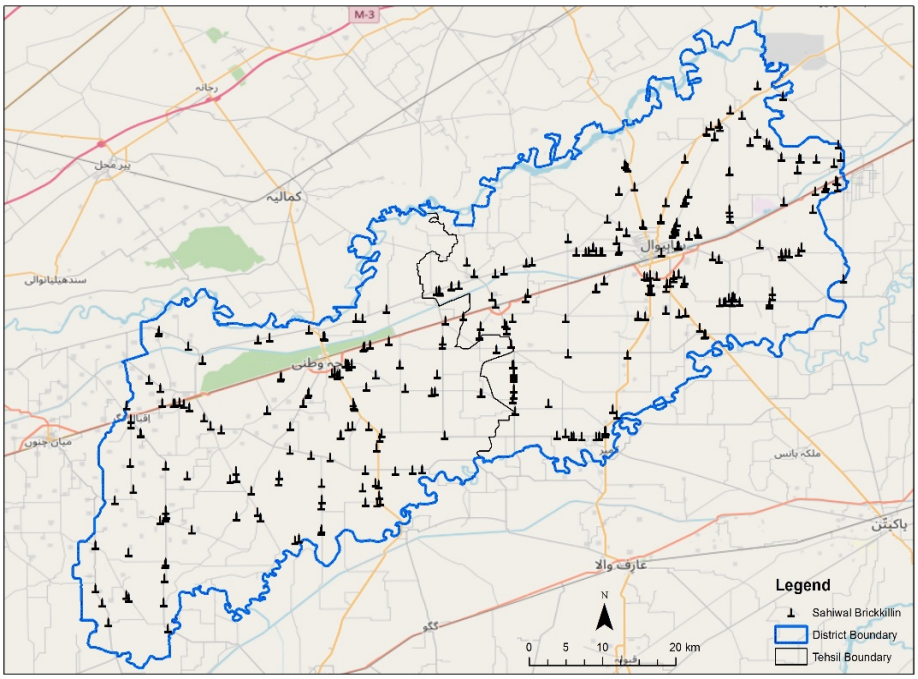
treatment of 40-50% of organic material, while left over materials will be disposed of in eco-friendly manner. Municipal Solid Waste (MSW) comprises of different recyclables and recovered materials that eventually will be used as Refuse Derived Fuel (RDF) and feedstock for composting. However, commissioning of the facility has been hampered due to litigation over acquired site. This turns out to be a wasteful expenditure on Land Acquisition. Fauna around dumpsites is also impacted either by direct consumption of the solid waste or by consumption of plants and animals with intakes of contaminated heavy metals, or as a result of leachate effects on groundwater and surface water. Plants near open dumpsites can be impacted directly by the waste dust or smoke from burning. Dumps affect the type and number of plants in the surrounding area and the presence of dead vegetation are often associated with the zone of direct impact around dumpsites. Dead vegetation is normally a result of trampling by foot, vehicle or animals, but may also be the result of direct contamination by waste or leachate. In short, open dumping and sewerage issues due to unplanned urbanization in the district have caused/created:

- Public health issues.
- Costs relating to environmental impacts are sky rocketing on account of loss of potable water, contaminated land etc.
- Decreased the value of land and surrounding real estate.
- Increased the cleanup cost and;
- Caused degradation of resources into mainstream arable packets of prohibited zones.

9.1.2.3 Brick kilns

With rising pace of urbanization, the housing needs are increasing day by day. One of the basic requirements for housing is bricks. The number of brick kilns in the area, thus, are increasing rapidly. The negative aspects of brick kilns are that these occupy sizable area in their surroundings. Location of most brick kilns as shown in the following

diagram are located in agricultural land which hampers the agricultural activity in the region.



Total area occupied by these 429 kilns is 4290 acres approximately as per survey conducted by urban unit Lahore in year 2017[83]. This clearly indicates that a sizeable agricultural land has been compromised due to construction activity related to urbanization.

9.1.3 Sahiwal Coal Power Plant Project:

Sahiwal coal-fired power plant is situated in district Sahiwal of province Punjab at 10 km away from the main Sahiwal city. Sahiwal coal-fired power plant is a part of CPEC project. It consists of two 660 MW plants and its combined installed capacity is 1320 MW. Its first unit was

83 As per survey of brick kiln conducted by Urban Unit, Lahore in 2017

inaugurated on 25th May, 2017. The plant employs 16667/tons of coal per day, if it is working on its full potential.[84]. Each one of the production unit consists of one boiler, steam turbine and generator, and is fueled by sub-bituminous coal (imported from South Africa and Indonesia) generating electricity, with a gross efficiency of 42.11% by the use of a supercritical steam generator, operating at a temperature of up to 580 degrees Celsius. The plant includes an air quality monitoring system (Flue Gas Desulfurization), and an electrostatic precipitator in order to reduce ash and sulfur emissions from the plant. It requires 60,000 cubic meters of water daily for operation, with water being drawn from the Lower Bari Doab Canal.

Air quality index readings for Pakistan and neighboring countries are not enviable either exceeding by 10 times above acceptable limits as per WHO guidelines.

Rank	Country/Region	2021	2020	2019	2018
1	Bangladesh	76.9	77.1	83.3	97.1
2	Chad	75.9	-	-	-
3	Pakistan	66.8	59	65.8	74.3
4	Tajikistan	59.4	30.9	-	-
5	India	58.1	51.9	58.1	72.5

84 https://www.beltroad-initiative.com/sahiwal-coal-power-project

An estimated 4.48 million tons of coal is required annually for the plant, based on a calculation of 22 hours of power generation per day against 9.8 million metric tons of CO2 exhausted. Indonesia is identified as a primary source for its high-quality coal, reliable production, and short transit times to Pakistan. A mixture of Pakistani indigenous coal with imported coal was also deemed to be unsuitable as it would decrease heat production from coal to be burnt, and would compromise safety of the boilers which are to be used in the project. [85]

This plant has been installed on the agricultural land as is evident from the following satellite image of January, 2015.

85 Liu, Youliang (9 March 2015). "Application For A Generation License Of Huaneng Shandong Ruyi (Pakistan) Energy (Private) Limited For Its 2 X 660 Mw Imported Coal Fired Power Project At Sahiwal, Pakistan" (Pdf). Nepra. P. 109. Retrieved 17 December 2015.

9.1.3.1 Reduced Agricultural Output

Currently whole crop area has been abandoned for cultivation as is evident from the above image taken on 2017 after installation of coal power plant:

It is pertinent to mention here that the area rendered uncultivated by the plant had remained irrigated directly through canal water.

The impact of coal-fired power plant emissions on certain physical and chemical properties of the soil cannot be neglected. A research study concluded that significant increase in bulk density and a decrease in porosity were observed at the sites receiving higher pollution. Soil pH was mostly alkaline at the polluted sites. The organic carbon content of the soil increased with increasing pollution load. Thermal power plant emissions have led to significant increases in the soil sulphate sulphur and exchangeable calcium contents whereas changes in total and organic sulphur, exchangeable potassium, and available phosphorus contents of soil were not significant[86].

The changes in total and organic sulphur, exchangeable potassium, and available phosphorus contents of soil were not significant. Significant positive correlations were found between dust fall rate and exchangeable Ca, Z+ and K+ contents of the soil and between ambient SO2 concentrations and soil SO42-S contents[87].

Furthermore, in a separate study, it was found that Coal thermal power plants are critical sources of heavy metal pollution in groundwater

86 Singh, Jyoti, M. Agrawal, and Deo Narayan. "Changes in soil characteristics around coal-fired power plants." Environment international 21, no. 1 (1995): 93-102.

87 Wyszkowski, Mirosław, Arkadiusz Chełstowski, Zdzisław Ciećko, and Radosław Szostek. "Long-time effect of hard coal ash on the content of some elements in soil." Journal of Ecological Engineering 15, no. 1 (2014): 55-60.

with a significant health hazard. The study assessed the seasonal (pre and post-monsoon) concentration of aluminum, arsenic, iron, cobalt, manganese, nickel, copper, chromium, cadmium, lead and zinc concentrations in groundwater along with heavy metal pollution index and human health risks. The results showed the mean higher concentration (µg/L) for aluminum (387.65, 399.184), arsenic (11.368, 17.288), lead (7.92, 9.59), iron (126.22, 272.24) and manganese (248.69, 825.82) throughout both seasons than the standard acceptable limits of national and international agencies.[88] The values of trace elements such as Mn, Fe, Cd Cu. Pb, and Ni were higher at sites closer to thermal power plants due to which in Sahiwal, it can be seen from Figure below that production of almost all the agriculture crops decreased except for rice.

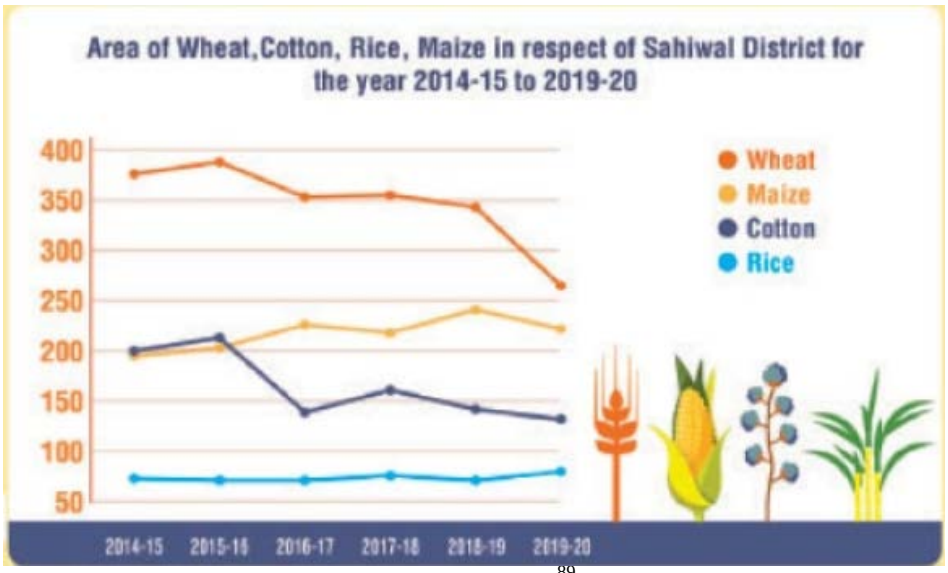


Figure: Crop Production trends for year 2014 to 2020[89]

88 Vig, N., Ravindra, K. & Mor, S. Heavy metal pollution assessment of groundwater and associated health risks around coal thermal power plant, Punjab, India. Int. J. Environ. Sci. Technol. (2022). https://doi.org/10.1007/s13762-022-04284-8

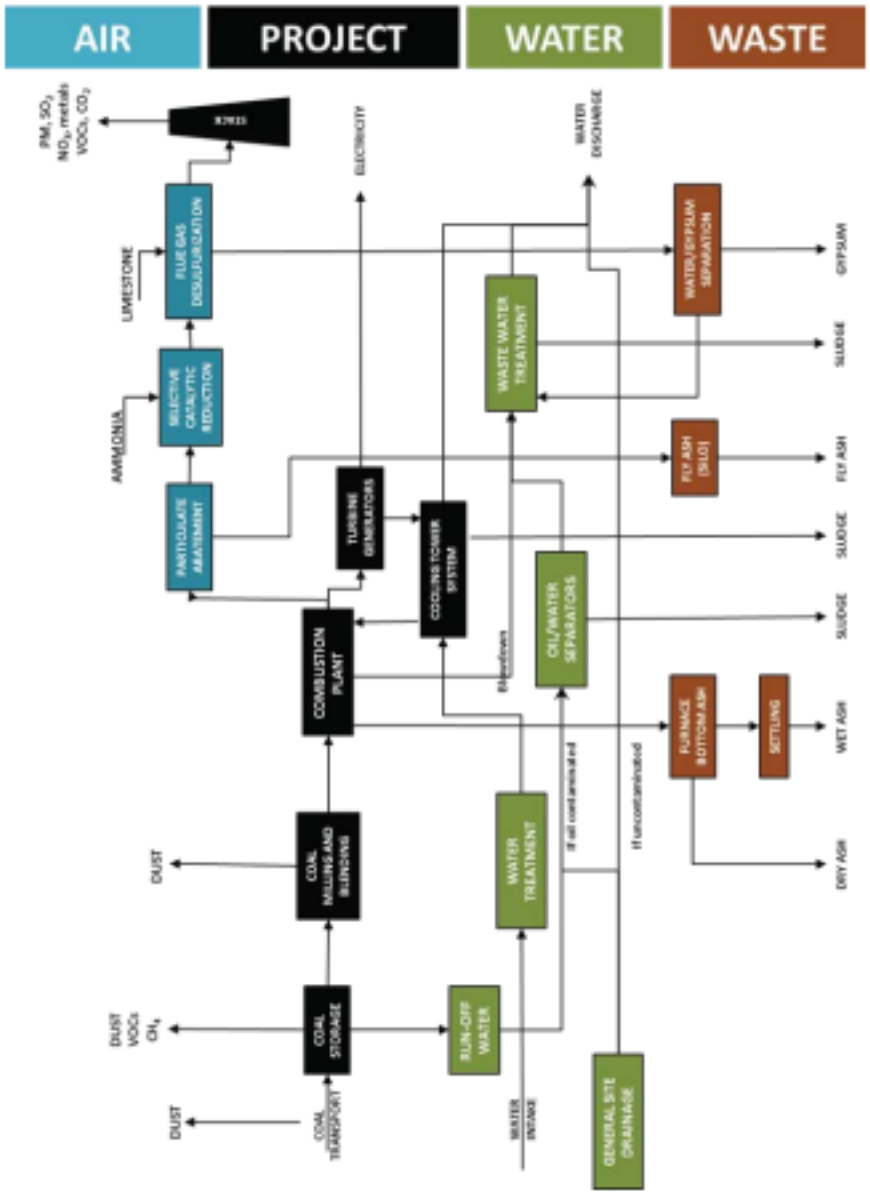
89 https://www.dawn.com/news/160737

9.1.3.2 Air pollution

Although, super critical technology at coal fired plant with built in environmental quality management system exists at Coal Power Plant, Sahiwal, still no technology in the world exists that can ensure 100 percent clean air from coal power plants which definitely has adverse environmental consequences. Waste generation is an integral part of design against which the installation was commissioned and scientific disposal of the same under polluter pays principle is yet to be enforced in this case.

Supercritical technology involves increasing of steam temperature and pressure; thus the efficiency of the steam turbine (and hence, of electricity generation) can be increased. As the steam pressure and temperature increases to a critical point, the characteristics of steam are altered to the extent that water and steam are no longer distinguishable. This is known as supercritical steam and is a more efficient technology[90]. Ultra super critical technology adoption despite being a far better option was thus abandoned at the outset. For Sahiwal Coal Fire Power Plant, energy production efficiency from consumption of coal has not been preferred, notwithstanding the fact that the Original Equipment Manufacturer was very much capable of delivering the ultra-super critical coal fired power plant. The legend for design adhered to was as per illustration reproduced below;

90 Coutinho, Miguel, Hamza K. Butt, and S. Rauf. "Environmental impact assessment guidance for coal fired power plants in Pakistan." The International Union for Conservation of Nature, Islamabad, Pakistan (2014).


AIR
PROJECT
WATER
WASTE
PM, SO2, NOx, metals, VOCs, CO2
STACK
ELECTRICITY
WATER DISCHARGE
LIMESTONE
FLUE GAS DESULFURIZATION
WATER/GYPSUM SEPARATION
GYPSUM
AMMONIA
SELECTIVE CATALYTIC REDUCTION
WASTE WATER TREATMENT
SLUDGE
PARTICULATE ABATEMENT
TURBINE GENERATORS
FLY ASH SILO
FLY ASH
COOLING TOWER SYSTEM
SLUDGE
OIL/WATER SEPARATORS
SLUDGE
COMBUSTION PLANT
Blowdown
FURNACE BOTTOM ASH
SETTLING
WET ASH
DRY ASH
If oil contaminated
If uncontaminated
DUST
COAL MILLING AND BURNING
WATER TREATMENT
DUST
VOCs
CH4
COAL STORAGE
RUN-OFF WATER
DUST
COAL TRANSPORT
WATER INTAKE
GENERAL SITE DRAINAGE

After a mineralogical study of the fly ash sampled in the electrostatic precipitators of the power station, several chemical and mineralogical patterns of the fly ash were employed as tracers of the power station emissions. At the same time, the study focused on the downwind evolution of secondary particulate matter, especially particulate sulphate.[91]. Thresholds have been prescribed to restrict emissions and enforce environmental sampling for the coal fired power plant before rolling out installation[92].

Source: Coutinho, Miguel, Hamza K. Butt, and S. Rauf. "Environmental impact assessment guidance for coal fired power plants in Pakistan." The International Union for Conservation of Nature, Islamabad, Pakistan (2014).

Results of requisite environmental samples have not been accounted for by EPD Government of Punjab. The pollutants with the greatest health impacts are particulate matter and ozone[93]. Once released into the atmosphere, there is no practical way to remove air pollutants[94]. The pollutants in this peculiar context are a subset of those that constitute particulate matter (PM)2 or ozone (O3, the primary constituent of photochemical smog) and their precursors:PM2.5, PM10, oxides of sulfur (SOx), oxides of nitrogen (NOx), carbon monoxide (CO), ammonia

91 Querol, Xavier, Andrés Alastuey, Angel Lopez-Soler, Enrique Mantilla, and Felicia Plana. "Mineral composition of atmospheric particulates around a large coal-fired power station." Atmospheric Environment 30, no. 21 (1996): 3557-3572.

92 Coutinho, Miguel, Hamza K. Butt, and S. Rauf. "Environmental impact assessment guidance for coal fired power plants in Pakistan." The International Union for Conservation of Nature, Islamabad, Pakistan (2014).

93 Zhang, Junfeng, Yongjie Wei, and Zhangfu Fang. "Ozone pollution: a major health hazard worldwide." Frontiers in immunology 10 (2019): 2518.

94 Ness, J. Erik, Vikram Ravi, and Garvin Heath. "An overview of policies influencing air pollution from the electricity sector in South Asia." (2021).

(NH3), and volatile organic compounds (VOCs)[95]. In the atmosphere, NOx and SOx are noxious alone and can also undergo physical and chemical transformation. PM2.5. PM2.5 tends to penetrate deep into the lungs and bloodstream[96] causing respiratory issues, lung cancer, cardiovascular problems, and strokes—and can also degrade physical infrastructure, mainly through corrosion of building exteriors[97]. Ozone exacerbates respiratory problems in the short term; long-term exposure causes Chronic Obstructive Pulmonary Disease (COPD), an inflammatory lung disease that obstructs airflow from the lungs.

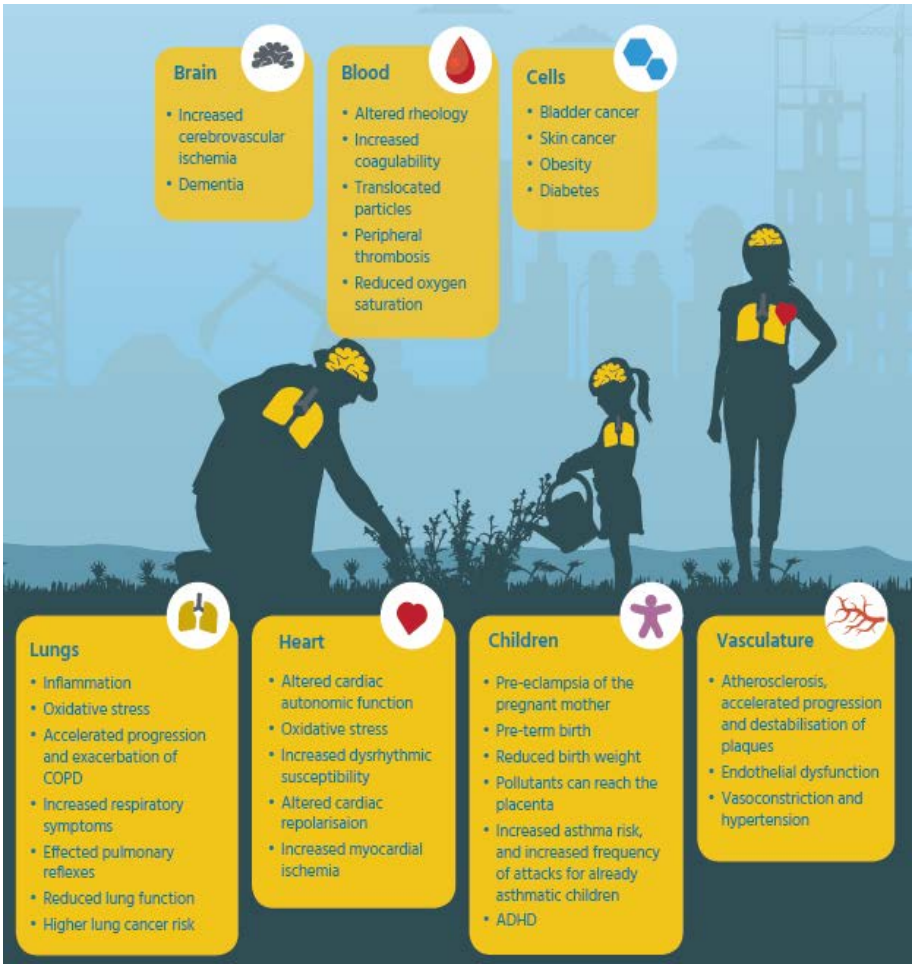
When burning coal to generate electricity, three main health-harming pollutants are released into the air: Particulate matter (PM): Small particles in the air. The number next to the abbreviation PM indicates the size of the particle: PM10 is 10 micrometers or less, while PM2.5 is 2.5 micrometers or less. When inhaled, particles travel into the bloodstream and cause harm to our lungs and heart. They can cause stroke and lead to premature death. New studies also link particulate matter with harm to the healthy development of children, and diseases such as obesity and Alzheimer's. Sulphur dioxide (SO2) is classified as very toxic for humans when inhaled. It can cause severe irritation of the nose and throat. High concentrations can cause a life-threatening accumulation of fluid in the lungs (pulmonary edema). Symptoms may include coughing, shortness of breath, difficult breathing and tightness in the chest. Even a single exposure to a high concentration can cause a long-lasting condition like asthma. It can react in the atmosphere to form PM, called 'secondary PM'.

95 Zhang, Xing. "Emission standards and control of PM2. 5 from coal-fired power plants." IEA Clean Coal Centre, London (2016).

96 Ness, J. Erik, Vikram Ravi, and Garvin Heath. "An overview of policies influencing air pollution from the electricity sector in South Asia." (2021).

97 Ivanova, Veselina R. "The anthropogenic air pollution and human health." Journal of IMAB–Annual Proceeding Scientific Papers 26, no. 2 (2020): 3057-3062.

Nitrogen oxides (NOx) are gases that cause inflammation of the airways. They are oxidizers which means they cause oxidative stress which can disrupt normal cell mechanisms and cause damage to tissues, reducing the immune abilities of the body[98]. They can react in the atmosphere to form PM, called ‘secondary PM’.



98 Wong, Tit-Yee. "Smog induces oxidative stress and microbiota disruption." journal of food and drug analysis 25, no. 2 (2017): 235-244.

Reference: “Chronic coal pollution” by Europe Beyond Coal campaign (2019)

In addition to the above mentioned pollutants, the release of natural radioactive materials with the emission of fly ash as a result of coal burning in Sahiwal Power generation plant is considered amongst the sources that elevate environmental radioactivity level.

WHO has classified the carcinogens as following:

Metals and others	• Arsenic and inorganic arsenic compounds • Beryllium and beryllium compounds • Cadmium and cadmium compounds • Chromium (VI) compounds • Nickel compounds • Halo Ethers
Radiation	• Ionizing radiation • Radon

Source: https://monographs.iarc.who.int/agents-classified-by-the-iarc/

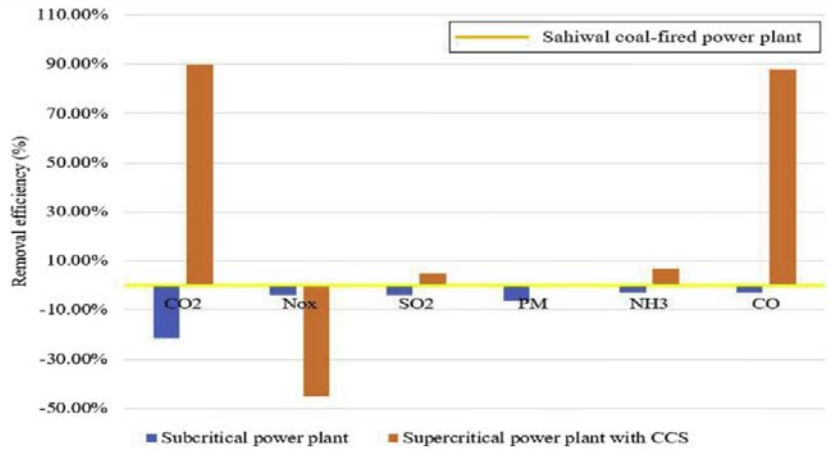
The assessment of various radiological parameters including excessive lifetime cancer risk significantly rises due to natural radioactive contents associated with fly ash emitted to the surrounding environment from the stack of 1320 Mw Sahiwal coal-fuelled power generation plant (CFPP). For this samples were collected, the activity concentrations of radium-226, potassium-40, and thorium- 232 in collected samples was found to be in the range of 20 to 138, 43 to 860, and 27 to 127 Bq/kg with average values of 66, 409, and 67 Bq/kg respectively. Activity concentrations of radium-226 and thorium-232 were observed

significantly higher than UNSCEAR reported typical global average values[99].

CFPP (country)	Radium-226 range (mean)	Thorium-232 range (mean)	Potassium-40 range (mean)
Sahiwal, Pakistan $D = 1$ Km	23–86 (48)	43–96 (62)	96–860 (504)
Sahiwal, Pakistan $D = 1$–3 Km	37–138 (86)	36–83 (62)	76–798 (427)
Sahiwal, Pakistan $D = 3$–4 Km	20–79 (53)	27–126 (77)	43–576 (297)
Baoji, China	23.6–40.2 (32.7)	38.0–66.3 (50.6)	498.0–857.9 (691.2)
Baqiao, China	27.6–48.8 (36.1)	44.4–61.4 (51.1)	640.2–992.2 (733.9)
Mawan, China	72–358 (204)	118–432 (265)	101–2168 (1269)
Kolaghat, India	--	33.1–193.5 (104.5)	367.2–3163.5 (1492.3)
Kapar, Malaysia	79.5–92.2 (86.7)	69.6–83.7 (73.4)	263.1–308.7 (297.3)
Lodz, Poland	9–23 (16.6)	9–21 (15.7)	222–434 (306)
Afsin-Elbistan, Turkey	7–78 (33)	26–49 (36)	304–744 (379)
Megalopolis, Greece	21.5–125 (45.0)	24.5–40.2 (32.5)	228–404 (337)
Velilla, Spain	13–67 (38.7)	15–68 (42.9)	97–790 (445.3)
World's values	33	45	420

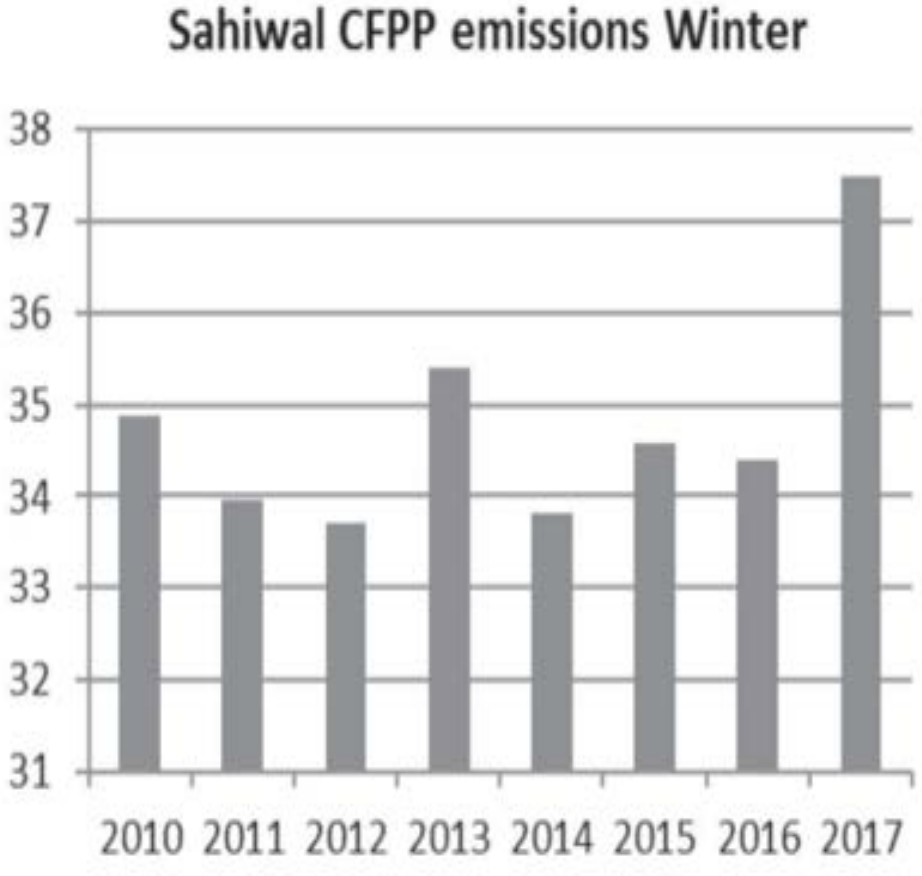
D, distance

The pollutants removal efficiency of Sahiwal power plant has been compared with subcritical coal plant and supercritical coal-fired power plant equipped with Carbon Capture Storage.



99 Khan, Ihsan Ullah, Weimin Sun, and Elfed Lewis. "Estimation of various radiological parameters associated with radioactive contents emanating with fly ash from Sahiwal coal–fuelled power plant, Pakistan." Environmental Monitoring and Assessment 192.11 (2020): 1-11.

It is evident that the removal efficiency of subcritical power technology, is significantly less while in supercritical power plant with CCS system, the removal efficiency for CO2 and CO is considerably higher[100]. Storage (CCS) system .



Source: Polish Journal of Environmental Studies[101] .

100 Rizwan Rasheed, Hajra Javed, Asfra Rizwan, Faiza Sharif, Abdullah Yasar, Amtul Bari Tabinda, Sajid Rashid Ahmad, Yubo Wang, Yuehong Su, Life cycle assessment of a cleaner supercritical coal-fired power plant, Journal of Cleaner Production, Volume 279, 2021,123869,ISSN 0959-6526.

101 Munir, Ramsha, and Umer Khayyam. "China-Pakistan Economic Corridor and the Impact of Coal-Based Energy Projects on Tropospheric Ozone in Pakistan." Polish Journal of Environmental Studies 29, no. 5 (2020): 3729–47. doi:10.15244/PJOES/112895

It is worth mentioning that the Ultra-Supercritical Carbon Capture Storage (SCCS) is expected to have much higher removal efficiency when compared with conventional supercritical at the same environment[102]. On the other hand, advanced ultra-super critical with CSS already stood commissioned by OEM in our neighboring country since 2018[103]. Moreover, the Yuhuan partner company of Sahiwal coal power plant has also deployed ultra-super critical technology since 2006[104]. Reasons for not commissioning ultra super critical technology, a preferable options for Sahiwal to curb environment adverse impact are inscrutables.

9.1.3.3 Reduced water flow at canal and adverse implications

Water is essential for power generation. Heat (from the combustion of coal) is used to convert water into high pressure, high temperature steam, which is expanded through a turbine to produce electricity. There are many different designs for pulverised coal-fired power plants. Water exits the system in various ways. These can be broadly classified as:

- unavoidable losses, such as through the evaporation of recirculated water in wet cooling towers, and minor steam leaks;
- losses to the formation of products, such as gypsum from the wet FGD (flue Gas Desulphurization) scrubber;
- deliberate blowdown from various recirculating streams, including boiler feed water, FGD streams and cooling water. Blowdown is necessary to preserve water quality and remove impurities; and
- handling products, such as ash sluicing.

102 Swapan Basu, Ajay Kumar Debnath, Chapter 13 - Advanced Ultrasupercritical Thermal Power Plant and Associated Auxiliaries,Editor(s): Swapan Basu, Ajay Kumar Debnath,Power Plant Instrumentation and Control Handbook (Second Edition), Academic Press,2019, Pages 893-988.

103 Qurat ul Ain Ali, Umer Khayyam, Umair Nazar, Energy production and CO2 emissions: The case of coal fired power plants under China Pakistan economic corridor, Journal of Cleaner Production, Volume 281, 2021

104 https://www.power-technology.com/projects/yuhuancoal/

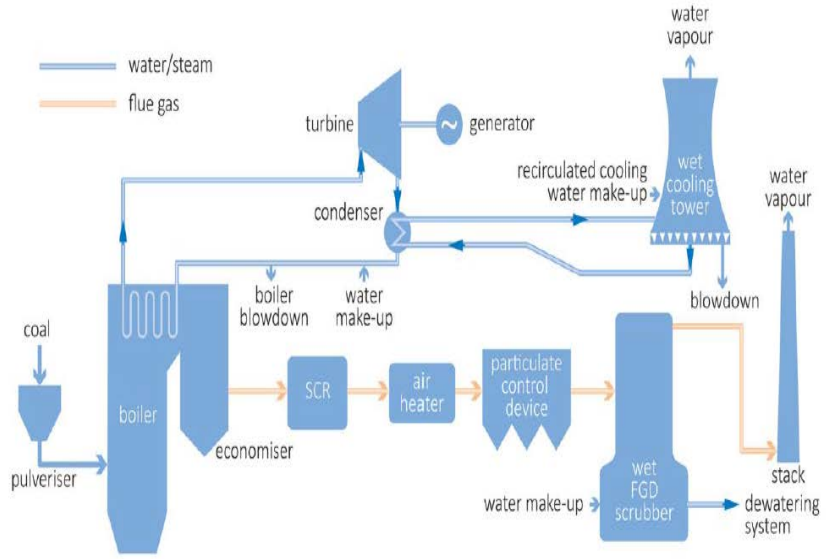


Figure: Schematic illustrations of a coal power plant showing where water is lost and added

Due to utilization of water as an input for boiler combustion in Sahiwal Coal Power Plant, the utilized water evaporates. This evaporation results in reduced water flow in the canal. The lower riparian growers of LBDC face shortage of water required for irrigation purposes.

Nevertheless, the groundwater table has decreased by up to 15 feet over the last three to four years. This could be the result of over-pumping of groundwater for utilization by the coal power [plant], given the context that during the winter season, canal water available with reduced flows from January to March. This is none other than uninvited trouble as a negative externality for farming community.

- **Pollutant leaching from overburdened dump**

Overburdened dump is the waste material which has to be removed before the mineral resources can be salvaged. The waste materials can contain pollutants in the form of heavy metals of other chemicals which

leach out during the rains and pollute the surrounding areas. The environmental aspects in this particular sense are quite alarming since coal power plants acquire natural water reservoirs to fulfill their needs. Polluted water can affect the bio-diversity of the area. Increase or decrease in pH of the water can affect or prevent the growth of the plants in the area. Similarly, increase in other physical and chemical parameters directly or indirectly affects vegetation of the area.

Analysis of the samples showed that arsenic concentrations in 45 percent of the samples were above the World Health Organization's safe limits in drinking water (10 micrograms per liter). Worse still, 30 percent of the well water samples contained arsenic levels above the Pakistan-EPA safe limit, which is set at 50 micrograms per liter. Other water quality parameters that include sulphate, chloride and sodium were also higher in 30 to 40 percent of the samples. There is a potential threat to groundwater quantity and quality in the vicinity of the Sahiwal Coal Power Plant, which is posing a health risk to the people living there.

9.1.4 Peri-Urban Area

Under Rule 11 of Punjab Land use (Classification, re-classification and re-development) Rules, 2009, the peri-urban areas are defined as "the areas that span the landscape between contiguous urban development and rural countryside with low population density and are predominantly used for agricultural activity and are likely to be urbanized in the next twenty years."

Under the Punjab Land Use Rules 2009, a peri urban structure plan is a legal requirement which a city District Government or a Tehsil Municipal Administration has to fulfill under these rules for the peri urban area falling within its geographical limits. A peri ruban structure plan generally is a set of maps/illustrations and reporting documents combined

to form a plan and is used to guide and control the future growth of peri-urban areas. As suggested in the Land Use Rules, 2009, it may contain:

1. Proposed Road Networks
2. Division of areas into blocks; and
3. The proposed land uses of various blocks.

9.1.4.1 Growth of peri-urban areas in Sahiwal

The analysis of peri urban area through GIS system available with Urban unit, Lahore indicates that the area is exponentially increasing around main city cluster. If we can have a look at the conversion of agricultural land into urban areas since last 32 years as per GIS analysis of urban unit, a total 31053.93 acres have been converted into urban structures. It accounts for almost 3.93 percent of the total area of district. Moreover, the trend indicates that the rate of expansion is rapidly increasing in recent years as indicated by the figures given below[105]:

Year	Sahiwal	%age of Agri Area converted into urban Land scape
2008B-2002V (Area Acre)	10248.01	1.30
2014B-2008V (Area Acre)	15511.33	1.96
2022B-2014V (Area Acre)	5294.59	0.67
Total	**31053.93**	**3.93**

9.1.4.2 Expected Economic Loss in Peri-Urban Area

Given the definition of peri-urban area, an area that is expected to be fully urbanized in the next 20 years, the expected loss of agricultural production as per current economic value of crops as calculated in Section 9.1.1.4 can be:

Area x Per acre loss = Loss per year.

1356459091 / 19240 x 31034.09 = 2,187,966,398.72 per year

105 As per data provided by PMU, Urban Unit, Lahore

9.1.4.3 Sewerage, Sanitation Drainage & Solid Waste Management

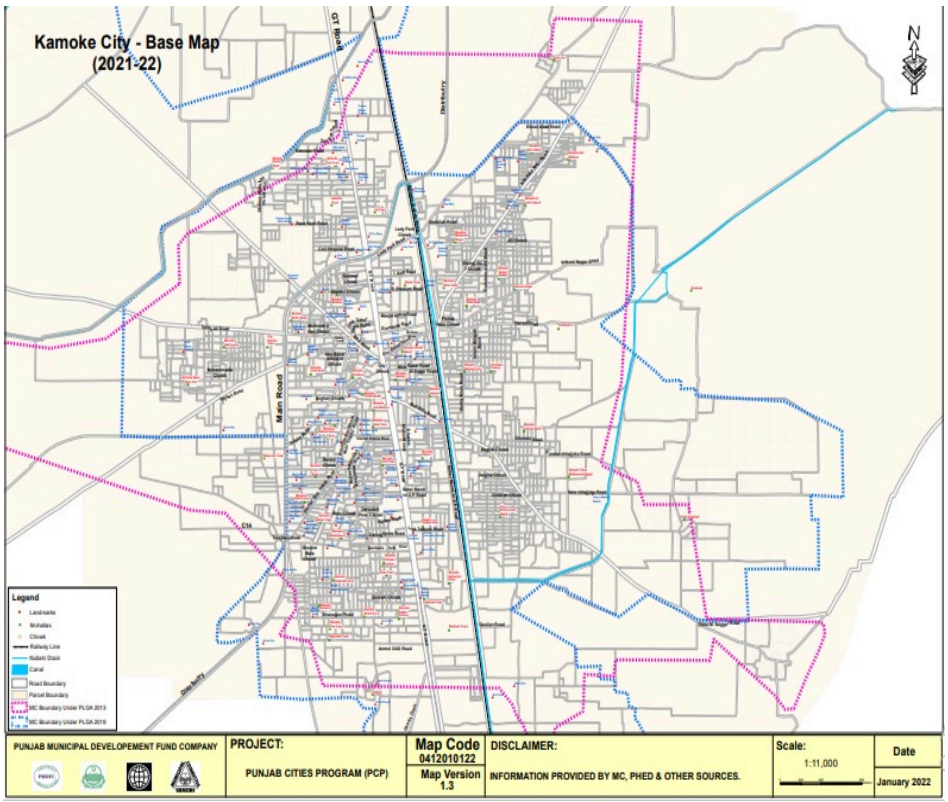
The sewerage and drainage system only covers 90% of the total area around main population clusters of district Sahiwal[106]. The areas devoid of such facilities are at the outskirts of urban centers. Thus, peri-urban area is least covered by such facilities. Moreover, the expansion of main city cluster in Sahiwal is towards north whereas the drainage system services concentration are at the eastern side, aggravating the situation particularly due to mushroom growth of housing societies.

106 (Punjab cities improvement program/ executive summary of Sahiwal city project).

10. Case Study 2: Urban Growth Across Kamoke

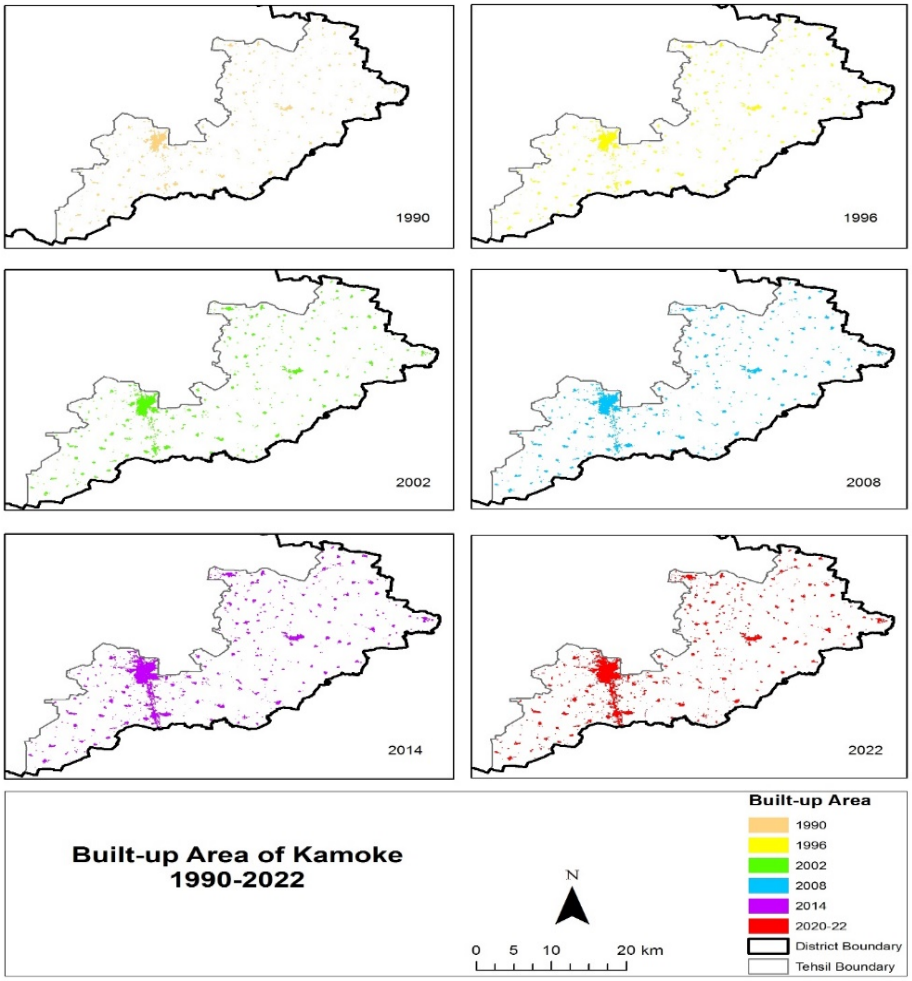
Kamoke is a Tehsil of Gujranwala District in Punjab, Pakistan. It is the 30th largest city of Pakistan and further sub-divided into eight union councils. It is located on the Grand Trunk Road 20 KM (13 Miles) from Gujranwala and 44 KM (27.3 Miles) from Lahore. It was declared as Tehsil in 1992 and is administered by TMA. Kamoke

Kamoke is also located at the main Lahore – Rawalpindi Railway line. The population of Kamoke was 152288 in 1998. The 2017 census shows a population of 249,769 with an average annual growth of 2.6% since 1998, slightly above the national average of 2.4 %.



Built up of Urban Sprawl in Tehsil Kamoke

The rate of urbanization as evident from GIS imagery obtained from 1990 to 2022 and with gap of six years interval is around 2.2799 percent. The urban area of the Tehsil as per this data has increased from 2414 acres in 1990 to 6323 acres in 2022. The urban sprawls for the given period are as under:



The imagery clearly indicates that the land surrounded by GT Road is being urbanized very rapidly. The images of 1990 and 1996 does not indicate any significant urbanization along GT Road. However, the images of 2014 and 2022 indicate a significant build-up area expanding across GT Road.

10.1 Agronomy of Kamoke

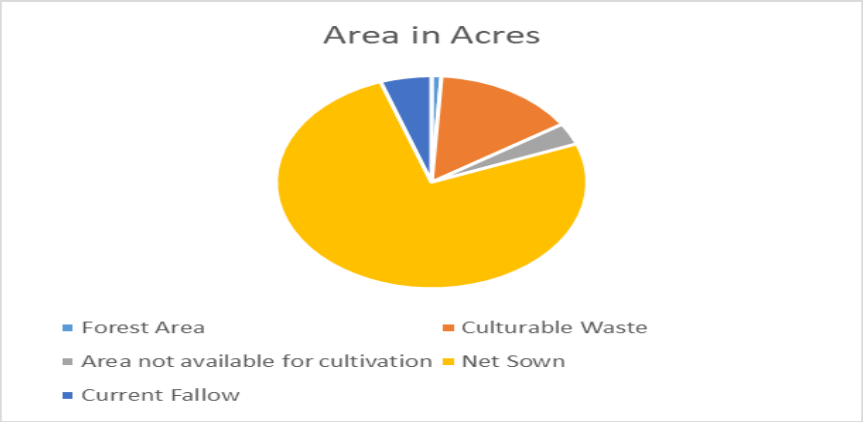
Economy of Kamoke is largely dependent on agriculture. Kamoke is mainly irrigated through a canal. However, with the expansion in population and main city cluster, a variety of industry has also emerged. New housing societies are also emerging in the city raising pace of urbanization.

10.1.1 Agriculture

Kamoke is a tehsil rich in agriculture. Major crops in the districts are wheat, rice, barley, gram, sugarcane, jawar and maize etc. As per data obtained from Bureau of Statistics Government of the Punjab[107], average Forest area, Culturable waste, area not under cultivation, net sown, current fallow and total is given as under:

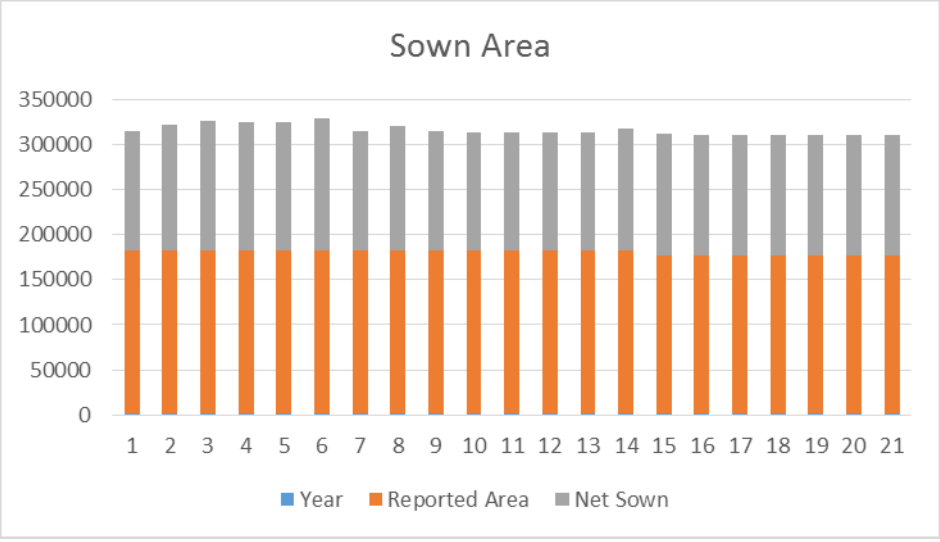
Description	Area in Acres	Percentage
Forest Area	1813.62	1.01447553
Culturable Waste	26469.67	14.8062066
Area not available for cultivation	5910.86	3.30632812
Net Sown	135091.71	75.5655725
Current Fallow	9488.29	5.30741721
Total	**178774.15**	**100**

107 Pakistan Bureau of Statistics. 2017.



10.1.1.1 Net Sown Area

The above depiction is an average obtained since 2000 to 2021. However, over the years net sown area of the district has remained consistent around 80 percent i.e. out of total 144,550 acres of total district land, around 80 percent remained utilized and sown for different crops as detailed under:



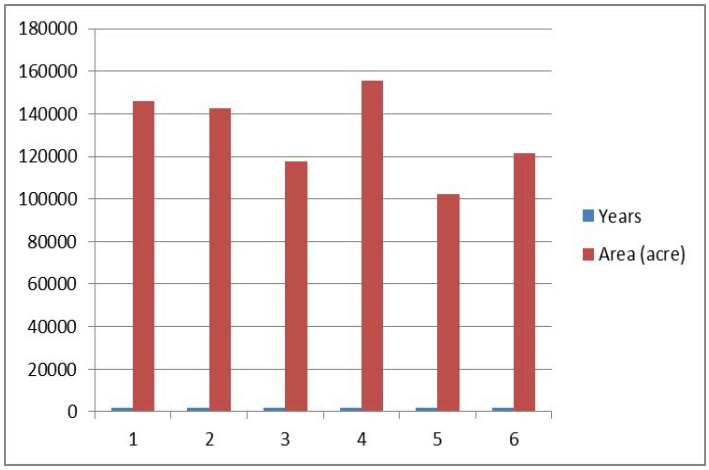
It is an indication that despite area occupied due to urbanization and resultant industrialization, the net agricultural area remained unaffected. It can be due to the fact that culturable waste i.e. the land available for cultivation may have been utilized over the period for a land lost at the expense of urbanization. One of its consequences is disappearance of forest land as discussed in the following section.

10.1.1.2 Disappearance of Forest Land

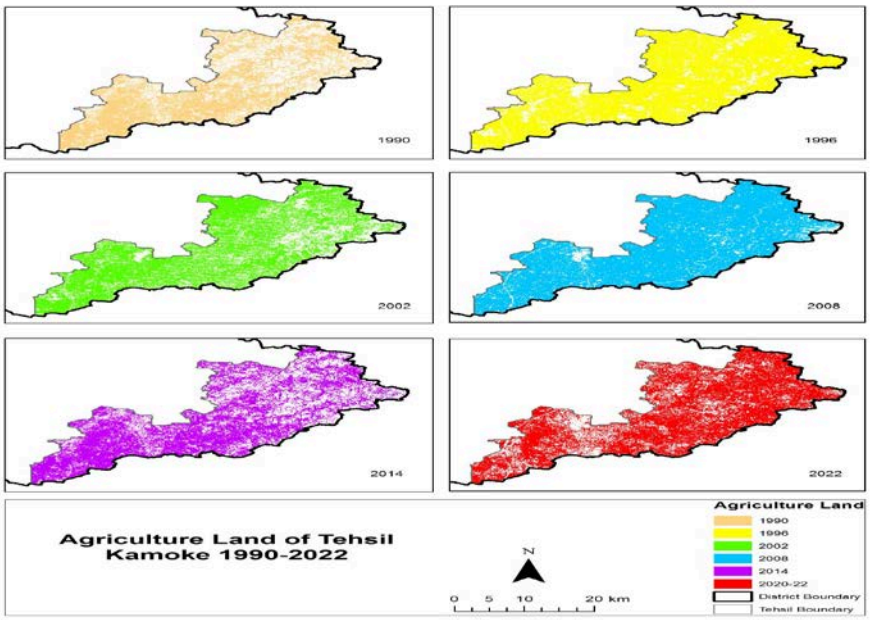
As is evident by analyzing data obtained through query analyzer from the data base available with Bureau of Statistic, Government of Punjab, a substantial area of land in Kamoke was covered under the forest i.e 7805 acres in 2006 and in 2012, this area was reduced to 5044 acres only. Since 2013, this area also disappeared and zero land was being shown as covered by forest in Kamoke Tehsil. Audit apprehends that this land has been compromised and sown area is enhanced artificially at the expense of this forest land. Indirectly, we can say that urbanization has put a significant pressure to enhance crop production which resulted in eradication of land previously covered under forest.

10.1.1.3 Availability of Agricultural Land:

To assess the available land for agriculture, again data related to the availability of land in the district is obtained through GIS from Urban Unit Lahore. GIS imagery and data from years 1990, 1996, 2002, 2008, 2014 & 2022 was gathered and it showed an overall downward trend. Total available land for agriculture in 1990 was 145784 acres while in 2022 a total land of 121502 remained available for agriculture, as depicted by the diagram given below:



This loss of land mainly can be attributed to the factor of urbanization. This is evident from the satellite images of agricultural land obtained through GIS. The images show a consistent growth in main cluster of urbanization as under:



It can be concluded from above mentioned data that although the net sown area generally remained consistent and net sown area could have been enhanced much more, had the area not been lost due to urbanization.

10.1.1.4 Impact of Urbanization on availability of Land for Agriculture:

Urbanization definitely has reduced the available land for agricultural activities. The combination of data received from GIS system of urban unit reveals the facts as under:

Year	Urbanized Land (Acres)	Remaining Land(Acres)	Net Sown Area (Acres)	Loss of area due to Urbanization (Acres)
1990	2414	169041	-	0
1996	2599	166442	-	0
2002	3102	163340	635687	143540
2008	3664	159676	636842	132350
2014	5611	154065	636691	134734
2022	6323	147742	636404	132649
Total Area lost from 1990 to 2022				**3909**

Aforementioned data clearly indicates that although, the total sown area of the district remained quite consistent but the arable land lost at the cost of urbanization is not less than 3909 acres since 1990 to date.

10.1.1.5 Calculating the Volume of Impact of Urbanization on the Economy

Major crops of the district are sown in Rabi and kharif seasons. Major five crops for the Rabi season are wheat, barley, gram, sarson and linseed crops and major five crops for the Karif season are rice, sugarcane, jawar and bajra etc. These major five crops are selected for evaluation of the economic impact of the land lost due to urbanization. Their selection is justified because their data of last six years as obtained from the Bureau of Statistics reveals that they cover around 80 and 62 percent of the total area under cultivation in Rabi and Kharif respectively during the last six years. Moreover, the trend indicates that their percentage is continuously

increasing in the overall share of the total crops sown as detailed hereunder:

(Acres)

Year	Total sown area for Rabi	Total sown area for Kharif	5 Major Rabi crops and Sown area/Percentage	5 Major Kharif crops and Sown area/Percentage
2015	130593	152379	117077(89.65)	148266 (97.30)
2016	138669	132537	114920(82.87)	128923 (97.27)
2017	142340	127360	119597(84.02)	117122 (91.96)
2018	152758	120922	131118(85.83)	117884 (97.49)
2019	171081	131592	131907(77.10)	126251 (95.94)
2020	155292	149392	108646(69.96)	144943 (97.02)

In 32 years, a total 3909 acres of land has been urbanized evidently at the expense of the agricultural land. To evaluate the economic impact this land has been distributed in both seasons as per proportion of their cultivated area in last 6 years as under:

(Acres)

Crops	Season	2015	2016	2017	2018	2019	2020	Total	Percentage of land used
Wheat	Rabi	116930	114850	119254	130886	131907	108646	722437	99.89
Barley		122	21	176	178	0	0	497	0.07
Gram		11	8	25	7	0	0	51	0.01
Rape Sarson		14	41	22	47	0	0	124	0.02
Linseed		0	0	120	0	0	0	120	0.02
Total Rabi Season Land Usage over the last 6 years								**723229**	
Rice	Kharif	145881	125373	113572	113705	122596	143452	764579	97.59
Sugarcane		224	235	235	433	195	135	1457	0.19
Cotton		3	0	0	0	0	0	3	0
Jawar		1729	2982	2982	3578	3195	1261	15727	2.01
Bajra		429	333	333	168	265	95	1623	0.21
Total Kharif Season Land Usage over the last 6 years								**783389**	

From the analysis of the land usage for major crops in both season i.e. Kharif and Rabi, it is clear that wheat covered more than 99.9 percent land in Rabi season and similarly 3 major crops of Kharif season i.e. Rice, Sugarcane and cotton covers around 98 percent of land. Hence, the economic impact is based on the production of these four crops by extrapolating this land to 100 percent against the urbanized land as already calculated above. Average yield based on last three years from 2018 to

2020 obtained from Punjab Development Statistics 2020, Bureau of Statistics, Planning & Development Board, the Government of Punjab. The economic impact is calculated as follows:

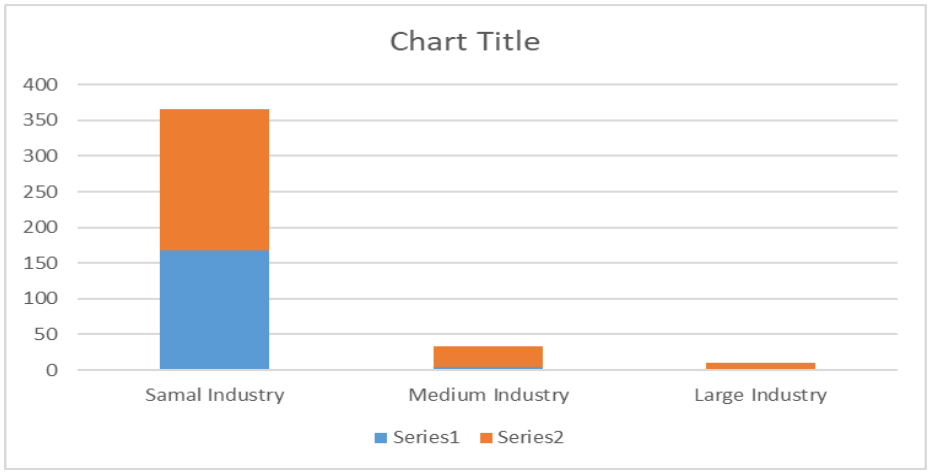
Crops	Season	Percentage of land (extrapolated)	Distribution of 3909 acres amongst major crops	Average yield per acre (As per last 3 years production)	Rates per 40kg as per 2022 (Rs.)	Value (Rs.)
Wheat	Rabi	100	3909	1.3891/40 kg	2,200	8,599,800
Rice	Kharif	100	3909	0.8753/40kg	10,000	39,090,000
Total Economic Loss per year of crops due to urbanized land from 1990 to 2022						**47,689,800**

Total loss calculated above represents the economic loss per year and with ever increasing rate of urbanization, this loss would keep on increasing steadily.

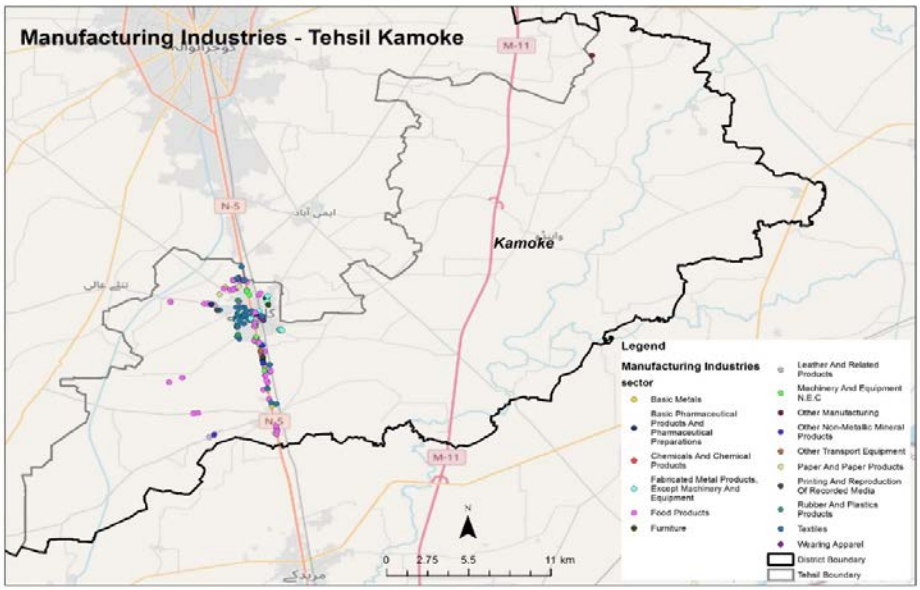
10.1.2 Industrialization in Kamoke

The latest available survey in 2017 by the PMU, Urban Unit indicates substantial existence of small, medium and large scale industries as detailed under:

Industry	No. of Industries	Area Occupied (Acres)
Small	168	198.053
Medium	5	28.5
Large	2	8
Total	**175**	**234.553**



These industries mainly consist of Beverages, Pharmaceuticals, metals, chemicals, electric equipment etc. as depicted by their respective locations in the following diagram:



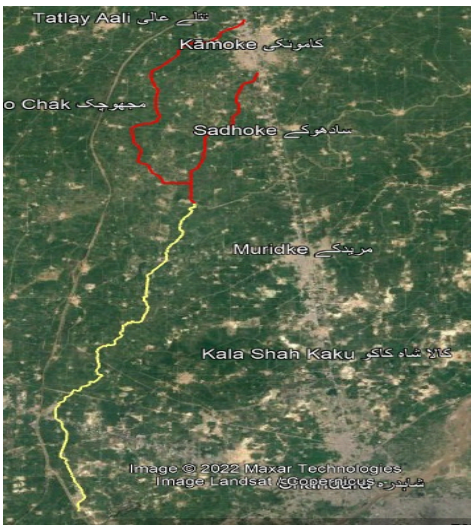
Total area occupied by these industries is 235 acres mainly around the peripheries of GT Road. Industry wise area occupied is reflected hereunder:

Industry Type	Number of Units	Total area Occupied (Acres)
Food Products	42	155.05
Basic, Fabricated Metallic Other Non-Metallic Mineral Products	30	23.847
Furniture, Leather and Machinery & Equipment	23	10.55
Paper, Printing, Plastic & wood Products	10	7.975
Textiles	59	31.769
Others	11	5.363
Total	**175**	**234.554**

The direct economic loss to ruralists due to land occupied by these industries is negligible as these occupy a very small land i.e 234.554 acers of land. However, the socio-economic impact of such industries combined with drainage of sewerage and effluents for these urbanized cluster can be very significant.

10.1.2.1 Drainage system of Kamoke

There are two main drainages that emerge from the city center of Kamoke. One is from the north side (23.47 KM) known as Khowt seepage drain and the other is from the south (12 KM) of the city. The Khowt seepage drain traverses across 23.47 KM agricultural lands of Kamoke before falling in Nalla Dek. The southern drainage (Saim) also traverses across agricultural land for about 12 KM when it merges with Khowt seepage drain before flowing the run off into Nalla Dek. Nalla Dek also acts as a flood water drainage system and ultimately falls after passing through 36 KM agricultural area into upper Channab Canal at Dhingan, Sheikhupura. The following Google Earth images represents the area traversed by these drainage system.



Thus vast agricultural areas are not only directly polluted by the drainage system disturbing the areas surrounding these drains but underground water is also affected by this drain system.

Most ironic fact makes it evident that untreated effluents are drained into the canal water which ultimately pollutes the downstream irrigation network.

It can easily be concluded that sewerage and drainage system of Kamoke disposes of effluents and sewerage into the irrigation system. There are 12125 household connections and these only cover 46 percent of the urban city center[108]. This state of affairs leads towards multiple sewerage and drainage related nuisances. The problem is further aggravated in the absence of any sanitation plan as highlighted here under:

- Contamination of irrigated water of upper Channab Canal.
- Contamination of food supply claim.
- Mushroom growth, of housing colonies without any master planning and proper approval of TMA.
- Sewerage is laid down quite often by other agencies and no proper map/records are available with TMA.
- Encroachments
- Plastic Bags
- Open drains
- Cattle dung
- Damaged sewerage lines
- Poor maintenance and supervision.

108 As per web-site mckamoke.lgpunjab.org.pk/SDD.html

10.1.2.2 Solid Waste Management

The are two dumping sites. A smaller private dumping site is situated at southern suburb areas near Nalla Dek. On the other hand majority of solid waste is dumped at a disposal site outside Kamoke at a place on GT Road, near to close proximity of upper Channab Canal, Chianwali, Gujranwala. The dumping site can be seen in the GEE image given bellow:

Only a fraction of solid waste is picked out of total waste generated as detailed under[109]:

Months	Estimated Solid Waste Generated per day (Tons)	Average waste lifted per day (Tons)	% of waste lifted
July 2021	117.42	77.25	65.8
Aug 2021	117.67	90.50	76.91
Sep 2021	117.92	86.84	73.64
Oct 2021	118.18	82.99	70.22
Nov 2021	118.43	90.18	76.15
Dec 2021	118.69	87.27	73.52
Jan 2022	118.95	84.04	70.65
Feb 2022	119.19	100	84.7
Mar 2022	119.45	100	84.1
Apr 2022	119.7	107.38	89.71
Total	**1185.6**	**906.45**	**76.45**

A vast amount of waste is dumped into the streets, open spaces, roads, canals, open drainage system, agricultural lands etc. This causes chemical and physical contamination of surface water especially because of intake of heavy metals from above mentioned industries result in risk of further long term environmental degradation of the drains and nullahs meant for conveyance and passage of discharged urban sewerage. Uncontrolled and open burning of solid waste (particularly certain types of plastics) releases smoke and gaseous contaminants into the air. The smoke commonly contains particulates, carbon monoxide and other contaminated gases including low level of dioxins, all of which can be hazardous to health. In some cases, direct hazard is caused from the generation of hydrogen sulphide due to disposal of certain types of waste, or the development of reducing, anaerobic conditions in the waste mass.

Fauna in and around dumpsites is impacted as a result of leachate and the same has adverse effects on groundwater and surface water. Plants near open dumpsites can be impacted directly by the waste dust or smoke from burning.

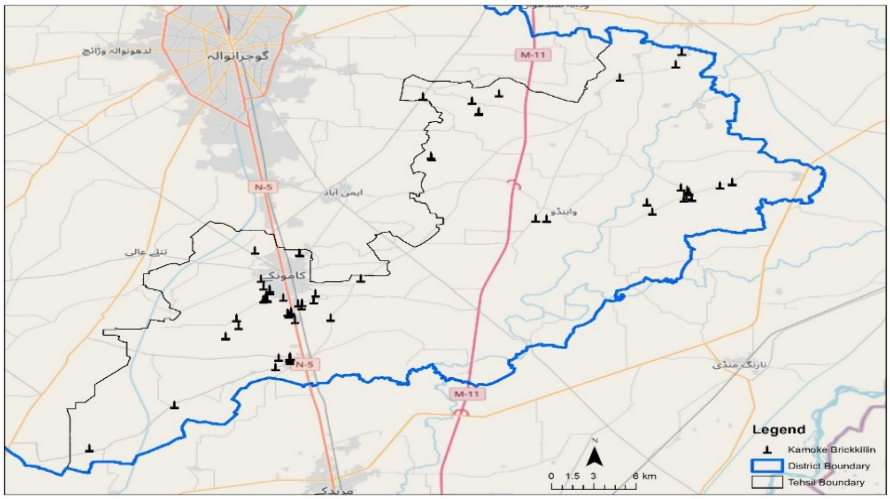
109 As per web-site MC kamoke.lgpunjab.org.pk/SDD.html

In short, open dumping and sewerage issues due to unplanned urbanization in the district cause:

- Public health issues
- Increase in Costs, relating to environmental impacts causing loss of potable water
- Decrease in the value of land in the surrounding real estate.
- Increase in the cleanup cost and
- Degradation of resources

10.1.2.3 Brick kilns

With rising pace of urbanization, the housing needs are increasing day by day. One of the basic requirements for housing is bricks. The number of brick kilns in the area, thus, are increasing rapidly. Brick kilns involve usage of large area and digging of pits and consumption of top soils in their surroundings. Location of most brick kilns as shown in the following diagram are within the confines of agricultural land which hamper the agricultural activity in the region[110].



110 Survey conducted by PMU, Urban Unit Lahore in 2017

Total area occupied by these 61 kilns is 610 acres approximately. This clearly indicates that a lot of agricultural land has been compromised due to construction activity related to urbanization.

Peri-Urban Areas

As stated earlier that as per Punjab Land Use Rules, 2009 peri-urban areas are those that span the landscape between contiguous urban development and rural country side with low population density and close proximity with agricultural activity and are likely to be urbanized in the next twenty years.

10.1.3 Growth of Peri-Urban Areas in Kamoke

The analysis of peri urban area through GIS system available with urban unit, Lahore indicates that the area is exponentially increasing around main city cluster. If we look at the conversion of agricultural land into urban areas since last 22 years as per GIS analysis of urban unit, a total 4,663.62 acres has been converted into urban structures where previously agriculture was practiced. Moreover, the trend indicates that the rate of expansion is rapidly increasing in recent years[111]:

Year	Kamoke	%age of Agri Area converted into urban Land scape
2008B-2002V (Area Acre)	1421.45	0.83
2014B-2008V (Area Acre)	2936.52	1.71
2022B-2014V (Area Acre)	2105.65	1.23
Total	**6463.62**	**3.77**

10.1.3.1 Expected Economic Loss in Peri-Urban Area

Given the definition of peri-urban area, an area that is expected to be fully urbanized in the next 20 years, loss of agricultural production as per current economic value of crops is expected to rise with the passage of time.

111 As per information obtained from PMU, Urban Unit, Lahore

10.1.3.2 Sewerage, Sanitation Drainage & Solid Waste Management

As stated earlier, only 46 percent of city's sewerage system is serviced by TMA. This area is mainly confined to the urban centers whereas the peri-urban area is devoid of such facilities. Similarly, solid waste management system is already weak, because as per website, only 76 percent of the waste is lifted from the urban center[112]. The situation is even worse in peri-urban where new societies are mushrooming unplanned and these areas are literally not covered by local bodies.

10.1.3.3 Housing Societies

New housing societies in great number are mushrooming in the peri-urban areas of the Tehsil Kamoke of various sizes. Main societies are Walid Town, Sabri Town, Aghosh Town, Mian Nadim Town etc. There are around 39 new housing societies with different names in the periphery of Kamoke occupying 438 acres of agricultural land. The most ironic factors observed in these societies is the fact that vast area of these colonies remained unoccupied but these sites are also devoid of any agricultural activity. Empty plots with provision of few infrastructural developments are in huge numbers. These lands just few years ago were being utilized for agricultural purposes.

10.2 Key Informant Interviews from Area Experts

During the execution of this study, Audit team coopted a number of area experts for offering their expert opinion on key contentious issues. The gist of the discussion with them is outlined hereunder:

a) Mr. Saad Yasin (Saad Seed Corporation)

In a formal discussion, Mr. Saad Yasin, a major supplier of vegetable seeds apprised the study group that they are selling local and imported seeds all over Pakistan dating back to early 1970s. Over the last

112 As per web-site mckamoke.lgpunjab.org.pk/SDD.html

decade, they had observed a marked decline in the sale of seeds of vegetables and fruits in Gujranwala region and claimed that situation was similar in Kamoke Tehsil. On further inquiry for the reason of decline in sale, he apprised that seeds of vegetables and fruits were normally grown in close proximity of the urban cluster, however, due to emergence of new housing societies such land was being overtaken by different groups and individuals for construction of housing societies. A large chunk of land had been handed over to these individual/groups who had abandoned any agriculture related activities in these areas. As a result, despite the absence of any meaningful housing or infrastructural activities in such areas in Proximity of Kamoke, sale of seeds of vegetables and fruits had declined drastically over the years.

b) Director General Agriculture Extension

This Audit team had a very meaningful and lengthy discussions with Director General Agriculture Extension. During discussions, it was made clear by the DG Agriculture Extension that if sown area was analyzed all over Punjab including Kamoke and Sahiwal, the cultivation area had increased to some extent and so was the per acre production with better technological interventions over a period of time. However, he showed his concerns regarding compromising of highly fertile land due to rapid and unplanned urbanization. He was of the view that no doubt, more area had come under cultivation which previously was not utilized but the area compromised was of highly fertile land with ready availability of water through irrigation system and losing the same involves irreparable depletion of best repositories of irrigated cultivable fields.

c) Director General Agriculture (Water Management)

During discussion with Director General Agriculture (Water Management), Lahore, it transpired that availability of water both on surface and underground was declining fast. This scarcity of water availability could be detrimental to our survival as a society. He blamed

unplanned urbanization in the cities and towns as one of the key factors causing lowering of underground water table. With more population, water extraction had increased and on the other hand reduced rainfall and flow of rivers and canals was not allowing proper recharge of underground water. He was also of the view that infrastructural developments were also creating hurdles in underground recharging of water tables. He claimed that reduced availability of water was attributable to lack of storage capabilities. Moreover, as Global environmental factors and climate change was beyond our control, so there was an urgent need for smart technological interventions with the help of which crops with better yield could be grown with minimum quantity of water. He emphasized on adoption of such technology to overcome water shortages and described various initiatives that Director General Water Management was undertaking in this regard. He claimed that Drip Irrigation System and use of HEIS were steps taken by them in this regard which used less water and provided better production.

d) Views expressed by Dr. Shaukat Ali, an eminent Faculty member in Environmental Chemistry Punjab University with Water as an area of Specialization.

Dr. Shaukat Ali opined that it was necessary to develop an approach that facilitates integration of the environmental and social assessments. Surface water and groundwater (separately or in combination) were used to fulfill the crop water requirements. The declining water resources needed to be managed in an integrated way at basin scale. In fact, water management had to undergo significant improvements in terms of vision, targets, decision-making, and accounting. Hydrological simulation models could be used as analytical tools for determining the water flow paths. Spatial information of topography, land use, rainfall, soil moisture, evapotranspiration, and leaf area index, derived from remote sensing could be used for, and will enhance spatially distributed modeling. Such data could also be used to validate and calibrate hydrological models.

Conventional water resource planning and management was mainly focused on blue water (water in streams, rivers, aquifers, lakes and reservoirs). There was a need to incorporate rainfall, especially in arid and semi-arid basins, that infiltrated naturally into the soil and on its way back to the atmosphere in the form of evapotranspiration (green water). Managing non-beneficial evaporation would result in a significant reduction in water use that could be re-allocated to other users. Groundwater could be a primary buffer against drought, as its response to short term climate variability was slower than surface water systems. The mismanagement of this buffering system could lead to serious impacts on the environment and ultimately on food security. Sustainable management of groundwater was considered a more serious challenge than development. The challenge was complex. The absence of a robust knowledge base was a major hindrance to sound management. In general, the integrated system, correctly managed, would yield more water at more economic rates than separately managed surface and groundwater systems.

The problem of parameterization and lack of data for sound validation of modeling of large basins could be overcome by hydro-meteorological information from earth observation satellites. Land use, rainfall, soil moisture, water levels, total water storage changes, evapotranspiration, etc. were examples of data that could be obtained via satellites. These spatially distributed parameters could be used for distributed hydrological modeling and validation.

e) Views shared by Mr. Babar Bashir, former Deputy Commissioner Sahiwal

The peculiar nature of the District Sahiwal as a repository of Fertile agricultural cropland warranted customized solution for conservation of spatial zones including peri urban and agro forestry Zonal delimitation. All such interventions needed to be reinforced handling the litigations denting enforcement under existing legal framework.

TMOs tended to lodge FIRs in police station under Section 420 of Pakistan Penal Code and provisions of the Punjab Private Site Development Schemes (Regulation) Rules, 2005 but to no avail. The Revenue department banned commercial housing societies at intermittent intervals because they did not fulfill legal requirements provided in "The Punjab Private Housing Schemes and Land Sub Division Rules 2010 (Amended 2012)", yet the sale and exchange of files of plots continued on ground.

A number of cases were registered under Sections 7, 09, 13, Schedule 4, Part II of the Punjab Local Government Act -2013 and sealing of premises were also resorted to as teams sealed officer of housing schemes but only with short lived deterrence because of proceedings seized of before honorable courts and restraining orders obtained by beneficiaries.

There were missing links in legal frameworks which allowed the perpetrators of serious violations to go scot free. This umbrella was extendable by way of invoking the following;

I. Charging of condonation fee for conversion of agriculture lands to nonagricultural purposes
II. The *Punjab* Commission for regularization of irregular. *Housing schemes ordinance* 2021.

A comprehensive legal instrument with biting penal provisions was direly needed to restore semblance of normalcy for preventing housing schemes to defeat conservation of arable landed assets.

f) Opinion given by Sardar Asif Siyal , an eminent environmental jurist and an Alumini from University of Berkley USA

Sardar Asif Siyal, an eminent Environmental Jurist shared his words for mentoring when he cautioned that it was but imperative to advert to the Medium-Term Strategy (2022-2025) expounded by United

Nations Environment Program that sought to ensure that the link between science, policy and decision-making forged a catalytic response to the challenges of climate change, biodiversity loss and pollution. In particular, cross-sectoral planning and integrated policy mixes were essential to find synergies in managing the use of lands and waters across sectors and jurisdictions, designed for resilience. Governance approaches that coordinate and monitor multiscale policy actions and trade-offs across sectoral, local, national, regional and international levels were best suited for sustainable development.

In the context of arable lands in Sahiwal eaten up primarily by built up area due to urban sprawl and mushrooming increase in housing societies, the number of local varieties and breeds of domesticated plants and their wild relatives had been reduced sharply as a result of land use change. At a broader level, the spread of invasive species was one of the most important direct driver of biodiversity loss. Biodiversity loss and decline in regulating ecosystem services did pose risks to food production through impacted on pollination, resistance to more frequently applied pesticides and soil nutrient losses. Ground-level ozone was a strong oxidant that could enter plants through the leaves, affecting photosynthesis and other physiological functions, and thereby affecting forest productivity and agricultural yields.

Combined with scarcity of water in river channels and excess pumping of groundwater, an emerging challenge to land managers and policymakers was deterioration of water quality, negatively affected by waste discharges, including pathogens from wastewater, untreated sewage discharges, and heavy metals and organic chemical from industrial sectors. New pollutants not easily removed by current wastewater treatment technologies were of grave concern. Drought resilience policies have to factor in drought preparedness planning, early warning and monitoring, and improving water use efficiency

Government policy and incentives could speed the phase-out of fossil fuels in power generation such as coal fired power plants and transportation, including by supporting the development of renewable energy storage with a view to adopt plans and goals consistent with the Paris Agreement. This would lead to adaptation and resilience to climate change also developing policies and strategies to integrate biodiversity conservation into the many uses of terrestrial, freshwater, besides expanding and improving protected areas so as to drastically reduce deforestation.

Multifunctional landscapes and waterscapes could be the basis for a shift towards ecological intensification or biodiversity-based agriculture, which aimed to enhance ecosystem services generated by agro-diversity, some of which boosted production. Options include protecting or expanding green spaces that could reduce the Urban heat island effect and absorb rainwater, retrofitting infrastructure, and promoting urban and peri-urban agriculture. Cities must also address the issue of informal settlements, which contributed to environmental degradation and bore the brunt of its consequences. City planners must deliver or facilitate high-density, mixed-use and resource-efficient settlements, low-carbon transport and other infrastructural systems, with access to safe and abundant green space.

g) Focused Group Discussion with Residents and stakeholders of Sahiwal

During visit to Sahiwal, many residents shared their common issue regarding construction of power plant. They complained that traffic of trucks carrying coal had increased in the area. Many residents complained cutting off irrigation outlet from LBDC canal for entire mauza of 76-5 R for an arable tract of 325 Acre. Ground water quality also reportedly suffered after commissioning of the coal fired power plant at Qadirabad Sahiwal.

11. INSTITUTIONAL GAPS IDENTIFIED DURING THE STUDY

Some of the major concerns observed are outlined hereunder:

a) Director Crop Reporting, Agriculture Department Government of Punjab was requested repeatedly for providing data regarding various crops grown in Tehsils Kamonke, Sahiwal and Chichawatni but the said office showed a lackluster response and instead after the lapse of almost 6 months of serving the requisition, the said office contended that data cannot be provided Tehsil-wise (Annexure-4). This contention was not tenable as samples were to be based on methodology (Area Frame Sampling) adopted by Crop Reporting Services. Already Directorate of Crop Reporting Services had admittedly put to use Tehsil Level data being applied by Crop Reporting services for processing crop insurance compensation claims as is evident from Directorate Crop Reporting letter dated 22-04-2020, addressed to DG PBS it has been asserted that statistics are consolidated at all tiers of administrative units. In relation to Crop Insurance facility extended under SMART Program, Area yield Index model had been adopted. This model at present operated at Tehsil level. Moreover, the expenditure charged related to the heads of accounts of travelling allowance and POL with nothing spent on acquisition of hardware and software to operationalize GIS based Remote Sensing with no data consolidation possible for commissioning of area frame sampling methodology in Punjab.

b) Similarly, Director General Soil Survey was contacted to share relevant data for the study area as the said office had the basic function of maintaining Database regarding the

soil composition and quality in its repository from time to time but it also declined that it did not have any such information available with it.

c) Environment Protection Agency and Tehsil administrations did not respond in a timely manner and after lapse of considerable time directed their sub-offices to provide the requested data to Audit (Annexure-5) but to no avail. The sub offices did not provide any information despite repeated contacts till finalization of this report.

d) GIS Cell of the Forest Department also did not provide any useful input sequel to the request of Audit. Audit deemed it important to analyze the impact of Urbanization on Forest area in the region but either such information was not available with the Forest Department or they showed their unwillingness to provide the same (Annexure-6).

e) Similarly, Director Soil survey has withheld readings of samples for soil examination of the study area not yet shared with Audit

f) The entire outlay of Development spending by Agriculture Department is thus based on feasibility and data devoid of assurance.

g) Environmental samples with results of monitoring from lab based reports have not been shared from EPD. The enforcement of polluter pays principle thus ceases to be a pragmatic possibility.

h) Data despite computerization of land record for Ginswar and assessed taxation based on Geo mapping for assessed properties by excise Department was not made privy to the Audit Team.

i) Departments have commissioned ICT and reporting modules such as Area Yield index model yet disowned the validity of both

j) District Governments are clueless about obligations to notify master plan or enforcing zoning restrictions and have not bothered to respond to relevant queries (Annexure-7)

k) Vegetation Cover is being lost due to loss of forest land vital for watershed management, soil conservation and carbon sequestration as 2079.70 Acres of Forest Land is a Built up area in Chichawatni (Annexure-8) Forest. Valuation of encroached upon land is not less than worth Rs 6239.1 Millions.

l) In the surrounding localities, Depalpur Forest has 115 Acre of built up Area for rest house and colony, and 387.8 Acre has been depicted occupied by other Departments whereas Pirowal (Annexure-9) Forest satellite image depicts sizeable chunks lost to other Departments.

m) Notified spatial plans, master plans, zoning, land use plans, including classification and reclassification of land, urban design, urban renewal are non-existent and hence represent neglect of authorities.

n) Lack of master planning for urban centers and peri-urban areas is another matter of concern as the problems associated with unplanned urbanization are exacerbating unabated. Cropland loss has unfolded as a significant concern imperiling self-sufficiency in food production particularly, bringing unavoidable challenges for competitive land use. Data discrepancies reporting misleading figures on cultivated and fallow arable lands for successive crop seasons are areas of serious concerns (Annexure-10). Already, the country has turned into a net importer of agricultural products despite being one of the

world's large growers of wheat, rice, cotton, fruits, livestock, and livestock products.

o) Punjab Housing and Town Planning Agency (PHATA) is devolved the responsibility to establish a comprehensive system of town planning at provincial, regional, district, tehsil and union council levels in order to ensure systematic, integrated growth of urban and rural areas in the province of Punjab. Barring three major cities masterplans of intermediate cities are conspicuous by absence.

p) The inaccuracies in crop reporting data directly impact and lead to lack of well-informed decision making at Government level.

Wheat Crop Area in Acres			
Year	**Crop Reporting Services**	**Board Of Revenue**	**Difference**
2017-18	16,210,000	18,646,000	2,436,000
2018-19	16,052,000	18,756,000	2,704,000
2019-20	16,099,960	17,685,000	1,585,040
2020-21	16,670,000	17,962,000	1,292,000

Source: Crop reporting Services & Mechanical Tabulation Reports of Punjab Bureau of Statistics)

The above table illustrates that there was lack of transparency and accuracy in the crop area reporting by different government department

q) Due to duality of policy framework, multifold enforcement problems encountered putting the sanctity of the master plan at stake, without exception, all tehsil/district governments were using commercialization fee as a tool of generating revenue. According to the policy, every residential use can convert into commercial with few restrictions as imposed by the commercialization committee.

r) More so, the supply of serviced land is constrained by inadequate trunk infrastructure provision to developable sites, inappropriate and inefficient land use plans. These all factors make land so expensive and unaffordable by low-income group, making dream of good living as unachievable. Haphazard arrangements of informal housing settlements on the outskirts of cities as well as near the urban centers give an image of poor urban management.

12. CONCLUSION AND WAY FORWARD

Present day Intermediate Cities such as Sahiwal and Kamoke are a mixture of quite often divergent and incompatible uses. The Land Use of the urban area as a whole can be described as developed out of sprawl without any preconceived plan.

Originally, the area of the Sahiwal Town was 307 acres only. Town started eating up peri urban tracts indiscriminately and expanded towards vacant parcels in all directions.

The Outline Development plans of the cities show that out of the total area surveyed, the largest portion is of the undeveloped area. It accounts for 41.70% of the total area surveyed. It is found in scattered pockets within the built up areas and in open strips between various built up belts which ultimately join the agricultural land around the city. Same is the analogy of Urban Sprawl set in motion at Kamoke.

Dormant response mechanism by government departments and agencies is in vogue as delineated hereunder:

I. There is no mechanism in place for conservation of Agriculture land.

II. New housing societies are mushrooming without due approvals from the responsible government agencies.

III. Provision of necessary facilities like sanitation, sewerage etc. are facing coverage deficit in rural areas.

IV. Peri-urban areas are not well defined, with proper delimitation.

Urban-rural diffusion is taking place alongside the major highways at a faster pace. There has not evolved any comprehensive and exhaustive urban planning/town planning law at provincial level and as such Master

Plans and Peri-urban plans are yet to be devised across the board to avoid the negative consequences of ill-planned urbanization.

Ultimately, how urbanization is required to be managed for being integrated into agriculture has not been understood holistically. Neither it has been revamped institutionally as a priority in governance agendas nor streamlined in such a manner that the benefits driven from ecosystems are integrally recognized across general policy and actionable deliverables. Anticipated urban growth in Punjab is still to be transformed into a window of opportunity to forge an urban form that could acknowledge and embrace the role of biodiversity. While this can assuredly be informed and aided by experiences gleaned from the sustainability driven livable cities, unique nature of urbanization in Punjab has not so far been grappled with inclusive of particularities and opportunities presented by the study area.

The environmental consequences of land degradation are vast, including amplified soil losses, water quality deterioration, biodiversity decline and degradation of ecosystem services. The ultimate goal is however to attain self-sustainability whereby environmental and production potentials are supported by self-regulating processes within the system.

National Environment Quality Standards (NEQS) are notified yet not enforced through regular checks of environmental sampling leading to dormant invocation of polluter pays principle and yields degradation of ecosystem services. Most important factor is to conserve precious agriculture land from being urbanized or degraded. Sample case study of two cities clearly indicates that urbanization has a direct impact on the agricultural production. Inaction and inattention is trademark response for undertaking Spatial urban planning taken at Government of the Punjab's level for controlling the urbanization without compromising the industrial and economic growth. Such a planning in peri-urban areas is more

important because these areas normally emerge as new epicenters of economic activities.

Adverting to the key research question whether current state of affairs could be allowed to perpetuate, it is imperative to forge concerted efforts revolving around broad based remedial action plan, reinforced by synergy of multi pronged interventions. The core areas which need to be focused upon include, concrete interventions targeting conservation of arable lands, taking recourse to spatial planning, strict implementation of restrictions upon land use and land conversion changes in protected zones, doing away with governance gaps and improvising reform agenda based on a well conceived action plan.

Polluted water from urbanized and industrial waste remains untreated while being disposed of into the irrigated system. Remote sensing technology is to be considered essential for dealing with dynamic phenomenon, like urban sprawl. Without remote sensing data and GIS analysis, one may not be able to monitor and estimate the urban sprawl effectively over a time period, especially for elapsed time period. Also the use of satellite images does assist in identifying the spatial and temporal patterns of urban land expansion from the urban core, and in detecting land-use change in urban fringes, especially in what concerns the relation between urban and agricultural land uses.

Unplanned and unwieldy urbanization by way of consumption of arable land occasioned by urban sprawl have had negative impact on prospects of achieving sustainable development, contrary to the agenda of 2030. This agenda provides benchmarking for the prosperity of people and planet now and into the future.

13. RECOMMENDATIONS AND ACTION PLANS

A series of recommendations are recorded which merit consideration for implementation, given the backdrop that looming threat of ill-planned urbanization carries a huge cost which entails damage to ecosystem, if not tackled in a timely manner.

Proper planning and research needs to be undertaken before giving approval of new housing societies. These societies are causing fast conversion of agriculture land into a denomination of urban land use. Need assessment, compatibility with spatial plans and zoning restrictions, and environment impact assessments ought to be specific prerequisites before earmarking and approving the area for housing societies.

Options include protecting or expanding green spaces that can reduce the heat island effect and absorb rainwater, retrofitting infrastructure, and promoting urban and peri-urban agriculture.

City planners must deliver or facilitate high-density, mixed-use and resource-efficient settlements, and other infrastructural systems, with access to safe and abundant green space.

It is crucial to promote more intensive and smarter use of space and regeneration of city centers. Urban systems transitions require deep and far-reaching solutions, significant up scaling of investments and institutional capacity development.

Integrated city-specific and landscape-level planning, nature-based solutions and responsible production and consumption are key solutions, simultaneously promoting ecosystem-based adaptation within communities; maintaining and designing for ecological connectivity within urban spaces; increasing urban green spaces and improving access to them; increasing access to urban services for low-income communities; and promoting urban agriculture to increase local food supply.

Air pollution such as ground-level ozone, smog and escalating Land Surface Temperature also negatively impacts agricultural yields.

Future agricultural expansion need to be earmarked to take place on more marginal lands with lower yields.

Biodiversity loss poses risks to food production. Water pollution has continued to worsen over the last two decades, increasing the threats to freshwater ecosystems and human health.

Sustainable policies, technologies and management practices need to be implemented within the interconnected agriculture-fisheries-forestry-water-energy systems given their impact on climate, biodiversity and land degradation. Transforming the nexus of energy, human settlements, agriculture, forestry and water systems is among the highest priorities for which a strategic intervention is called for aiming at sustainable land management practices for agriculture and forestry.

Water quality is negatively affected by waste discharges, including pathogens from wastewater, nutrients from untreated sewage discharges and agriculture, and heavy metals and organic chemical from industrial and agricultural sectors. New pollutants not easily removed by current wastewater treatment technologies are of emerging concern.

One of the key elements which can help in warding off the negative hazards of environmental pollution is a robust environmental monitoring mechanism. Such gaps not only require a mechanism of environmental readings but also a mechanism to ensure that gaps found as result of such readings are evaluated and actions are initiated where ever such gaps are found.

Modern techniques and technologies for higher agricultural yield need to be introduced.

Master Plans and Peri-urban plans need to be devised across the board to avoid the negative consequences of ill-planned urbanization.

Modern water conservation technologies like Sprinkle and Drip Irrigation system need to be introduced to reduce the pressure on underground water and allowing aquifer to recharge.

Well planned industrial zones need to be established, so that mushroom growth of industry without planning by way of usurping agricultural lands be avoided and socio-economic negative impact of such industry can be warded off.

Encroachments can be seen all around and district administration has failed to control the illegal encroachment in the urban centers as well as rural areas. An immediate campaign needs to be undertaken by district administration for removal of illegal encroachments.

A comprehensive legal instrument with biting penal provisions are direly needed to restore semblance of normalcy for preventing housing schemes to defeat conservation of arable landed assets

As has been illustrated in this study, a number of initiatives to conserve agricultural land and to avoid negative consequences of unplanned urbanization need to be undertaken. An out of the box thinking is needed to devise such initiatives that can add true value to the agriculture and urbanization.

It is imperative to guide the spatial zoning of intermediary cities, from a very early stage for improved climate resilience and reduced emissions, by building them as climate-proof cities instead of climate-proofing them later avoiding the “grow now, clean later” path, which definitely costs more.

Timely interventions are mid-course corrective measures in spatial planning is a critical aspect for building climate resilience and avoiding

carbon lock-in. This includes integrating infrastructure, housing and transport policies into spatial planning, while accounting for the needs of vulnerable populations in informal settlements.

Some of the action plans are proposed in Annexure-3 as a way forward to tackle the problems confronted.

14. REMEDIAL MEASURES

Based on the observed consequence of urbanization, this study has produced a number of recommendation and action plans, enumerated hereunder:

i. There is a strong need to clearly delineate zonal boundaries to distinguish between residential, large scale commercial, industrial and other Land Uses in the District. The purpose is to control and direct the use and development of land and properties.

ii. In the District Land Use Plan, like all other zones, specific Land Use parameters need to be formulated for different zones to facilitate better and effective planning control in the area. An Electronic Data Bank (EDB) should be developed to serve as the eyes and ears to the monitoring process.

iii. Improvements in urban planning, governance, infrastructure and the use of nature-based solutions can be cost-effective to reduce pollution and prove to be resilient to climate change impacts such as increased urban heat island effects accentuating rise in Land Surface Temperature inimical to crop productivity patterns.

iv. The Land Use Land Conversion (LULC) change studies need to be commissioned to obtain useful information for a better understanding of previous practices, current LULC patterns, and future LULC trajectory. This purpose will also be well served if the proposed study also coopts a techno-legal area expert having the credentials of eminent environmental jurist for evolving a stringent legal framework capable of salvaging ecosystem management, besides paying specific attention to inventories and

valuation of biodiversity, environmental monitoring and species habitat suitability investigation pivoted around conservation of arable land.

v. Efforts to reduce local air pollution, such as from black carbon (soot), and ground-level ozone and its precursors, can also contribute to mitigating climate change. The geo-spatial techniques particularly remote sensing augmented with GIS are to be harbored as vital tools and are preferably to be used in studying landscape changes and decision making for sustainable urban development. Ecosystem services losses are in need of being reversed, mitigated and arrested by way of forging inter agency and intra agency linkages.

vi. Achieving sustainability will require increased water use productivity in agriculture, improved management of urban water and other water users.

vii. Improving surface irrigation water quality through urban and industrial effluent controls needs to be an area of early intervention, also entailing improved interface between provincial and local governments.

viii. There has been an exponential rise in the number of tube-wells due to which water table is going down in many parts of the country. Therefore, an implementation of strict policy is needed to regulate the number of tube-wells. Furthermore, in the overexploited region, artificial groundwater recharge might help to improve the water table.

ix. Reaching climate goals in the building sector require more stringent renovation and construction standards than those currently in place to optimize the energy structure, promote

industrial upgrading, develop low-carbon economy, build a resources conserving and environment-friendly society.

x. The potential impacts from resource consumption such as hydrocarbons, timber, and coal-fired energy needs to be reduced, besides local emissions leading to reduction of the carbon footprint from energy consumption.

xi. The ecological and carbon-sink functions of the land has not been preserved. Energy efficiency has to be improved and the circular economy should be promoted.

xii. On the level of architectural characteristics that can be described through the development code, the topic of sustainability has not been tackled through the development of typologies that wed traditional climatic expertise with contemporary lifestyle to be regulated by master planning – as a starting point for bio-climatic principles

xiii. Sewerage and industrial effluents need to be treated before spilling the same to some water bodies. Outreach of facilities like solid waste management, sanitation, drainage etc. need to be enhanced to provide maximum overage.

xiv. Master plans are to be revised. Peri-urban planning needs to be revamped.

xv. There is a dire need for integrated rural development strategy to increase agricultural production by increasing rural labor productivity through improved farm technology, increasing farm inputs such as fertilizers, high yielding variety of seeds, insecticides, adequate agricultural extension services, price incentives and better access to financial credit and market facilities.

xvi. Resettlement on voluntary basis from highly degraded areas to where there are vacant and potentially productive

irrigable lands can reduce the flow of people towards urban areas are to be improvised.

xvii. Efficient use of water and building proactive partnerships that involve the private sector need to be ensured which will contribute to fulfillment of agriculture's potential for diversification and growth.

xviii. Pollution of the surface water bodies and groundwater aquifers affect the whole ecosystem in general and the human health in particular. Therefore, the industry and other sectors polluting the water bodies should be charged by imposing Pollution Tax using the "polluter pays" principle.

xix. Research efforts in crop and the related sectors should be enhanced to produce varieties having flexibility and tolerance to drought, heat and salinity. An alternate cropping system needs to be developed to reduce irrigation requirements during the dry period.

xx. Studies should be undertaken for developing innovative technologies to create flexibility in the existing rigid warabandi system so as to provide water at the critical stages of crop growth in various parts of the Indus Basin.

xxi. A regulatory framework should be devised and strictly implemented for the installation and operation of tube wells to reduce and control the over extraction of groundwater. Investments in urban management infrastructure and services across clusters of cities in Punjab has to focus on making cities more efficient and services more sustainable to promote safe, reliable, and more widely available water, sanitation, and transport.

xxii. Urban sewerage and water treatment systems require revamping, conforming to demonstrated demand and

stakeholder acceptance, once the concerns over management and pricing of utilities are resolved.

xxiii. By recourse to urban renewal interventions, a large number of poor people residing in informal settlements, katchi abadis and sub-standard nai abadis are to be provided with adequate access to clean water, sewage draining, waste disposal, being worst prey to environmental deterioration.

15. ANNEXURES

Annexure-1

Generic Audit Finding Supplementing Core Issues identified

i. Land acquisition for establishing coal-fired power plant, land fill site for municipal waste disposal, construction of motorways particularly in the case of Lahore-Sialkot motorway passing through Kamoke have also led to depletion of arable land in respective district and tehsil selected as study area.

ii. Conversion of arable land into urban use is an easy option to exercise but the process once triggered is not reversible as the alternative option of capitalizing upon agricultural productivity enhancement for rain fed produce in arid zones are not viable.

iii. Urbanization is also having indirect contribution in degradation of soil fertility also leading to decreasing water table of subsoil ground water due to extraction from ground through tube-wells.

iv. Adverse socio-economic effects of unplanned urbanization in the shape of pollution exacerbated by degraded sewerage system, and lack of sanitation facilities are also observed.

v. Quality of underground water has degraded due to pollution hazards created by unplanned urbanization.

vi. Poor waste management system and location of dumping sites are not only adversely degrading soil fertility but also creating health hazards for the population.

vii. Uncontrolled urbanization is creating slum like situation in urban fringes of the city areas. Such a situation has created

health, education and sanitation problems for the slum dwellers and agricultural pockets in peri urban areas.

viii. Mixing of untreated sewerage of urban centers and industrial waste into the irrigation system is a serious concern as it is poisoning the food chain of the bread basket of the country.

ix. Efforts for water conservation technology are not yet orchestrated to factor in comprehensive regulatory framework securing conservation of agricultural lands, irrigated through canal system.

x. No road-map is in place to meet SDGs' target set by UN by the year 2030.

xi. Improvements in the welfare of the rural poor have not occurred who are deprived of significant investments in infrastructure and improvements in social services, including safety nets.

xii. The vast actual or perceived difference between rural-urban incomes causes population migration. Since poverty is a pronounced rural phenomenon, migration from rural areas is tied to the income gap between rural and urban areas.

xiii. Two critical elements must underpin the necessary transformation of the rural sector. First is the efficiency of public institutions and the need to make these more accountable and flexible. Second is the capacity to organize the "people sector" so that farmers, communities and villages gain a voice and achieve the scale needed to attract the private sector and financial services as well as to strengthen the demand side of development by making government more accountable.

xiv. Improvements need to be made in water delivery (including investments in drainage, control structures and conveyance mechanisms), better water management (through strengthening of water course organizations, area water boards or professional canal management agencies) and greater efficiency of water use at the farm level (crop choice and adoption of water saving technologies) as the most promising approaches in the short to medium-term.

xv. Government need to build a coherent strategy (or framework of strategies) for quality and Sanitary and Phytosanitary (SPS) management in relation to its trade. Organizationally, there is a need to consolidate and enhance the fragmented, isolated, and non-coordinated capacity of SPS management institutions and regulations in order to exploit immense export potential of agricultural produce which will reduce pressure of rural-urban migration immensely.

xvi. Faster growth in Pakistan's exports of non-traditional agricultural products (fruits and vegetables, meat, fish) need to develop improved capacity to meet Sanitary and Phytosanitary (SPS) standards imposed by importing countries. This can be achieved by better defining the roles and responsibilities of the various agencies involved in SPS management, strengthening technical capacity for risk assessment, and re-institutionalizing early warning and surveillance systems for pests, diseases and contaminants.

xvii. Trade policies and governance issues that reduce efficiency of supply chains for processing, transport and commercialization of high-value agricultural products also need to be addressed. These issues are particularly

important for products destined for highly competitive international markets.

xviii. CSA initiatives sustainably increase productivity, enhance resilience, and reduce/remove greenhouse gases (GHGs), and require planning to address tradeoffs and synergies between these three pillars: productivity, adaptation, and mitigation.

xix. Mainstreaming CSA requires critical stocktaking of ongoing and promising practices for the future, and of institutional and financial enablers for CSA adoption.

xx. Market linkages need to be facilitated by supporting the creation and development of more effective local business associations or organizations. These organizations could arrange product fairs, help develop business directories, and provide information services and details on how to undertake market research. They could also share information on prices, quality standards and how to access technical, financial and organizational services for greater value addition.

xxi. Various measures are needed to increase the flow of credit and spur investment and growth:

   a. Develop alternative forms of collateral acceptable to banks. Make procedures for loan applications less cumbersome

   b. Provide practical training for entrepreneurs in accounting and preparation of business plans to improve their ability to signal credit-worthiness to financial institutions.

c. Organize potential borrowers in groups or professional associations to reduce risks and transaction costs for lenders

d. Strengthen the institutional and regulatory framework for the enforcement of contracts, arbitration and conflict resolution

xxii. Group marketing and business clusters need to be facilitated in order to help rural enterprises take advantage of scale economies, thereby allowing them to purchase inputs at lower prices, access larger markets and share the use of equipment and infrastructure.

xxiii. Major infrastructure constraints (e.g. roads and electricity) that hinder growth of the rural non-farm sector need to be addressed in order to ensure greater flow of resources to local governments and increased efficiency of public current and development spending.

xxiv. Improvements in public-service delivery in health, education, water supply and sanitation are needed to enhance welfare of the poor and build human capital for future income growth.

xxv. Provision of infrastructure, particularly roads and reliable electricity needs to be ensured to reduce operating and marketing costs, making investments in enterprises in rural areas and small towns more profitable.

xxvi. Modern techniques and technologies needs to be practiced for improved agricultural production and water conservation.

xxvii. Forest coverage needs to be enhanced. Ways and means are to be explored for development and management of water resources by way of small dam reservoir build up that

should be given top priority to address the water and food security issues to store excess water from melting glaciers and runoff from Monsoon rainfall so as to provide relatively cheap hydropower while controlling floods and droughts caused by climate changes.

xxviii. Building small and medium size dams and ponds is equally important to store runoff and any excess water. These dams and ponds can also contribute in recharging aquifer at local level.

xxix. Immediate measures should be taken to minimize water losses from water courses and wastage of water at field level. This can be done by properly improving the water courses to minimize seepage and leakage, while wastage in the field should be minimized by adopting laser leveling and appropriate sowing methods such as bed planting etc.

xxx. Pricing system of water use for agriculture, industrial and domestic purposes needs to be developed and effectively implemented.

xxxi. Spending on rural public service delivery is highly fragmented, with major components allocated across the various levels of Government. A concerted effort has not been put in place to coordinate government's rural development efforts.

xxxii. Access to electricity remains a major challenge in many villages and small towns, and even among enterprises which confront electricity access with questionable reliability of supply devoid of certainty. The median number of days with power outages in a typical month was reported as 15 days in villages and 10 days in small towns.

xxxiii. The Climate Smart Agriculture (CSA) concept is a concomitant of integration of agriculture development and climate responsiveness. This entails opportunity cost at the expense of food security and broader development goals under a changing climate and increasing food demand.

xxxiv. As evident from the study, that Solid Waste Management Systems in both of the locations failed to lift 100 percent litter from the urban centers which ultimately contributes to environmental hazards. The situation is not expected to be different in other parts of the province. Hence, there is urgent need to enhance the capacity of the TMAs in lifting the litters. The locations of disposal sites in both urban centers of Sahiwal and Kamoke observed to be in the peripheries of dense population pockets and on the banks of canal water used for irrigation purposes. This clearly indicates lack of proper planning in this regard. Steps need to earmark lands away from populations and disposals should be made with proper SOPs to ward off the negative fallout of handling scientific landfills and leachate disposal. Drainage system of the urban centers in both regions are not up to the mark and contributes a great deal in polluting environment, underground water, surface water sources like canals. Hence, problems with drainage system need to be resolved to avoid the negative consequences faced by them. The drains from urban center of Kamoke are mixing with flood water drain of Dek which ultimately discharge untreated effluents in Lower Channab Canal used for agricultural purposes. Steps needs to be taken to properly dispose of effluents after due treatment rather than polluting the irrigated water with toxic deposits of heavy metals to save the food chain from being polluted.

xxxv. The facilities of sanitation, solid waste disposals, drainage etc. in terms of coverage of serving area delimitation are not extended in the peri-urban areas. Peri-urban areas and to provide these facilities at later stages would be more costly, problematic and much delayed.

xxxvi. Brick manufacturing units or brick klins are fast spreading in both regions i.e. Kamoke and Sahiwal to fulfill the housing needs of the urban centers. However, traditional kilns occupy a lot of land that results in abandoning agriculture in such areas. Traditional klins has been replaced in other regions of the world. Small manufacturing units that occupy a much smaller space and can be installed in any area without disturbing agricultural lands.

xxxvii. Ash wood making techniques and methods are fast replacing traditional bricks as raw material for house construction in many parts of the world and in Pakistan too. These bricks are cheaper, stronger and can be produced in more quantity. Government should initiate steps to encourage such technologies to conserve maximum land for agriculture.

xxxviii. Reducing the chunk of arable prime land concedes a loss monetized with value of the five Ecosystem Services (food production, water conservation, climate regulation, habitat support and cultural service) which indicate that the increases in construction land area have a negative impact on ES.

xxxix. It is important that the government fulfills its obligations to strengthen urban land-use planning systems so that there is increased stakeholder participation in land use planning to prevent the indiscriminate arable land sale. Finally, the

government is yet to encourage vertical-type building construction for commercial and residential purposes.

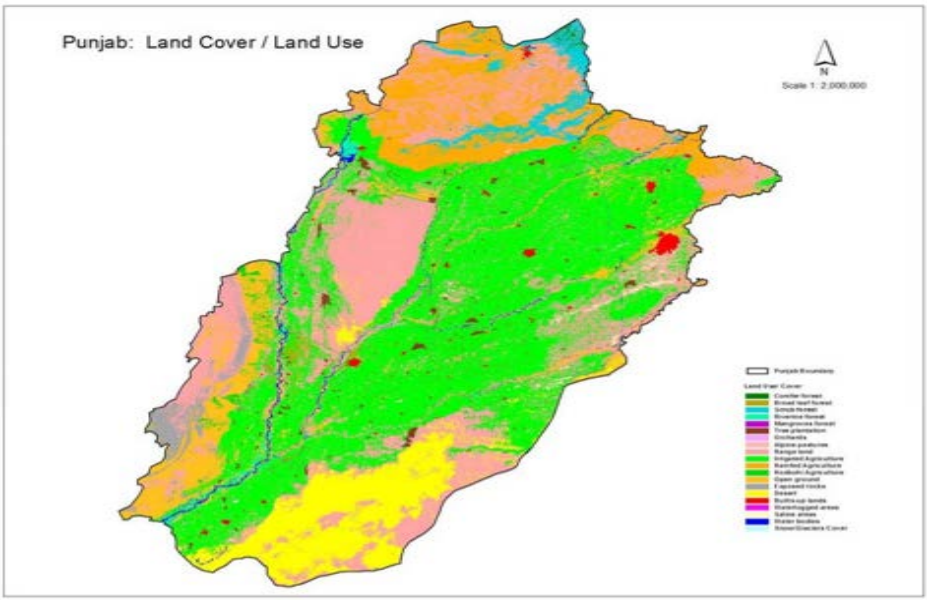
xl. Master Plan finalization is taking multiple years to complete and after completion, it could not be adopted or implemented. It is necessary to set development priorities in light of fiscal and administrative/organizational constraints of government that are ultimately responsible for implementation of the plans. Development plans turn in the fiasco if not backed by legislation, organizational setup and dynamic policy.

xli. Master planning is key tool for development as per law in force. Active master planning which leads to sustainable growth of the city cannot be achieved without addressing root barriers. Organizations, responsible for urban planning carry out their functions independently; egoistically, with minimum coordination and blurred vision.

Annexure-2

Macro level overview at a glance

In Pakistan, urbanization is not only about big cities getting bigger, it has made itself manifest by virtue of increasingly expanding densely populated rural regions—areas that are not officially designated as city space, yet nonetheless have many trappings and characteristic of urban life[113]. According to this density-based definition, vast swaths of rural Pakistan can be regarded as urban[114].



Source : Land Use Atlas of Pakistan:

In Pakistan the transformation of cultivated land to built-up area is the major challenge of 21st century. In Lahore, the capital of the Punjab

113 Bhalli, M. N., A. Ghaffar, and S. A. Shirazi. "Remote sensing and GIS applications for monitoring and assessment of the urban sprawl in Faisalabad, Pakistan." Pakistan Journal of Science 64, no. 3 (2012): 203-208.

114 Mehmood, H., S. H. Sajjad, and S. A. Shirazi. "Spatio-temporal trends and patterns of urban sprawl in Gujranwala city, Punjab-Pakistan." Pakistan Journal of Science 69, no. 1 (2017): 63.

557, in Faisalabad 73, in Gujranwala 87, in Hafizabad 53, in Sialkot 57, in Multan 215, and in Bahawalpur 27 residential colonies have been declared illegal by LDA, FDA, GDA, HDA, SDA, MDA, and CDA, respectively.[115] The studies included in this review revealed that in Lahore, 11,4630 ha of arable land was converted for urban use[116] out of which 18% converted land is under 252 housing schemes during the last 40 years[117]. It has also been estimated that in 49% schemes, 50% plots are those on which houses have not been constructed and 75% of these plots are in the hands of professional speculators[118] which factors raised the cost of plots and house building reached beyond the low middle-income group.

With the rapid urban sprawl more and more fertile agricultural land would be converted to commercial utilization which consequently will result in the considerable reduction of the agricultural productivity[119].

During the period of 2006 to 2015, a considerable change in the land holding has taken place. 53.9 % of the farmers now own less than 2 acres of land. In the past 48.9 % of the farmers responded that they owned up to 5 acres Division of land by inheritance (17.8 %)[120] and occupation of land by the housing colonies (56.9 %) are the prime factors behind land ownership patterns. 88.4 % of the respondents despite the reduced farm

115 Akmal, Farkhanda, Sami Ullah Khan, Muhammad Luqman, and Sajid Rashid Ahmad. "Urban Sprawl Susceptibility Analysis of Sialkot City by Using Multicriteria Evaluation and Analytical Hierarchy Process." Journal of Urban Planning and Development 148, no. 2 (2022): 04022013.

116 Uz-Zaman, K, and Baloch, A. A. 2011. Urbanization of Arable Land in Lahore City in Pakistan: A Case Study. Canadian Social Science, 7(4): 58-66.

117 Ahmed, Shabbir, Wu Huifang, Saira Akhtar, Shakeel Imran, Gulfam Hassan, and Chunyu Wang. "An analysis of urban sprawl in Pakistan: consequences, challenges, and the way forward." International Journal of Agricultural Extension 8, no. 3 (2021): 257-278.

118 Ahmed, Shabbir, Wu Huifang, Saira Akhtar, Shakeel Imran, Gulfam Hassan, and Chunyu Wang. "An analysis of urban sprawl in Pakistan: consequences, challenges, and the way forward." International Journal of Agricultural Extension 8, no. 3 (2021): 257-278.

119 Malik, Rabia, and Maisam Ali. "The impact of urbanization on agriculture sector: a case study of Peshawar, Pakistan." Journal of resources development and management 8 (2015): 79-85.

120 Ahmed, Shabbir, Wu Huifang, Saira Akhtar, Shakeel Imran, Gulfam Hassan, and Chunyu Wang. "An analysis of urban sprawl in Pakistan: consequences, challenges, and the way forward." International Journal of Agricultural Extension 8, no. 3 (2021): 257-278.

size were still attached with the agriculture sector for their sustenance. Moreover, it was also found that the crop patterns were the same, but the production was decreased due to the reduced farm size owing to urbanization.[121]

While 9 % increase was found in the built-up land area, Forest area, on the other hand, has reduced up to 10% due to the rapid urban sprawl, it was found that even though there was no major change in the trends of rainfall was recorded, during high to low inflow seasons, the suspended sediment load was found to be varied from 16.5 tons/day to 1045 tons/day. [122] Internal migration are mainly responsible for the expansion of the city to north, west, and east directions, respectively[123].

The laboratory analysis of the soil samples (14 in total) revealed that the soil of the residential colonies has loamy to moderate loamy texture which is highly suitable for cultivation all types of crops.[124]

"Pull Factors" play a vital role in shaping the migratory attitude of the respondents as 74 % (young adults) of them migrated to the urban areas to enjoy a better lifestyle, and consequently become responsible for the expansion of the cities, settling on the fertile agricultural land (peri-

121 Farah, Naveed, Izhar Ahmad Khan, Adeela Manzoor, and Baber Shahbaz. "Changing Land Ownership Patterns and Agricultural Activities in the Context of Urban Expansion in Faisalabad, Pakistan." Pakistan Journal of Life & Social Sciences 14, no. 3 (2016).

122 Afzal, M., Awais, M., Shah, S. M. S., Mahmood, S., and Sarwar, M. K. 2016. Impact of urbanization on inflows and sedimentation load in Rawal Lake of Pakistan. Pakistan Journal of Agricultural Sciences, 53(3): 673-677

123 Minallah, M. N., A. Ghaffar, M. Rafique, and M. Mohsin. "Urban growth and socio-economic development in Gujranwala, Pakistan: a geographical analysis." Pakistan Journal of Science 68, no. 2 (2016): 176.

124 Mohsin, Muhammad, Farrukh Jamal, Asad Ali Khan, and Fahad Ajmal. "Transformation of fertile agricultural soil into housing schemes: A case of Bahawalpur City, Punjab, Pakistan." International Review of Social Sciences and Humanities 6, no. 2 (2014): 141-156.

urban areas) sold by the real estate advisors without any approval of the respective development authorities[125]"

Swift urbanization has badly degraded the urban environment. It was observed during the process of the study that rapid urbanization has caused low resilience, psychological stress, depression, and symptoms of low self-esteem in the urban settlers[126].

Due to the unequal distribution of the resources among the districts of Punjab, Lahore is often criticized that it is devouring the major portion of the resources of the Punjab, the infrastructural development in the district is not interconnected and it is poorly planned, an integrated and consolidated administration is missing, strict building regulation is missing, and initiatives should be taken to resolve these challenges.[127]

Due to the rapid urban expansion, the urban area of Bahawalpur has stretched from 590 acres in 1951 to 1500 acres in 2012[128]. Moreover, around the outer rim of the city 25 Katchi Abadies (slums) have been developed. Due to population pressure, the administrative area of Municipal Corporation was extended in which half of the area was built-up and it was urban[129] and the water demand of the inhabitants which was

125 Farah, Naveed, Muhammad Iqbal Zafar, and Naima Nawaz. "Socio-Economic and Cultural Factors Affecting Migration Behavior in District Faisalabad, Pakistan." Pakistan Journal of Life & Social Sciences 10, no. 1 (2012): p28-32.

126 Khan, Nuzrat Yar, Naghmana Ghafoor, Rabia Iftikhar, and Maria Malik. "Urban annoyances and mental health in the city of Lahore, Pakistan." Journal of Urban Affairs 34, no. 3 (2012): 297-315.

127 Rana, Irfan Ahmad, and Saad Saleem Bhatti. "Lahore, Pakistan–Urbanization challenges and opportunities." Cities 72 (2018): 348-355.

128 Khan, Asad Ali, Sana Arshad, and Muhammad Mohsin. "Population growth and its impact on urban expansion: a case study of Bahawalpur, Pakistan." Universal Journal of Geoscience 2, no. 8 (2014): 229-241.

129 Arsalan, M. H., I. Ahmad, A. Aziz, M. Hussain, A. I. Osmani, and S. Perveen. "URBAN DEVELOPMENT STRATEGY FOR SUKKUR CITY, SINDH, PAKISTAN: A STEP TOWARDS VISIONARY PLANNING AND DEVELOPMENT." Pakistan Journal of Science 67, no. 1 (2015).

around 22.1 MGD (Million Gallons per Day) of which hardly 50% fulfilled by the regular low-quality piped water[130].

A reasonable approach is missing to allocate areas for growing cities and protecting the peri urban agricultural land[131]. Judging from the maps, areas adjacent to the main road network are more prone to change to urban areas[132].

This issue is also linked to distance to commercial land-use since this type of land-use is habitually located on the main road network[133].

The rapid urban expansion along with industrial development and swift population growth have transformed the traditional uses of agricultural land in the villages[134] situated at the fringes of all major cities of Pakistan[135]. The higher land values and selling price of agricultural land offered by the urban developers is the most powerful motive in the farmer's decision of agricultural land use change in the villages at rural-urban interface [136].

130 Ahmed, Shabbir, Wu Huifang, Saira Akhtar, Shakeel Imran, Gulfam Hassan, and Chunyu Wang. "An analysis of urban sprawl in Pakistan: consequences, challenges, and the way forward." International Journal of Agricultural Extension 8, no. 3 (2021): 257-278.

131 Farah, Naveed, Izhar Ahmad Khan, Ashfaq Ahmad Maan, Babar Shahbaz, and Jahanzeb Masud Cheema. "DRIVING FACTORS OF AGRICULTURAL LAND CONVERSION AT RURAL-URBAN INTERFACE IN PUNJAB, PAKISTAN." Journal of Agricultural Research (03681157) 57, no. 1 (2019).

132 Farah, Naveed, Izhar Ahmad Khan, Asif Ali Abro, Jehanzeb Masood Cheema, and Muhammad Luqman. "The nexus of land use changes and livelihood transformation of farmers at rural-urban interface of Pakistan." Sarhad Journal of Agriculture 38, no. 1 (2022): 46-59.

133 Hussain, Sajjad, Linlin Lu, Muhammad Mubeen, Wajid Nasim, Shankar Karuppannan, Shah Fahad, Aqil Tariq, B. G. Mousa, Faisal Mumtaz, and Muhammad Aslam. "Spatiotemporal variation in land use land cover in the response to local climate change using multispectral remote sensing data." Land 11, no. 5 (2022): 595.

134 Thomas, D., E. Zerbini, P. Parthasarathy Rao, and A. Vaidyanathan. "Increasing animal productivity on small mixed farms in South Asia: a systems perspective." Agricultural Systems 71, no. 1-2 (2002): 41-57.

135 Tahir, Muhammad, and Tasneem Khaliq. "Land Use in Pakistan." In Developing Sustainable Agriculture in Pakistan, pp. 33-57. CRC Press, 2018.

136 Farah, Naveed, Izhar Ahmad Khan, Asif Ali Abro, Jehanzeb Masood Cheema, and Muhammad Luqman. "The nexus of land use changes and livelihood transformation of farmers at rural-urban interface of Pakistan." Sarhad Journal of Agriculture 38, no. 1 (2022): 46-59.

Pakistan once a predominantly rural country is now the most urbanized country in South Asia. At present, there are about 50,000 villages in the country with populations below 10,000; around 448 small towns with population less than 100,000; 40 medium size towns with population above 100,000; 7 metropolitan cities which include Faisalabad, Multan, Gujranwala, Hyderabad, Peshawar, Rawalpindi and Quetta with population in excess of I million; and the two mega cities (Karachi and Lahore).

The dynamics in the settlement system in Pakistan shows a tendency of people to move from small settlements to more urbanized centers in expectations of better employment opportunities and higher incomes. With the concentration of resources and more investment in industry and commerce the urbanization is likely to increase at a rapid pace. The urban population is therefore expected to rise by another 70- 80 million by 2030. Karachi and Lahore will be among the world's leading mega cities. The urbanization and urban development impact positively on urban growth due to the fact that the provision of infrastructure and housing enhances the efficiency of urban economy. However, the urbanization of land over surface and consumption of agricultural land have negative impacts on the environment. So, with rapid urbanization coupled with inadequate investment, the quality of infrastructure has deteriorated with the passage of time. Unlike other countries, there is no urban planning/town planning law either at national or provincial level. Provincial and Local Governments play a vital role in the provision of urban and rural infrastructure like water and sewerage, inter-city and intra-city transport systems and some cases even electric power.

There is no comprehensive legislation covering all town planning issues. Previously, the statutory powers were used from the Punjab Town Improvement Act, 1922, Municipal Administration Ordinance of 1960 and Local Government Ordinance 1979. At present, a muddled system of

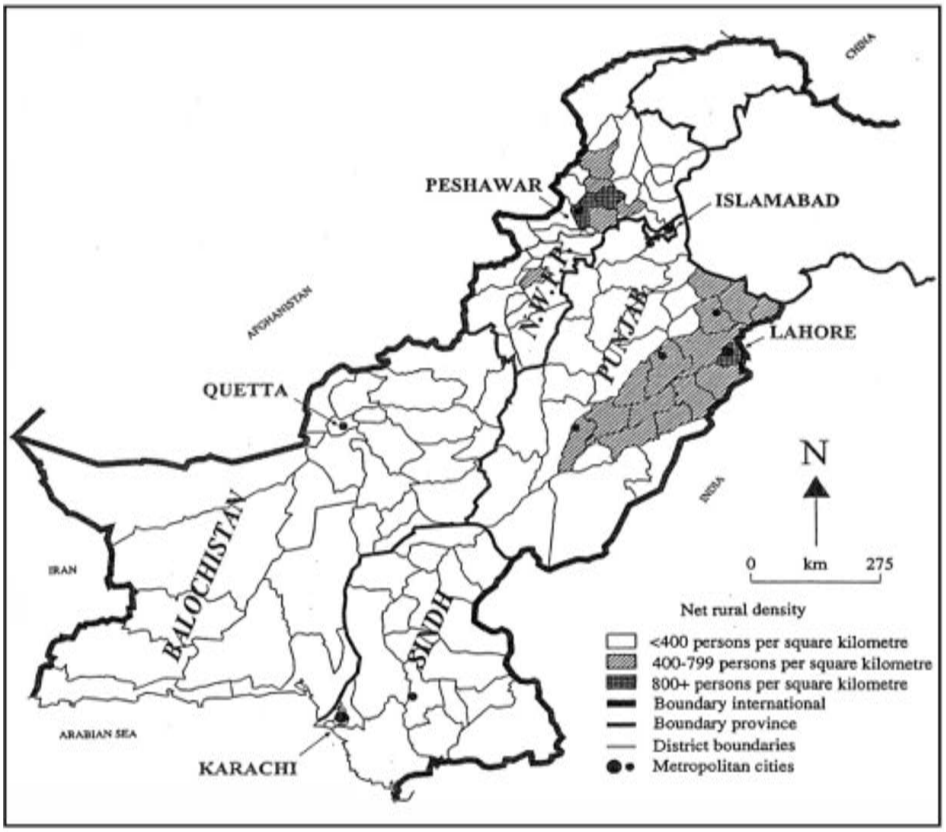
legislative framework related to town planning functions prevails in the province of Punjab. In a particular city existing statutory powers emanate from various Acts/Ordinances. For instance, in Lahore, complexity of legislative framework could be seen with the fact that PLGO 2001, PHAT Ordinance 2002, DHA Lahore Order 2002, Development of Cities Act 1976 and LDA Act 1975 are in practice within the jurisdiction of the relevant agencies.

For illustrative purposes, Lahore, Gujranwala and Sheikhupura, would emerge as a relevant study area constituting an urban agglomeration[137], bounded by 73-75 E longitudes and 31-33 N latitudes. The total area of this urban agglomeration was 29355 square km, including 21933 square km were green index 4595 square km was under human settlements and 2827 square km was the water body in 1990. On the contrary, the area of human settlements had been increased in 2005, in comparison to 1990 from 4595 km2 to 9366 km2, the volume of water body was reduced to 2111 km2 and the vegetation was also degraded to 17878 km2. Landsat 8 image of year 2019 shows a reasonable jump in built up area that reached to 16105 km2 and hence causing a decline to vegetation as the area under vegetation was observed as 11888 km2.

This agglomeration of urbanized settlements and rural-polis have not been recognized in the development paradigm of Development Authorities, HUD & PHE, LG&CD, PHATA or Urban Unit, yet UN Habitat adverts to this harsh reality on ground with the unrefuted assertion that physically, density of population crossing the thresh hold of 400 persons per square kilometer, or sq km (1,000 persons per square mile) attracting the criterion set forth by the United Nations Population Division

137 Saifullah, Muhammad, Memoona Zafar, Anam Sohail, Faiza Mehmood, Muhammad Musharaf, Jehanzaib Khan, Ayesha Ashfaq, and Syed Amer Mahmood. "Appraisal of Urban Sprawl in Mega Cities of Punjab Pakistan in context of Socio-Political Issues using RS/GIS." International Journal of Innovations in Science & Technology 1, no. 3 (2019): 108-119.

and UN-HABITAT to classify an urban place makes Pakistan a predominantly urban country .



Lahore-Gujranwala-Faisalabad triangle alone contained a population of about 20 million. In Punjab, a region forming a rough rectangle of Gujrat-Sargodha-Khanewal-Sialkot had surpassed urban thresholds in rural population densities in 1998. This is a mega-urban region brought about by the convergence of expanding cities and the implosion of the rural population. These “ruralopolises” could make Pakistan 60 to 65 percent urban.

As a city grows, prime agricultural lands are turned into non-agricultural uses[138]. Urbanization and population pressure have led to increases in land values. In developing countries, land is intensively utilized for agriculture to enhance production, in order to satisfy the food demand of rapid population expansion.

The haphazard growth often resulted in the development of slums or undesirable residential areas with lack of services and amenities, piecemeal commercial development, and intermix of conforming and non-conforming land uses.

Along with densification within the built-up area, peripheral growth is persistently growing informally and haphazardly in the form of the creation of new commercial and residential schemes. Some traditional land custodians also take advantage of the higher demand for land to supply land to urban developers and this results in an uncontrolled land market in the urban and urban fringes. To curb this phenomenon, it is important that the government fulfills its obligations to strengthen urban land-use planning systems so that there is increased stakeholder participation in land use planning to prevent the indiscriminate arable land sale.

Urban growth, changes in city lifestyles, increases in industrial water demand, and demand from small-holder farmers have all contributed to greater groundwater extraction in the past. This suggests a proportionate increase in groundwater demand in the future, placing additional pressure on aquifers, particularly in areas under stress. Removal of vegetation for construction of buildings, malls and plazas, is considered the main cause of rise in urban temperatures.

138 Ahmed, Shabbir, Wu Huifang, Saira Akhtar, Shakeel Imran, Gulfam Hassan, and Chunyu Wang. "An analysis of urban sprawl in Pakistan: consequences, challenges, and the way forward." International Journal of Agricultural Extension 8, no. 3 (2021): 257-278.

Pakistan ranks 78th out of 113 countries in the Global Food Security Index, with more than half of the population (60%) experiencing food insecurity. The average food supply in the country is estimated at 2,440 kcal/person/day, yet this is rated insufficient to meet demand (the country boasts an index score of 39.7, where 100 indicates sufficiency of supply) given high geographical disparities in food production and supply. From a nutrition perspective, over one-fifth (22%) of the total population is undernourished, one-third (31%) of children are underweight for their age (15% are affected by wasting) and diets generally lack diversity (Pakistan scores a 53.60 on the food diversity index). Despite its critical importance to food security, livelihoods, economic growth and export revenues, agricultural productivity remains low in Pakistan, with significant yield gaps compared to global averages in key crops like wheat, rice and sugarcane. The average farm size in Pakistan is 2.6 hectares (ha), with approximately 43% of the respondent categorized as smallholders with holdings of less than one ha, while only 22% own more than 3 ha of land[139]. Pakistan is a natural resource–based economy[140]. According to the Labour Force Survey conducted by Pakistan Bureau of Statistic[141], thirty-nine percent of the country's labour force is engaged in agriculture (30.2 percent males and 67.2 percent females)[142]. In total, the agriculture sector contributes 18.5 percent to the country's GDP[143]. Out of the total area of 79.6 million hectares, 22.1 million hectares are cultivated; Cropped area constitutes 23.3 million hectares, while forests cover 4.6

139 Arif, G. M., Muhammad Riaz, Nadeem Faisal, Mohammad Jamal Khan Khattak, Zeba Sathar, Muhammad Khalil, Maqsood Sadiq, Sabahat Hussain, and Kiren Khan. "Climate, population, and vulnerability in Pakistan: Exploring evidence of linkages for adaptation." (2019).

140 Islam, Nurul, ed. Agricultural policy in developing countries. Springer, 2016.

141 Baig, Rubina. "Role of women in agriculture and rural development in Pakistan." Agricultural Management/Lucrari Stiintifice Seria I, Management Agricol 12, no. 2 (2010).

142 Hussain, Adnan. "A Review Study on Women Involvement in Agricultural Farming Systems in Pakistan: Constraints and Problems." Medicon Agriculture & Environmental Sciences 2 (2022): 47-56.

143 Khan, Nawab, Ram L. Ray, Hazem S. Kassem, Muhammad Ihtisham, Badar Naseem Siddiqui, and Shemei Zhang. "Can Cooperative Supports and Adoption of Improved Technologies Help Increase Agricultural Income? Evidence from a Recent Study." Land 11, no. 3 (2022): 361.

million hectares of the total land. The country has the world's largest contiguous irrigation system with almost 80 percent of the cultivated area irrigated.

Pakistan is also amongst the world's top ten producers of wheat, cotton, sugarcane, mango, dates and kinnow oranges, and is ranked 10th in rice production. Major crops (wheat, rice, cotton and sugar cane) contribute around 4.9 per cent, while minor crops contribute 2.1 percent to the country's total GDP. Livestock sector contributes 11 per cent to the country's GDP (60.5 per cent in agriculture sector) and employs approximately 35 million people. Fisheries and forestry sectors each contribute an estimated 0.4 per cent to the GDP (2.1 per cent in agriculture sector).

Despite its impressive and continuously growing agricultural production, the country is still facing high levels of food insecurity. According to a global report published jointly by FAO, WFP, UNICEF, WHO and IFAD in 2019, 20.3 per cent of Pakistan's population (40.0 million people) is undernourished/food insecure[144]. The prevalence of malnutrition amongst children aged 6-59 months is also very high[145], with an estimated 40% children stunted[146], 28% underweight, 18% wasted and 10% overweight[147]. Further, around one-fourth (24 per cent) of the country's population is living below national poverty line and 39.0 per cent is poor based on multidimensional poverty index (MPI)[148]. Large

144 Khan, Mohsin. "The COVID-19 Pandemic and Food Security in Pakistan." Khan, Mohisn (2021). The Covid-19 (2021).

145 Ubaid ur Rehman, Hafiz, Waqas Asghar, and Nauman Khalid. "Food security challenges for Pakistan during COVID-19 pandemic: An overview of the response plan." World Food Policy 7, no. 1 (2021): 82-89.

146 Khan, Mohsin. "The COVID-19 Pandemic and Food Security in Pakistan." Khan, Mohisn (2021). The Covid-19 (2021).

147 Ubaid ur Rehman, Hafiz, Waqas Asghar, and Nauman Khalid. "Food security challenges for Pakistan during COVID-19 pandemic: An overview of the response plan." World Food Policy 7, no. 1 (2021): 82-89.

148 Khan, Mohsin. "The COVID-19 Pandemic and Food Security in Pakistan." Khan, Mohisn (2021). The Covid-19 (2021).

amounts of agricultural production and the continuously increasing population places high demands on Pakistan's water resources.

The country's forested area represents only 2% of total land— compared to the world average of over 30% —and is declining at a rate of 0.2-0.5% per year[149]. Deforestation— driven by urbanization, a rural reliance on fuel-wood[150], and poor land planning— has been linked with socioeconomic vulnerability and a lack of effective policy and monitoring mechanisms to protect forests.

Despite extensive irrigation infrastructure, gaps in water management infrastructure[151] leave the country in water-stressed situation for the large part of the year[152]. This will have considerable impacts on key crops in Pakistan. Wheat and rice yield, for example, are expected to decrease in all areas[153].

Moreover, climate change impacts on water resources are unclear, due to the uncertain behavior of the northern glaciers. There is an increased risk of avalanches and Glacial Lake Outburst Floods (GLOFS) across the river systems of the country[154].

Groundwater already constitutes more than 50 percent of irrigation water demand in Punjab, as much as 20 percent of irrigation water demand

149 Arif, G. M., Muhammad Riaz, Nadeem Faisal, Mohammad Jamal Khan Khattak, Zeba Sathar, Muhammad Khalil, Maqsood Sadiq, Sabahat Hussain, and Kiren Khan. "Climate, population, and vulnerability in Pakistan: Exploring evidence of linkages for adaptation." (2019).

150 Shahzad, Laila, Arifa Tahir, Faiza Sharif, Waqas Ud Din Khan, Muhammad Ansar Farooq, Azhar Abbas, and Zulfiqar Ahmad Saqib. "Vulnerability, well-being, and livelihood adaptation under changing environmental conditions: a case from mountainous region of Pakistan." Environmental Science and Pollution Research 26, no. 26 (2019): 26748-26764.

151 Mustafa, Daanish, Majed Akhter, and Natalie Nasrallah. Understanding Pakistan's water-security nexus. Washington, DC: United States Institute of Peace, 2013.

152 Briscoe, John, Usman Qamar, Manuel Contijoch, Pervaiz Amir, and Don Blackmore. "Pakistan's water economy: Running dry." World Bank, Washington, DC (2005).

153 Bandara, Jayatilleke S., and Yiyong Cai. "The impact of climate change on food crop productivity, food prices and food security in South Asia." Economic Analysis and Policy 44, no. 4 (2014): 451-465.

154 Nie, Yong, Hamish D. Pritchard, Qiao Liu, Thomas Hennig, Wenling Wang, Xiaoming Wang, Shiyin Liu et al. "Glacial change and hydrological implications in the Himalaya and Karakoram." Nature reviews earth & environment 2, no. 2 (2021): 91-106.

in Sindh, and about 70 percent of domestic and industrial water demand[155]. An increase in the latter is predicted, with the balance likely to come from groundwater. This will mean a reduction in agricultural water, running counter to agricultural demand under many climate change scenarios, and is likely to result in crop stress.

Groundwater in Pakistan's Indus basin represents the largest volume of freshwater storage in the country, with an estimated volume of more than 1,200 billion cubic meters. The aquifer is part of the Indo-Gangetic basin that drains the Indus, Ganges, and Brahmaputra rivers and is a globally important transboundary water resource.

Average annual renewable groundwater is estimated at 61 billion cubic meters, of which 44 billion cubic meters is recirculated water from canal seepage or irrigation return flows[156].

The aquifer consists of a heterogeneous distribution and thickness of unconsolidated sands, silts, and clays with minor gravels. By virtue of transmissivity of the unconfined, and shallow aquifer, the water resource is both easily accessible for abstraction and easily penetrated by contaminants and pollutants.

Salinity is a major quality issue affecting groundwater in the Indus basin[157] and worsened by waterlogging and evaporative concentration of salts in irrigation water. The total additional influx of salt to the aquifer from canal irrigation is estimated to be about 16 million tons per annum.

Deteriorating groundwater quality is widespread, and most of the cities and towns in the Indus basin suffer from low-quality drinking water.

155 Qureshi, Asad Sarwar. "Groundwater governance in Pakistan: From colossal development to neglected management." Water 12, no. 11 (2020): 3017.

156 Lytton, Lucy, Akthar Ali, Bill Garthwaite, Jehangir F. Punthakey, and Basharat Saeed. "Groundwater in Pakistan's Indus Basin." (2021).

157 Greene, Richard, Wendy Timms, Pichu Rengasamy, Muhammad Arshad, and Richard Cresswell. "Soil and aquifer salinization: toward an integrated approach for salinity management of groundwater." In Integrated groundwater management, pp. 377-412. Springer, Cham, 2016.

Unsafe drinking water affects as much as 80 percent of the population of Pakistan. Microbial contamination of drinking water is a major problem, as well as salinity, arsenic, fluoride, and agricultural and industrial contaminants.

The National Water Policy 2018 has 33 embedded objectives within its folds[158], covering almost all aspects of water, including water resources development and management (both surface and groundwater), development of regulatory framework, urban water management, hydropower development, flood and drought management, rainwater harvesting, capacity building and institutional arrangements. Besides policy statements, it has set targets and timelines for some of the important tasks, such as development of new water reservoirs (up to 10 MAF), reduction in conveyance losses by 33%, enhancing water use efficiency by 30%, real-time river/canal flow monitoring[159] to develop transparent water accounting system by 2021 and so on. However, implementation of the NWP in true letter and spirit will be a great challenge[160]. A mechanism has been proposed in the NWP for its implementation that consists of a National Water Council (NWC) to be chaired by the Prime Minister and a Steering Committee (SC) with Secretariat at the Ministry of Water Resources (MoWR) to be chaired by the Federal Minister. The current NWC and SC, as given in the NWP, are skewed towards engineering profession. It is proposed that NWC and SC should include members from Ministry of Food Security and Research Division (dealing with the agriculture sector which is the largest water user), Ministry of Climate

158 Saddiqa, Aisha, Sarfraz Batool, Shahzad Ali Gill, and Ali Junaid Khan. "Water Governance and Management in the 21st Century: A Case Study of Pakistan." Pakistan Journal of Humanities and Social Sciences 10, no. 1 (2022): 29-42.

159 Qureshi, R., & Ashraf, M. (2019). Water security issues of agriculture in Pakistan. PAS Islamabad Pak, 1, 41.

160 Munir, Muhammad Umar, Anwar Ahmad, Jan W. Hopmans, Azaiez Ouled Belgacem, and Mirza Barjees Baig. "Water scarcity threats to National Food Security of Pakistan—Issues, implications, and way forward." In Emerging Challenges to Food Production and Security in Asia, Middle East, and Africa, pp. 241-266. Springer, Cham, 2021.

Change, relevant research organizations such as PCRWR, IWMI who can assist the SC on emerging issues. One of the important tasks for the MoWR would be to develop a strong coordination among the research and development agencies working in water sector. Because of the connected nature of all water resources in the Indus basin, and the time required to remediate contaminated groundwater, deteriorating groundwater quality poses a long-term threat to Pakistan's water resource base. Population growth and increasing urbanization increase volumes of urban wastewater[161], and leakage from sewerage systems is a serious and growing groundwater pollution risk[162]. Other sources of groundwater pollution in urban areas include industrial and commercial waste discharges, domestic refuse disposal, polluted surface water bodies, such as lakes and canals, and leaks and spills. These sources typically tend to be more concentrated in urban areas, compared with rural areas. Over exploitation of groundwater in urban areas can also cause salt water intrusion and the more rapid mobilization of other contaminants[163]. Media reports on the poor status of groundwater in Pakistani cities (declining trends in quality and groundwater level) have led to calls for groundwater regulation[164].

A study by Pakistan Council of Research in Water Resources (PCRWR) reveals that while covering 23 cities, it found 89 percent of the groundwater throughout the country has a drinking water quality outside

161 Foster, S. S. D. "The interdependence of groundwater and urbanisation in rapidly developing cities." Urban water 3, no. 3 (2001): 185-192.

162 Foster, S. S. D. "The interdependence of groundwater and urbanisation in rapidly developing cities." Urban water 3, no. 3 (2001): 185-192.

163 Bandeali, Marium Sara Minhas. "Water Governance and Management in Indus Basin-Challenges & Threats." Studies of Applied Economics 38, no. 3 (2020).

164 Munir, Muhammad Umar, Anwar Ahmad, Jan W. Hopmans, Azaiez Ouled Belgacem, and Mirza Barjees Baig. "Water scarcity threats to National Food Security of Pakistan—Issues, implications, and way forward." In Emerging Challenges to Food Production and Security in Asia, Middle East, and Africa, pp. 241-266. Springer, Cham, 2021.

the recommended safe limits for human consumption[165]. A subsequent PCRWR nationwide drinking water quality survey carried out in 2015–16 found that the groundwater used as the main source of drinking water in Punjab's major cities and towns was unsafe for drinking, according to the National Standards for Drinking Water Quality[166]. The results show the unsafe samples in the range varied from 40 to 60 percent. The groundwater quality in Lahore is reported to be deteriorating as untreated municipal waste from the city continues to be discharged into the nearby Ravi River[167]. As the city has become more developed, recharge from previously agricultural areas has reduced (as a result of the change of land use from agriculture to urban). The Ravi River is now estimated to contribute more than 80 percent of the recharge to the groundwater system [168], resulting in increased levels of pollution in the river basis aquifer[169]. Industries (textiles, chemical, paper, poultry, dairies, tanneries, and pharmaceuticals) also discharge untreated wastewater drawn into the aquifer as groundwater is pumped[170]. At the district level, the water quality analysis by PCRWR showed 85 percent of the 119 collected samples were found to be unsafe for drinking water[171].

165 Qurat-ul-Ain, Farooqi, A., Sultana, J. and Masood, N., 2017. Arsenic and fluoride co-contamination in shallow aquifers from agricultural suburbs and an industrial area of Punjab, Pakistan: Spatial trends, sources and human health implications. Toxicology and Industrial Health, 33(8), pp.655-672.

166 Azizullah, Azizullah, Nadia Taimur, Sarzamin Khan, and Donat-P. Häder. "Heavy Metals Pollution in Surface Waters of Pakistan." In Anthropogenic Pollution of Aquatic Ecosystems, pp. 271-312. Springer, Cham, 2021.

167 Hassan, Ghulam Zakir, Faiz Raza Hassan, and Saleem Akhtar. "Environmental Issues and Concerns of Groundwater in Lahore: Environmental Issues and Concerns of Groundwater in Lahore." Proceedings of the Pakistan Academy of Sciences: B. Life and Environmental Sciences 53, no. 3 (2016): 163-178.

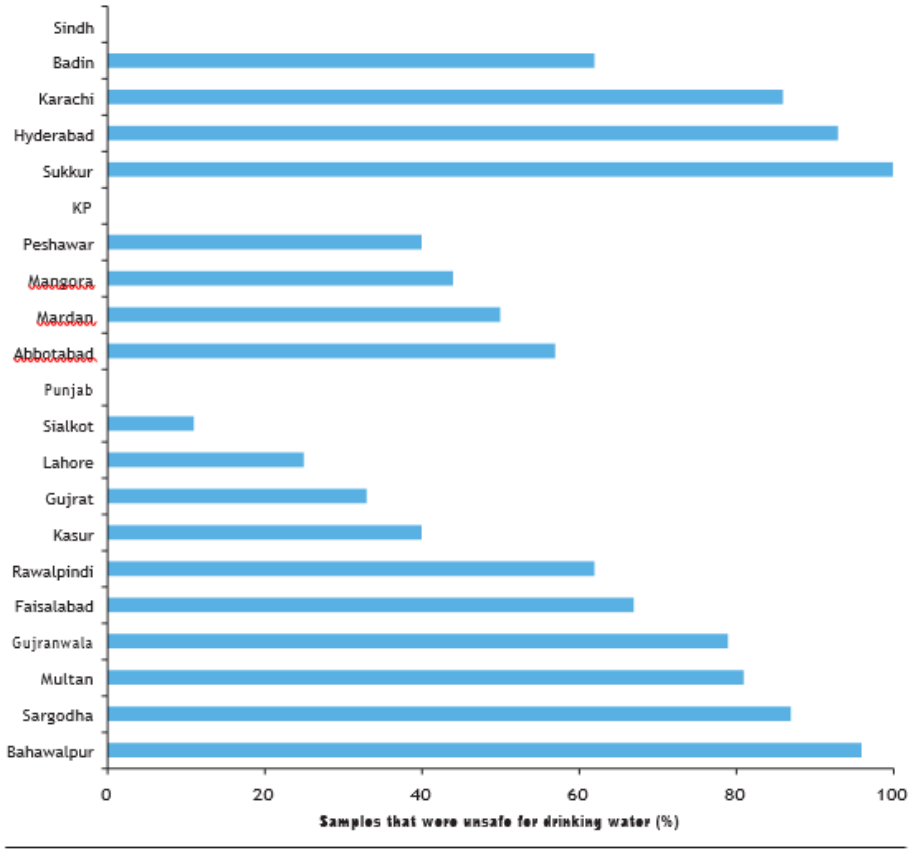
168 Qureshi, A., and Ali Hasnain Sayed. "Situation analysis of the water resources of Lahore establishing a case for water stewardship." WWF-Pakistan and Cleaner Production Institute (CPI), Lahore, Pakistan (2014): 1-45

169 Muzammil, Muhammad, Azlan Zahid, and Lutz Breuer. "Water resources management strategies for irrigated agriculture in the Indus Basin of Pakistan." Water 12, no. 5 (2020): 1429.

170 Lytton, Lucy, Akthar Ali, Bill Garthwaite, Jehangir F. Punthakey, and Basharat Saeed. "Groundwater in Pakistan's Indus Basin." (2021).

171 Jalees, Muhammad Irfan, Muhammad Umar Farooq, Mehwish Anis, Ghulam Hussain, Arfa Iqbal, and Sana Saleem. "Hydrochemistry modelling: evaluation of groundwater quality deterioration due to

FIGURE 3.17. Percent of Samples That Were Unsafe for Drinking Water in Sindh, KP, and Punjab, 2015–16



Source: Imran et al. 2016.
Note: KP = Khyber Pakhtunkhwa.

The health risk of poor groundwater management is concentrated in major cities because millions of people depend on the same water supply. The lack of reliable data on groundwater levels, abstraction volumes, salinity, and broader water quality parameters makes policy formulation more difficult, hindering action and preventing the optimal

anthropogenic activities in Lahore, Pakistan." Environment, Development and Sustainability 23, no. 3 (2021): 3062-3076.

use of resources. Groundwater is critically important to Pakistan, and the burden of poorly managed groundwater, including salinization, poor water quality, falling water tables, and waterlogging will continue to worsen.

Domestic and industrial use are currently the fastest-growing groundwater demand sectors. Domestic water demand in Pakistan is set to double by 2050, and deteriorating groundwater quality (including from salinity, microbial pollution, natural contaminants, such as arsenic and fluoride, and industrial pollutants) is an increasingly urgent issue.

The National Water Policy 2018 acknowledges the importance of groundwater to Pakistan's economy and highlights the country's increased attention to integrated water resource management. This is an important advance on the current approach that, through sectoral and institutional segregation, over- looks the large overlap between surface water and groundwater resources. However, there remains a lack of clarity about which are the responsible institutions in each tier of government; therefore, there is no accountability. As a result, across different sectors and among different tiers of government, groundwater management is being considered in the abstract, yet there is a failure in clear allocation of roles and responsibilities and in coordination among all these agencies. The resulting failure to collect reliable data has an ongoing adverse impact on Pakistan's ability to adequately provision for the increasing water demand in every sector. The outcome is a fragmented understanding of the trajectories of groundwater performance (level and quality) in different parts of the country and of the implications of these trajectories for different sectors. Inadequate knowledge is matched by infrequent and poorly targeted interventions aimed at tackling one issue without taking account of interlinked water and land management issues. Authentic data on static and dynamic groundwater conditions provide a basis for basin-scale modeling of the resource, including numerical modeling and coupled transport modeling of contaminants.

The identified technical and institutional challenges facing groundwater management in Pakistan's Indus basin are all clearly stated in the National Water Policy 2018. These challenges are common with other countries that share the aquifers. The reform path is an adaptive process and should therefore be seen as part of a continuum that, for successful implementation, must be inclusive and composed of multiple steps.

Given that many of the farmers in the study area do not have the technical skills to move into the non-farming sectors of the wider economy, and considering the rapidly growing population, the problem of large losses of arable lands needs to be ameliorated through State interventions to pre-empt occurrences of public insecurity driven by increased unemployment and underemployment of displaced farmers.

Critical investments in improved seeds, farming technology and techniques, and water infrastructure are needed to tackle the emerging challenges to the agricultural sector, especially in the context of declining water availability and climate change impacts.

Pakistan launched the NCCP in 2013. The ministry then created an action plan to implement the measures and actions proposed in the NCCP. In 2013, the ministry was degraded to a division. However, the government realized that it requires a full ministry so as to move forward for effective implementation of the NCCP and the ministry was reinstated in 2015. Therefore, the implementation of the NCCP was a major motivation factor to reinstate the ministry. In 2017, the climate change act was passed which "will fast-track measures needed to implement actions on the ground" in the country which is behind the effective implementation of climate actions. New institutional arrangements are set: Pakistan Climate Change Council, Pakistan Climate Change Authority, and Pakistan Climate Change Fund. The council is a decision-making body chaired by either the prime minister or a person nominated by him. The government appoints federal and provincial ministers, chief ministers

and chief secretaries as members of the council. The Climate Change Authority is an autonomous government department composed of scientists, academics, industrialists, agriculturalists and serving and retired government servants, etc. The task of the authority is to formulate adaptation and mitigation policies and projects designed to meet Pakistan's obligations under international climate accords like the Paris Agreement. The implementation of the NCCP is the driving force for all these new institutional arrangements in the country.

According to UN-HABITAT, the phenomena of overpopulation and alarming rate of population growth, the observable urban development at high speed concurrent with ceaseless and continued poverty[172] widely opened the gate for the unprecedented unban poorest of the poor. The slums and squatter settlement is very much disappointing. Rural urban migration might not have solved the problem of unemployment and has not tangibly improved the quality of employment, Workers do remain unprotected, with non-regular category of employment obtained and recoupments only to the extent of the lowest income and hence poverty incidence was more pronounced among these households. About 40 per cent of migrant households were living in slum dwellings, 30 per cent did not have access to safe drinking water, 65 per cent had no sewerage facilities, given the context that the pressure of unemployment and poverty caused by drought in the place of rural origin pushes the rural labour force[173] towards urban centers in search of survival. A low level of economic, social, human and political capital drives the migrant work force to over crowd in to the informal sector.

Historically, pull factors have predominated- urban environment provides better employment and income opportunities. But recently, it seems that push factors seem to be increasingly powerful. The towns

172 Davis, Mike. "Planet of slums." Open House Int 8, no. 5.

173 Siddiqui, Tasneem. "Pakistan's urbanization challenges: Housing for the low-income." Pakistan's Runaway Urbanization: What Can Be Done? (2014): 66.

hardly seem to be in any feasible way capable of absorbing the excessive inflow of migrants nor do they have the investment capacity to add to its urban resources. Migrants themselves are too poor to contribute to the investment sector of the capital resources to the town's growth and development. Rural push factors, by and large, are stronger than the urban pull factors causing excessive to urban areas. At the same time, rural areas because of lack of investment and economic growth are suffering from lack of agricultural or alternative employment, droughts and famines which were amongst reasons for migration. The urban pull factors are weak and the urban capacity is low, practically, the rural migrants perceived life chances in the destination town are highly misconstrued and rather exaggerated, based on hear-say and wrong information about the opportunities available in the town.

Biosphere's ability to generate resources and sequester waste per capita has shown a massive decline over the last five decades[174]. Conversely, urbanization has rapidly increased for the same period[175]. According to the Global Ecological Footprint Institute, the economies had an ecological footprint in 2018, that exceeded bio capacity by more than 50 percent and evidently, the environment requires 1.5 years to regenerate what the world consumes in one year[176]. This overshoot depletes the natural capital on which human life depends. In the event, current consumption patterns are maintained, the demand for ecosystems will exceed what nature can regenerate by approximately 75 percent[177].

174 McNeill, John Robert, and Peter Engelke. The great acceleration: An environmental history of the Anthropocene since 1945. Harvard University Press, 2016.

175 Newman, Peter, and Isabella Jennings. Cities as sustainable ecosystems: principles and practices. Island press, 2012.

176 Rees, W. E. (2020). Megacities at risk: The climate–energy conundrum. In Handbook of Megacities and Megacity-Regions (pp. 292-308). Edward Elgar Publishing.

177 Wackernagel, Mathis, and Chad Monfreda. "Ecological footprints and energy." Encyclopedia of energy 2, no. 1 (2004): 1-11.

Damage already done to climate by the greenhouse gas emissions will affect us for the next millennium (Hadley Centre, 2002)[178].

As global warming takes hold, soils will emit more natural CO2 which multiplies to man-made emissions[179], accelerating climate Change – CCPF (Carbon-Cycle-positive-feedback). The climate change precipitated by stupendous global burden of Green House Gas emissions has unfolded, heat waves, shortened winters, heavier monsoons, hill torrents, flash floods, glacial melts and cloud bursts which leave Pakistan alone to fight the menace of climate carnage, warranting a huge global support that is presently seen nowhere. Having fought the war on terrorism for the whole world, Pakistan with less than one percent share of carbon footprint is left alone and abandoned while bracing the vagaries of weather and insurmountable calamities of nature.

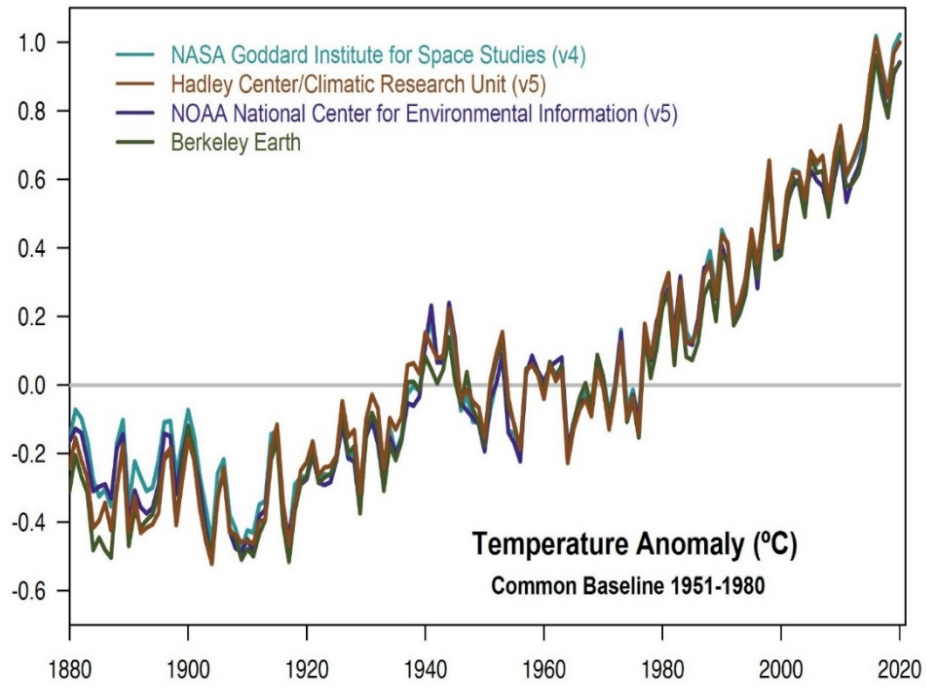
Climate change risks and hazards are horrific and horrendous for Pakistan that show the double standard of the world, especially the unreliable west who pledged climate finance to find ways and means of climate mitigation and adaptation, which turn out to be conspicuous by absence. Now we have Climate refugees rendered IDPs in all the regions and Provinces of the country.

Mitigation measures will not be possible as Pakistan is to confront a global problem, primarily being felt on local scales, that will be around for quite some times. Carbon dioxide, the heat-trapping greenhouse gas that is the primary driver of recent global warming, lingers in the atmosphere for many thousands of years, and the planet (especially the ocean) takes a while to respond to warming. The time series data analysis shows global changes in the concentration and distribution of carbon dioxide since 2002 at an altitude range of 1.9 to 8 miles with cumulative

178 Hillel, Daniel, and Cynthia Rosenzweig. "Desertification in relation to climate variability and change." Advances in agronomy 77 (2002): 1-38.

179 Yoro, Kelvin O., and Michael O. Daramola. "CO2 emission sources, greenhouse gases, and the global warming effect." In Advances in carbon capture, pp. 3-28. Woodhead Publishing, 2020.

rise since 2002 for readings of AIRs Mid Tropospheric CO2 escalating from 374 ppm to 465 ppm in 2022. The year 2021 tied with 2018 as the sixth warmest year on a record that extends back to 1880, according to NASA's annual analysis of global average temperatures. The year contributed to an unprecedented, but well-understood trend in which the last eight years have been the warmest ever recorded.



Global temperatures are rising at a pace that the planet has not experienced in millennia. The rising temperatures are causing ice sheets and glaciers worldwide to melt, heatwaves to be longer and more intense, and plants and animal habitats to shift as they respond to warming.

The World Meteorological Organization (WMO) has officially evaluated temperature record extremes of 54.0 °C at two locations, one in Mitribah, Kuwait, on 21 July 2016 and a second in Turbat, Pakistan, on 28

May 2017. In its most intensive evaluation ever undertaken, the WMO Archive of Weather and Climate Extremes, has verified the Mitribah observation as 53.9 °C (± 0.1 °C margin of uncertainty) and the Turbat one as 53.7 °C (± 0.4 °C). Pakistan being a negligible contributor to the overall carbon footprint, is a host to extreme weather events like the heat waves, forest fires, multiple glacial lake-outburst-floods and now disastrous monsoon floods. Moreover, the mean temperature across the country has increased by 0.5°C in the past 30 years. Projections indicate an increase in mean temperature of 1.4°C - 3.7°C by 2060 in Pakistan (higher than the expected global average), with the north potentially experiencing higher temperatures compared to the south of the country. Temperatures are also expected to increase more in winter than in summer in Pakistan. Projections for precipitation change are less clear, due to considerable model uncertainties for the region. Changes in monsoons and increased temperatures tend to bring considerable challenges to agriculture, particularly in northern Pakistan, where vulnerability to climate change is already high.

Increases in temperature will likely speed up crop growth cycles and shorten the time between sowing and harvesting, affecting crop yields. According to the Climate Change Vulnerability Index, droughts are expected to increase in winter, affecting the yield of cash harvests. Meanwhile, increase in precipitation in the summer season have already caused floods throughout different areas of Pakistan. Day and night temperatures in Pakistan have followed a significant increase during the last 50 years due to which heat stress on plant growth and development has also enhanced. Higher night temperatures have given rise to increase in respiration hence reducing the net gain in the form of grain yield. Sudden shoot up of air temperatures in early spring when wheat and other winter crops were at reproductive stage of their life cycle caused significant reductions in the grain yield despite affecting the apparent health of the crops. Current rise in temperature is likely to continue during

this century and extreme events associated with rise are also expected to increase in frequency, intensity and persistence increasing the uncertainty in sustainable crop production. We have to grow more by adopting a multidisciplinary approach to meet the food demand of ever increasing population of Pakistan with fewer amounts of available land and water resources in a highly hostile climate. Increased temperature will affect the physiological processes necessary for crop growth and development of crops and ultimately crop yields are most likely to drop over the present level. Climatic anomalies will play an important role in increasing the uncertainties in crop production. In 2021, Earth saw several extreme examples of how excess heat in the ocean and atmosphere can influence often devastating, sometimes unexpected, disasters including inundation of vast swathes of habitat by massive super flooding in Pakistan in 2022.

Annexure-3

Action Plan: Target	Actions	Responsibility	Resources	Timelines	KPIs
Treatment of Drainage water before mixing it with irrigated system	Treatment Plant for Treatment of Polluted Water	a) District Administration b) Tehsil Administration	a) Regular Budgets	12 to 24 months	• Ensuring Single outfall drainage system of the whole urban center • Installation of plant at the main drain in the outskirts of the urban center
Peri-Urban Planning	Devising a special plan) Roads b) Societies c) Industrial Estate d) Drainage System e) Sanitary System f) Waste management System	TMAs	Existing HR Mobilization	6 months	• Ensuring maps and drawings for main roads, buildings to be constructed, drainage system, Sanitary System, Solid Waste management System, Industrial Estate etc.
Use of latest Brick Manufacturing Techniques	Addressing sensitivities due to construction boom and demand for bricks	TMAs EPD	Existing HR Mobilization	3 months	• Ensuring that delayed and cumbersome procedures are eliminated for necessary approval process to establish such units • Encouraging Government contractors to use Ash bricks as raw material for building construction
Allocating and	a) Devising	DCs	Existing HR	3 to 36	• Irrigation

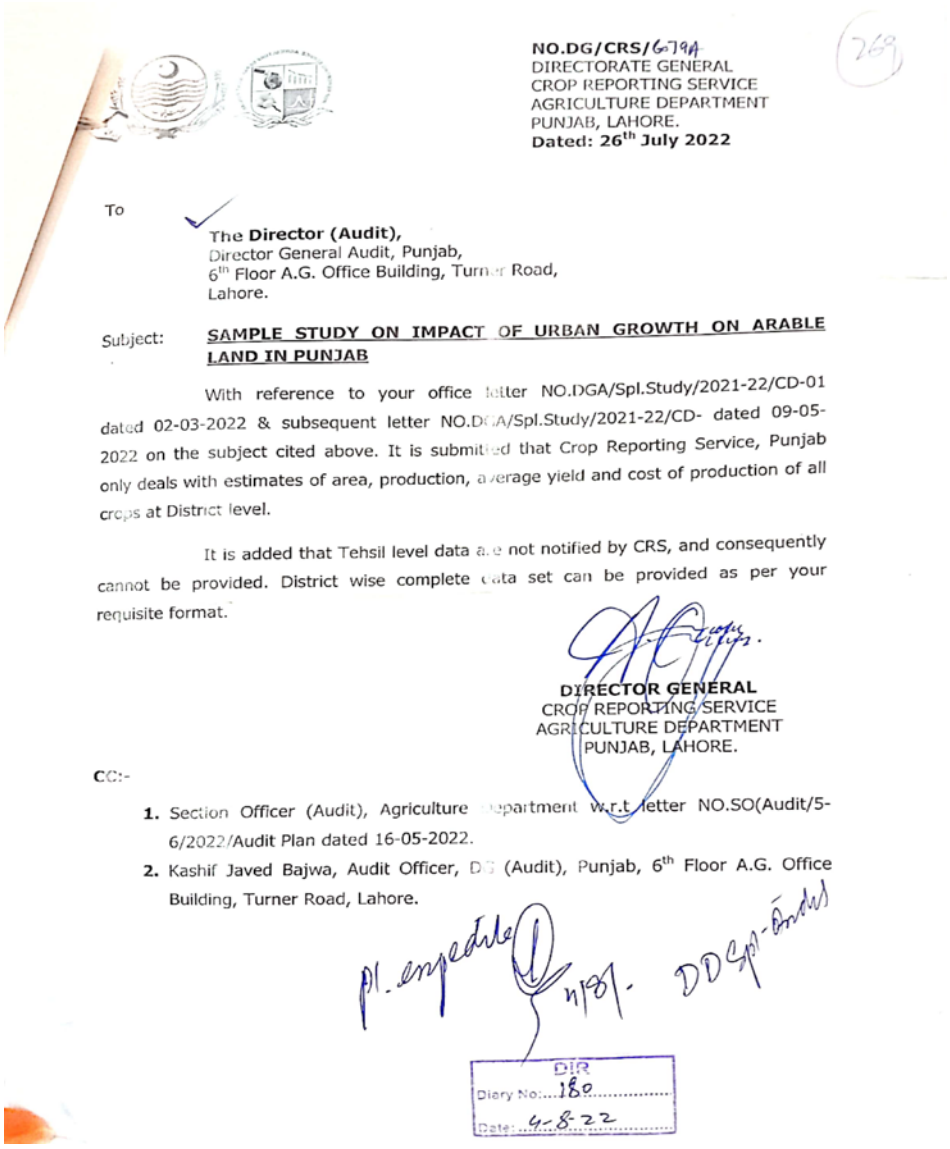
Action Plan: Target	Actions	Responsibility	Resources	Timelines	KPIs
Conserving Land reserved for Forest	Plan for Conserving Forest Land b) Planning for Plantation on Roads, Drains, Canals, Nalas c) Allocation of more land for Forest Plantation	DFOs TMAs NHA Irrigation Deptt.	Mobilization Hiring through Allocating budget Public Mobilization	months	Department may be engaged in Plantation at the banks of Nalas, Canals, Drains etc. • Highway Department may be engaged in Plantation across Highways • DFO may plan and engage in carrying out plantation activities in new reserved lands and to protect already forested area • DCs & TMAs alongwith DFO may also be engaged for forestation and protection of plantations
Improving Urban-Agriculture	Devising a Plan for encouraging Urban Agriculture in vacant plots and reserved areas	Agriculture Department Horticulture Department	Existing HR Mobilization	1 to 5 years	• Plan needs to be devised and executed for using vacant land pockets and plots for Fruits, vegetables plantations
Protecting & Recharging Under Ground Water Aquifers	Devising separate Plans for; a) Spreading Basins to trap	DG Water Management Irrigation Department TMAs	Existing HR Mobilization	3 to 12 months	• Land must be allocated for spreading basins, constructing

Action Plan: Target	Actions	Responsibility	Resources	Timelines	KPIs
	flood waters b) Recharging through Pits and shafts c) Ditches				pits and shafts, ditches etc. • Efforts are needed cleaning and reusing waste waters
Use of Technology for Enhanced Agriculture Produce	d) Initiating new Projects at Agriculture Departmen t level e) Engaging University students for research activities	Agriculture Department NARC	Existing HR mobilization Use of new budgets Involvement of Donor Funding agencies	1 to 5 years	• Mobilization of Agriculture Department for introducing and guiding about new technological interventions • Mobilization of Farmers • University students needs to be incentivized on innovative research
Use of water Conservative Agriculture Technology	Planning a Project for use of Land Levelers, DRIPS, Sprinklers	DG Water Management	Existing HR mobilization Use of new budgets Involvement of Donor Funding agencies	1 to 5 years	• Use of Land LASER levelers • Use of DRIP irrigation System • Use of Water Sprinklers
Improving Solid Waste Management System	Spreading Services Enhancing Capacity Engaging Public through Community Boards	TMAs DCs	Existing HR mobilization	6 to 2 years	• 100 percent urban populations must be provided with waste lifting facility • Peri-urban areas must be brought under serviced areas
Re-locating existing Waste Dumping Sites	Relocating Dumping sites	TMAs DCs	Existing HR mobilization	1 year	• Duping sites at appropriate places with minimum

Action Plan: Target	Actions	Responsibility	Resources	Timelines	KPIs
					environmental damages be allocated • Proper SOPs needs to be devised and followed while dumping at sites
Devising Master Plans	Revising Master Plans for Urban Centers	TMAs DAs PHATA Urban Unit	Existing HR mobilization	1 year	• Master Plans needs to be revamped after every 20 years regularly
Peri-Urban structure Planning	Comprehensive Plans, drawings for drainage, Sanitary, Waste Management needs to be compiled for Peri-urban areas	TMAs DAs PHATA Urban Unit	Existing HR mobilization	1 year	• Peri- Urban Planning as for every Urban centers needs to be ensured.
Establishment of Agro-economic Zones	Plans, Drawings, Allocation of land	GoPb TMAs DCs	Existing HR mobilization Funds from Development budget for infrastructure development	3 years	• Master Plan needs to be devised • SOPs needs to the formulated • Resources need to be earmarked

Annexure-4

Response from Agriculture Department



NO.DG/CRS/679A
DIRECTORATE GENERAL
CROP REPORTING SERVICE
AGRICULTURE DEPARTMENT
PUNJAB, LAHORE.
Dated: 26th July 2022

To

The Director (Audit),
Director General Audit, Punjab,
6th Floor A.G. Office Building, Turner Road,
Lahore.

Subject: **SAMPLE STUDY ON IMPACT OF URBAN GROWTH ON ARABLE LAND IN PUNJAB**

With reference to your office letter NO.DGA/Spl.Study/2021-22/CD-01 dated 02-03-2022 & subsequent letter NO.DGA/Spl.Study/2021-22/CD- dated 09-05-2022 on the subject cited above. It is submitted that Crop Reporting Service, Punjab only deals with estimates of area, production, average yield and cost of production of all crops at District level.

It is added that Tehsil level data are not notified by CRS, and consequently cannot be provided. District wise complete data set can be provided as per your requisite format.

DIRECTOR GENERAL
CROP REPORTING SERVICE
AGRICULTURE DEPARTMENT
PUNJAB, LAHORE.

CC:-

1. Section Officer (Audit), Agriculture Department w.r.t letter NO.SO(Audit/5-6/2022/Audit Plan dated 16-05-2022.
2. Kashif Javed Bajwa, Audit Officer, DG (Audit), Punjab, 6th Floor A.G. Office Building, Turner Road, Lahore.

Pl. expedite 4/8/- DDSpl-Audit

DIR
Diary No: 180
Date: 4-8-22

Government of Pakistan
Ministry of Planning, Development & Special Initiatives
PAKISTAN BUREAU OF STATISTICS
Sample Design Section
Islamabad

Director (SD)
Ph: 051-9106581
Fax: 051-9106548

rabia.awan@pbs.gov.pk

No. PBS.SD.B(358)/2016-/25 dated: 01-07-2020

Subject: INTRODUCTION TO AREA FRAME SAMPLING BY INTEGRATING GROUND & SATELLITE DATA SETS FOR THE IMPROVEMENT OF CROPS ESTIMATES IN PUNJAB

Reference Crop Reporting Service, Punjab Letter No.CRS.CI/2017/3189-90 dated 27-04-2020 and the relevant material on the proposed new Sample Design. I am directed to inform that PBS appreciates the efforts and work of new sample design of CRS, Punjab. The sample size selection process, optimum selection of plot size on the basis of Mean Square Error (MSE) and a published paper have been reviewed in this Bureau and found very sound. However, the Yield Estimation and weight file is complex and need explanations.

It is therefore, requested that CRS Punjab may arrange a comprehensive presentation about previous sample design & estimation procedures including details of weights and proposed new sample design including sample size determination, methodology, estimation procedure, result of pilot survey and CV etc. Comparative statement for major differences of both the designs and final estimates for major crops may also be prepared. Working paper showing all the relevant details may be shared with PBS at least one week before presentation.

With best regards,

(Rabia Awan)

Dr. Abdul Qayyum,
Director-CRS/PD-Crop Insurance,
Agriculture Department
Punjab, Lahore

REGISTERED 01
1/7/20

Fiscal Year	Project Description		Original Budget	Final Budget	Prog Releases	Progressive Exp
	Grand Total	**1**	**20.000**	**20.000**	**20.000**	**19.806**
LO21002856			**20.000**	**20.000**	**20.000**	**19.806**
LO21002856AT-UPGRADATION OF GIS-REMOTE SENSING BASED CROPS' ESTIMATES & STRENGTHENING OF AREA FRAME SAMPLING METHODOLOGY IN PUNJAB						
P50 - Agriculture			5004 - DG Agriculture (Research)			
AT4077 - Assistant Director(Stat) Crop Reporting Service Agriculture Department District Attock			**0.000**	**0.116**	**0.116**	**0.115**
2021			0.000	0.116	0.116	0.115
LO21002856BA-UPGRADATION OF GIS-REMOTE SENSING BASED CROPS' ESTIMATES & STRENGTHENING OF AREA FRAME SAMPLING METHODOLOGY IN PUNJAB						
P50 - Agriculture			5004 - DG Agriculture (Research)			
BA4077 - Assistant Director(Stat) Crop Reporting Service Agriculture Department District Bahkkar			**0.000**	**0.335**	**0.335**	**0.335**
2021			0.000	0.335	0.335	0.335
LO21002856BP1-UPGRADATION OF GIS-REMOTE SENSING BASED CROPS' ESTIMATES & STRENGTHENING OF AREA FRAME SAMPLING METHODOLOGY IN PUNJAB						
P50 - Agriculture			5004 - DG Agriculture (Research)			
BP4078 - Assistant Director(Stat) Crop Reporting Service Agriculture Department District Bahawalpur			**0.000**	**0.400**	**0.400**	**0.400**

2021			0.000	0.400	0.400	0.400
LO21002856BP-UPGRADATION OF GIS-REMOTE SENSING BASED CROPS' ESTIMATES & STRENGTHENING OF AREA FRAME SAMPLING METHODOLOGY IN PUNJAB						
P50 - Agriculture			5004 - DG Agriculture (Research)			
BP4077 - Statistician Crop Reporting Service Agriculture Department Bahawalpur Division			**0.000**	**0.070**	**0.070**	**0.070**
2021			0.000	0.070	0.070	0.070
LO21002856BW-UPGRADATION OF GIS-REMOTE SENSING BASED CROPS' ESTIMATES & STRENGTHENING OF AREA FRAME SAMPLING METHODOLOGY IN PUNJAB						
P50 - Agriculture			5004 - DG Agriculture (Research)			
BW4077 - Assistant Director(Stat) Crop Reporting Service Agriculture Department District Bahawalnagar			**0.000**	**0.440**	**0.440**	**0.440**
2021			0.000	0.440	0.440	0.440
LO21002856CK-UPGRADATION OF GIS-REMOTE SENSING BASED CROPS' ESTIMATES & STRENGTHENING OF AREA FRAME SAMPLING METHODOLOGY IN PUNJAB						
P50 - Agriculture			5004 - DG Agriculture (Research)			
CK4077 - Assistant Director(Stat) Crop Reporting Service Agriculture Department District Chakwal			**0.000**	**0.095**	**0.095**	**0.095**
2021			0.000	0.095	0.095	0.095
LO21002856CN-UPGRADATION OF GIS-REMOTE SENSING BASED CROPS' ESTIMATES & STRENGTHENING OF AREA FRAME SAMPLING METHODOLOGY IN PUNJAB						

P50 - Agriculture			5004 - DG Agriculture (Research)			
CN4077 - Assistant Director(Stat) Crop Reporting Service Agriculture Department District Chiniot			**0.000**	**0.182**	**0.182**	**0.182**
2021			0.000	0.182	0.182	0.182
LO21002856DK1-UPGRADATION OF GIS-REMOTE SENSING BASED CROPS' ESTIMATES & STRENGTHENING OF AREA FRAME SAMPLING METHODOLOGY IN PUNJAB						
P50 - Agriculture			5004 - DG Agriculture (Research)			
DK4078 - Assistant Director(Stat) Crop Reporting Service Agriculture Department District D.G.Khan			**0.000**	**0.255**	**0.255**	**0.255**
2021			0.000	0.255	0.255	0.255
LO21002856DK-UPGRADATION OF GIS-REMOTE SENSING BASED CROPS' ESTIMATES & STRENGTHENING OF AREA FRAME SAMPLING METHODOLOGY IN PUNJAB						
P50 - Agriculture			5004 - DG Agriculture (Research)			
DK4077 - Statistician Crop Reporting Service Agriculture Department D.G.Khan Division			**0.000**	**0.070**	**0.070**	**0.070**
2021			0.000	0.070	0.070	0.070
LO21002856FS1-UPGRADATION OF GIS-REMOTE SENSING BASED CROPS' ESTIMATES & STRENGTHENING OF AREA FRAME SAMPLING METHODOLOGY IN PUNJAB						
P50 - Agriculture			5004 - DG Agriculture (Research)			
FS4078 - Assistant Director(Stat) Crop Reporting Service Agriculture Department District			**0.000**	**0.245**	**0.245**	**0.245**

Faisalabad						
2021			0.000	0.245	0.245	0.245
LO21002856FS-UPGRADATION OF GIS-REMOTE SENSING BASED CROPS' ESTIMATES & STRENGTHENING OF AREA FRAME SAMPLING METHODOLOGY IN PUNJAB						
P50 - Agriculture			5004 - DG Agriculture (Research)			
FS4077 - Statistician Crop Reporting Service Agriculture Department Faisalabad Division			**0.000**	**0.070**	**0.070**	**0.070**
2021			0.000	0.070	0.070	0.070
LO21002856GJ-UPGRADATION OF GIS-REMOTE SENSING BASED CROPS' ESTIMATES & STRENGTHENING OF AREA FRAME SAMPLING METHODOLOGY IN PUNJAB						
P50 - Agriculture			5004 - DG Agriculture (Research)			
GJ4077 - Assistant Director(Stat) Crop Reporting Service Agriculture Department District Gujrat			**0.000**	**0.093**	**0.093**	**0.093**
2021			0.000	0.093	0.093	0.093
LO21002856GW1-UPGRADATION OF GIS-REMOTE SENSING BASED CROPS' ESTIMATES & STRENGTHENING OF AREA FRAME SAMPLING METHODOLOGY IN PUNJAB						
P50 - Agriculture			5004 - DG Agriculture (Research)			
GW4078 - Assistant Director(Stat) Crop Reporting Service Agriculture Department District Gujranwala			**0.000**	**0.098**	**0.098**	**0.097**
2021			0.000	0.098	0.098	0.097
LO21002856GW-UPGRADATION OF GIS-REMOTE SENSING BASED CROPS' ESTIMATES & STRENGTHENING OF AREA FRAME						

SAMPLING METHODOLOGY IN PUNJAB						
P50 - Agriculture			5004 - DG Agriculture (Research)			
GW4077 - Statistician Crop Reporting Service Agriculture Department Gujranwala Division			**0.000**	**0.070**	**0.070**	**0.070**
2021			0.000	0.070	0.070	0.070
LO21002856HA-UPGRADATION OF GIS-REMOTE SENSING BASED CROPS' ESTIMATES & STRENGTHENING OF AREA FRAME SAMPLING METHODOLOGY IN PUNJAB						
P50 - Agriculture			5004 - DG Agriculture (Research)			
HA4077 - Assistant Director(Stat) Crop Reporting Service Agriculture Department District Hafizabad			**0.000**	**0.136**	**0.136**	**0.136**
2021			0.000	0.136	0.136	0.136
LO21002856JE-UPGRADATION OF GIS-REMOTE SENSING BASED CROPS' ESTIMATES & STRENGTHENING OF AREA FRAME SAMPLING METHODOLOGY IN PUNJAB						
P50 - Agriculture			5004 - DG Agriculture (Research)			
JE4077 - Assistant Director(Stat) Crop Reporting Service Agriculture Department District Jhelum			**0.000**	**0.100**	**0.100**	**0.100**
2021			0.000	0.100	0.100	0.100
LO21002856JN-UPGRADATION OF GIS-REMOTE SENSING BASED CROPS' ESTIMATES & STRENGTHENING OF AREA FRAME SAMPLING METHODOLOGY IN PUNJAB						
P50 - Agriculture			5004 - DG Agriculture (Research)			
JN4077 - Assistant Director(Stat) Crop Reporting			**0.000**	**0.225**	**0.225**	**0.225**

Service Agriculture Department District Jhang						
2021			0.000	0.225	0.225	0.225
LO21002856KI-UPGRADATION OF GIS-REMOTE SENSING BASED CROPS' ESTIMATES & STRENGTHENING OF AREA FRAME SAMPLING METHODOLOGY IN PUNJAB						
P50 - Agriculture			5004 - DG Agriculture (Research)			
KI4077 - Assistant Director(Stat) Crop Reporting Service Agriculture Department District Khanewal			**0.000**	**0.225**	**0.225**	**0.225**
2021			0.000	0.225	0.225	0.225
LO21002856KO-UPGRADATION OF GIS-REMOTE SENSING BASED CROPS' ESTIMATES & STRENGTHENING OF AREA FRAME SAMPLING METHODOLOGY IN PUNJAB						
P50 - Agriculture			5004 - DG Agriculture (Research)			
KO4077 - Assistant Director(Stat) Crop Reporting Service Agriculture Department District Kasur			**0.000**	**0.117**	**0.117**	**0.117**
2021			0.000	0.117	0.117	0.117
LO21002856KU-UPGRADATION OF GIS-REMOTE SENSING BASED CROPS' ESTIMATES & STRENGTHENING OF AREA FRAME SAMPLING METHODOLOGY IN PUNJAB						
P50 - Agriculture			5004 - DG Agriculture (Research)			
KU4077 - Assistant Director(Stat) Crop Reporting Service Agriculture Department District Khushab			**0.000**	**0.218**	**0.218**	**0.218**
2021			0.000	0.218	0.218	0.218
LO21002856LD-UPGRADATION OF GIS-REMOTE SENSING BASED CROPS' ESTIMATES & STRENGTHENING OF AREA FRAME						

SAMPLING METHODOLOGY IN PUNJAB						
P50 - Agriculture			5004 - DG Agriculture (Research)			
LD4077 - Assistant Director(Stat) Crop Reporting Service Agriculture Department District Lodhran			**0.000**	**0.200**	**0.200**	**0.200**
2021			0.000	0.200	0.200	0.200
LO21002856LH-UPGRADATION OF GIS-REMOTE SENSING BASED CROPS' ESTIMATES & STRENGTHENING OF AREA FRAME SAMPLING METHODOLOGY IN PUNJAB						
P50 - Agriculture			5004 - DG Agriculture (Research)			
LH4077 - Assistant Director(Stat) Crop Reporting Service Agriculture Department District Layyah			**0.000**	**0.274**	**0.274**	**0.274**
2021			0.000	0.274	0.274	0.274
LO21002856LZ1-UPGRADATION OF GIS-REMOTE SENSING BASED CROPS' ESTIMATES & STRENGTHENING OF AREA FRAME SAMPLING METHODOLOGY IN PUNJAB						
P50 - Agriculture			5004 - DG Agriculture (Research)			
LZ5100 - Statistician Crop Reporting Service Agriculture Department Lahore Division			**0.000**	**0.070**	**0.070**	**0.069**
2021			0.000	0.070	0.070	0.069
LO21002856LZ2-UPGRADATION OF GIS-REMOTE SENSING BASED CROPS' ESTIMATES & STRENGTHENING OF AREA FRAME SAMPLING METHODOLOGY IN PUNJAB						
P50 - Agriculture			5004 - DG Agriculture (Research)			
LZ5101 - Assistant Director(Stat) Crop Reporting Service Agriculture Department District Lahore			**0.000**	**0.090**	**0.090**	**0.089**

2021			0.000	0.090	0.090	0.089
LO21002856LZ-UPGRADATION OF GIS-REMOTE SENSING BASED CROPS' ESTIMATES & STRENGTHENING OF AREA FRAME SAMPLING METHODOLOGY IN PUNJAB						
P50 - Agriculture			5004 - DG Agriculture (Research)			
LZ5099 - Director Crop Reporting Service Agriculture Department Punjab Lahore			**0.000**	**12.065**	**12.065**	**11.879**
2021			0.000	12.065	12.065	11.879
LO21002856MF-UPGRADATION OF GIS-REMOTE SENSING BASED CROPS' ESTIMATES & STRENGTHENING OF AREA FRAME SAMPLING METHODOLOGY IN PUNJAB						
P50 - Agriculture			5004 - DG Agriculture (Research)			
MF4077 - Assistant Director(Stat) Crop Reporting Service Agriculture Department District Muzaffargarh			**0.000**	**0.280**	**0.280**	**0.280**
2021			0.000	0.280	0.280	0.280
LO21002856ML-UPGRADATION OF GIS-REMOTE SENSING BASED CROPS' ESTIMATES & STRENGTHENING OF AREA FRAME SAMPLING METHODOLOGY IN PUNJAB						
P50 - Agriculture			5004 - DG Agriculture (Research)			
ML4077 - Assistant Director(Stat) Crop Reporting Service Agriculture Department District Minawali			**0.000**	**0.215**	**0.215**	**0.215**
2021			0.000	0.215	0.215	0.215
LO21002856MM-UPGRADATION OF GIS-REMOTE SENSING BASED CROPS' ESTIMATES & STRENGTHENING OF AREA FRAME SAMPLING METHODOLOGY IN PUNJAB						
P50 - Agriculture			5004 - DG Agriculture (Research)			

MM4077 - Assistant Director(Stat) Crop Reporting Service Agriculture Department District M.B.Din			**0.000**	**0.098**	**0.098**	**0.098**
2021			0.000	0.098	0.098	0.098
LO21002856MO1-UPGRADATION OF GIS-REMOTE SENSING BASED CROPS' ESTIMATES & STRENGTHENING OF AREA FRAME SAMPLING METHODOLOGY IN PUNJAB						
P50 - Agriculture			5004 - DG Agriculture (Research)			
MO4078 - Assistant Director(Stat) Crop Reporting Service Agriculture Department District Multan			**0.000**	**0.200**	**0.200**	**0.200**
2021			0.000	0.200	0.200	0.200
LO21002856MO-UPGRADATION OF GIS-REMOTE SENSING BASED CROPS' ESTIMATES & STRENGTHENING OF AREA FRAME SAMPLING METHODOLOGY IN PUNJAB						
P50 - Agriculture			5004 - DG Agriculture (Research)			
MO4077 - Statistician Crop Reporting Service Agriculture Department Multan Division			**0.000**	**0.070**	**0.070**	**0.070**
2021			0.000	0.070	0.070	0.070
LO21002856NA-UPGRADATION OF GIS-REMOTE SENSING BASED CROPS' ESTIMATES & STRENGTHENING OF AREA FRAME SAMPLING METHODOLOGY IN PUNJAB						
P50 - Agriculture			5004 - DG Agriculture (Research)			
NA4077 - Assistant Director(Stat) Crop Reporting Service Agriculture Department District Nankana Sahib			**0.000**	**0.095**	**0.095**	**0.095**
2021			0.000	0.095	0.095	0.095

LO21002856NO-UPGRADATION OF GIS-REMOTE SENSING BASED CROPS' ESTIMATES & STRENGTHENING OF AREA FRAME SAMPLING METHODOLOGY IN PUNJAB						
P50 - Agriculture			5004 - DG Agriculture (Research)			
NO4077 - Assistant Director(Stat) Crop Reporting Service Agriculture Department District Narowal			**0.000**	**0.097**	**0.097**	**0.097**
2021			0.000	0.097	0.097	0.097
LO21002856OR-UPGRADATION OF GIS-REMOTE SENSING BASED CROPS' ESTIMATES & STRENGTHENING OF AREA FRAME SAMPLING METHODOLOGY IN PUNJAB						
P50 - Agriculture			5004 - DG Agriculture (Research)			
OR4077 - Assistant Director(Stat) Crop Reporting Service Agriculture Department District Okara			**0.000**	**0.205**	**0.205**	**0.205**
2021			0.000	0.205	0.205	0.205
LO21002856PN-UPGRADATION OF GIS-REMOTE SENSING BASED CROPS' ESTIMATES & STRENGTHENING OF AREA FRAME SAMPLING METHODOLOGY IN PUNJAB						
P50 - Agriculture			5004 - DG Agriculture (Research)			
PN4077 - Assistant Director(Stat) Crop Reporting Service Agriculture Department District Pakpattan			**0.000**	**0.169**	**0.169**	**0.169**
2021			0.000	0.169	0.169	0.169
LO21002856RS1-UPGRADATION OF GIS-REMOTE SENSING BASED CROPS' ESTIMATES & STRENGTHENING OF AREA FRAME SAMPLING METHODOLOGY IN PUNJAB						
P50 - Agriculture			5004 - DG Agriculture (Research)			
RS4078 - Assistant			**0.000**	**0.108**	**0.108**	**0.108**

Director(Stat) Crop Reporting Service Agriculture Department District Rawalpindi						
2021			0.000	0.108	0.108	0.108
LO21002856RS-UPGRADATION OF GIS-REMOTE SENSING BASED CROPS' ESTIMATES & STRENGTHENING OF AREA FRAME SAMPLING METHODOLOGY IN PUNJAB						
P50 - Agriculture			5004 - DG Agriculture (Research)			
RS4077 - Statistician Crop Reporting Service Agriculture Department Rawalpindi Division			**0.000**	**0.310**	**0.310**	**0.310**
2021			0.000	0.310	0.310	0.310
LO21002856RU-UPGRADATION OF GIS-REMOTE SENSING BASED CROPS' ESTIMATES & STRENGTHENING OF AREA FRAME SAMPLING METHODOLOGY IN PUNJAB						
P50 - Agriculture			5004 - DG Agriculture (Research)			
RU4077 - Assistant Director(Stat) Crop Reporting Service Agriculture Department District Rajanpur			**0.000**	**0.255**	**0.255**	**0.255**
2021			0.000	0.255	0.255	0.255
LO21002856RY-UPGRADATION OF GIS-REMOTE SENSING BASED CROPS' ESTIMATES & STRENGTHENING OF AREA FRAME SAMPLING METHODOLOGY IN PUNJAB						
P50 - Agriculture			5004 - DG Agriculture (Research)			
RY4078 - Assistant Director(Stat) Crop Reporting Service Agriculture Department District Rayim Yar Khan			**0.000**	**0.440**	**0.440**	**0.440**
2021			0.000	0.440	0.440	0.440

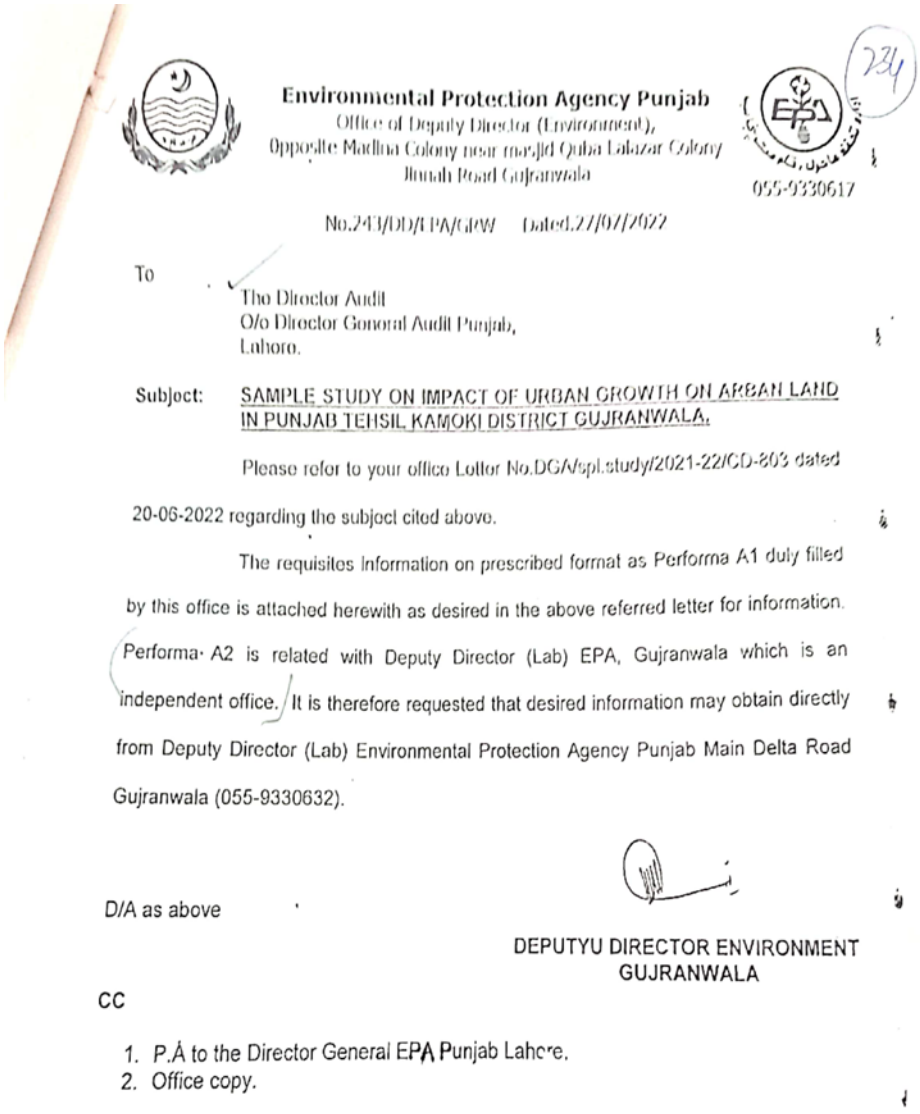
LO21002856SB-UPGRADATION OF GIS-REMOTE SENSING BASED CROPS' ESTIMATES & STRENGTHENING OF AREA FRAME SAMPLING METHODOLOGY IN PUNJAB						
P50 - Agriculture			5004 - DG Agriculture (Research)			
SB4077 - Assistant Director(Stat) Crop Reporting Service Agriculture Department District Sialkot			**0.000**	**0.122**	**0.122**	**0.122**
2021			0.000	0.122	0.122	0.122
LO21002856SE-UPGRADATION OF GIS-REMOTE SENSING BASED CROPS' ESTIMATES & STRENGTHENING OF AREA FRAME SAMPLING METHODOLOGY IN PUNJAB						
P50 - Agriculture			5004 - DG Agriculture (Research)			
SE4077 - Assistant Director(Stat) Crop Reporting Service Agriculture Department District Sheikhupura			**0.000**	**0.105**	**0.105**	**0.105**
2021			0.000	0.105	0.105	0.105
LO21002856SO1-UPGRADATION OF GIS-REMOTE SENSING BASED CROPS' ESTIMATES & STRENGTHENING OF AREA FRAME SAMPLING METHODOLOGY IN PUNJAB						
P50 - Agriculture			5004 - DG Agriculture (Research)			
SO4078 - Assistant Director(Stat) Crop Reporting Service Agriculture Department District Sargodha			**0.000**	**0.250**	**0.250**	**0.249**
2021			0.000	0.250	0.250	0.249
LO21002856SO-UPGRADATION OF GIS-REMOTE SENSING BASED CROPS' ESTIMATES & STRENGTHENING OF AREA FRAME SAMPLING METHODOLOGY IN PUNJAB						
P50 - Agriculture			5004 - DG Agriculture (Research)			

SO4077 - Statistician Crop Reporting Service Agriculture Department Sargodha Division			**0.000**	**0.070**	**0.070**	**0.070**
2021			0.000	0.070	0.070	0.070
LO21002856SS1-UPGRADATION OF GIS-REMOTE SENSING BASED CROPS' ESTIMATES & STRENGTHENING OF AREA FRAME SAMPLING METHODOLOGY IN PUNJAB						
P50 - Agriculture			5004 - DG Agriculture (Research)			
SS4078 - Assistant Director(Stat) Crop Reporting Service Agriculture Department District Sahiwal			**0.000**	**0.167**	**0.167**	**0.167**
2021			0.000	0.167	0.167	0.167
LO21002856SS-UPGRADATION OF GIS-REMOTE SENSING BASED CROPS' ESTIMATES & STRENGTHENING OF AREA FRAME SAMPLING METHODOLOGY IN PUNJAB						
P50 - Agriculture			5004 - DG Agriculture (Research)			
SS4077 - Statistician Crop Reporting Service Agriculture Department Sahiwal Division			**0.000**	**0.070**	**0.070**	**0.070**
2021			0.000	0.070	0.070	0.070
LO21002856TT-UPGRADATION OF GIS-REMOTE SENSING BASED CROPS' ESTIMATES & STRENGTHENING OF AREA FRAME SAMPLING METHODOLOGY IN PUNJAB						
P50 - Agriculture			5004 - DG Agriculture (Research)			
TT4077 - Assistant Director(Stat) Crop Reporting Service Agriculture Department District T.T.Singh			**0.000**	**0.184**	**0.184**	**0.184**
2021			0.000	0.184	0.184	0.184
LO21002856-UPGRADATION OF GIS-REMOTE SENSING BASED						

CROPS' ESTIMATES & STRENGTHENING OF AREA FRAME SAMPLING METHODOLOGY IN PUNJAB						
P50 - Agriculture			5004 - DG Agriculture (Research)			
LE4267 - AGRICULTURE RESEARCH & EXTENSTION SERVICES			**20.000**	**0.000**	**0.000**	**0.000**
2021			20.000	0.000	0.000	0.000
LO21002856VH-UPGRADATION OF GIS-REMOTE SENSING BASED CROPS' ESTIMATES & STRENGTHENING OF AREA FRAME SAMPLING METHODOLOGY IN PUNJAB						
P50 - Agriculture			5004 - DG Agriculture (Research)			
VH4077 - Assistant Director(Stat) Crop Reporting Service Agriculture Department District Vehari			**0.000**	**0.230**	**0.230**	**0.230**
2021			0.000	0.230	0.230	0.230

Annexure-5

Response from Environment Department



Environmental Protection Agency Punjab
Office of Deputy Director (Environment),
Opposite Madina Colony near masjid Quba Lalazar Colony
Jinnah Road Gujranwala
055-9330617

No.243/DD/EPA/GdW Dated.27/07/2022

To

The Director Audit
O/o Director General Audit Punjab,
Lahore.

Subject: SAMPLE STUDY ON IMPACT OF URBAN GROWTH ON ARBAN LAND IN PUNJAB TEHSIL KAMOKI DISTRICT GUJRANWALA.

Please refer to your office Letter No.DG/N/spl.study/2021-22/CD-803 dated 20-06-2022 regarding the subject cited above.

The requisites information on prescribed format as Performa A1 duly filled by this office is attached herewith as desired in the above referred letter for information. Performa- A2 is related with Deputy Director (Lab) EPA, Gujranwala which is an independent office. It is therefore requested that desired information may obtain directly from Deputy Director (Lab) Environmental Protection Agency Punjab Main Delta Road Gujranwala (055-9330632).

D/A as above

DEPUTYU DIRECTOR ENVIRONMENT
GUJRANWALA

CC

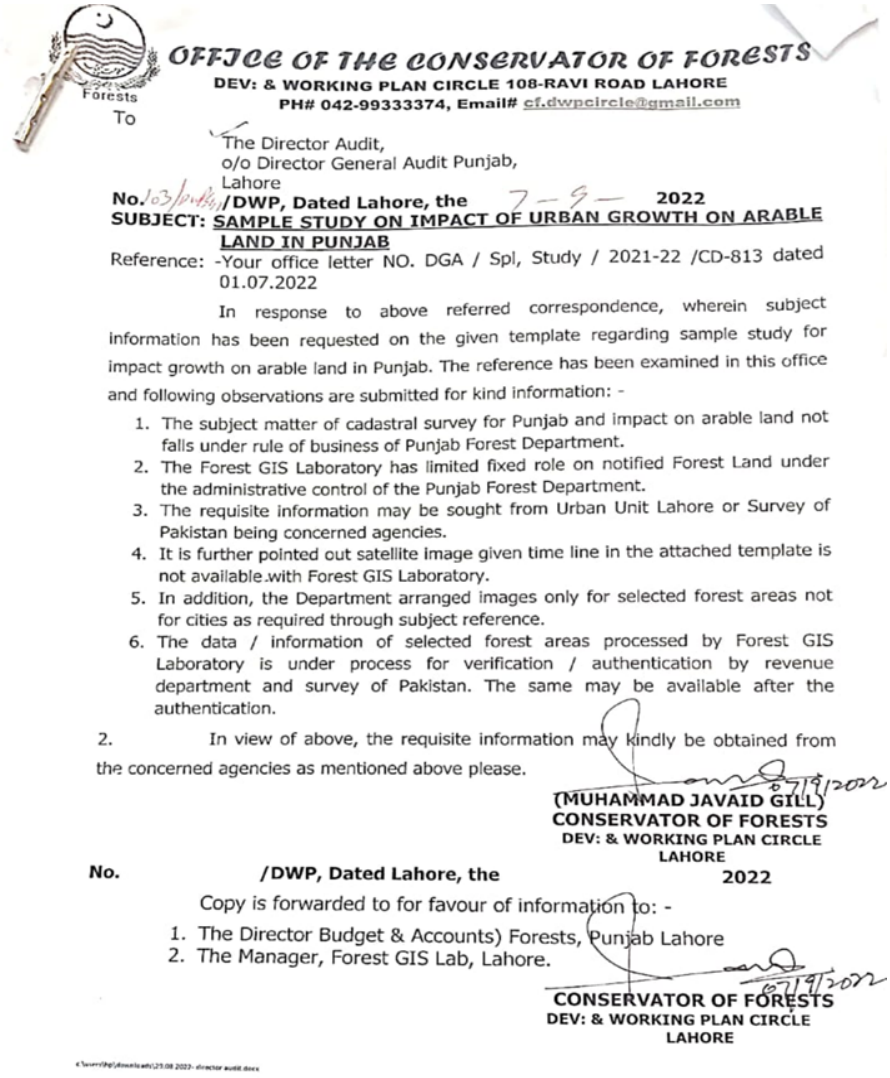
1. P.A to the Director General EPA Punjab Lahore.
2. Office copy.

Queries un-responded by Environmental Protection Agency were set forth on proforma given in the link reproduced below:

https://docs.google.com/spreadsheets/d/1MFcxU4xuSPtO9Meqf8ufci2Y_WPPr_cv/edit?usp=sharing&ouid=101126852447453440494&rtpof=true&sd=true

Annexure-6

Response from l Forest Department.



OFFICE OF THE CONSERVATOR OF FORESTS
DEV: & WORKING PLAN CIRCLE 108-RAVI ROAD LAHORE
PH# 042-99333374, Email# cf.dwpcircle@gmail.com

To
The Director Audit,
o/o Director General Audit Punjab,
Lahore

No.103/DWP/84/ /DWP, Dated Lahore, the 7-9- 2022
SUBJECT: SAMPLE STUDY ON IMPACT OF URBAN GROWTH ON ARABLE LAND IN PUNJAB

Reference: -Your office letter NO. DGA / Spl, Study / 2021-22 /CD-813 dated 01.07.2022

In response to above referred correspondence, wherein subject information has been requested on the given template regarding sample study for impact growth on arable land in Punjab. The reference has been examined in this office and following observations are submitted for kind information: -

1. The subject matter of cadastral survey for Punjab and impact on arable land not falls under rule of business of Punjab Forest Department.
2. The Forest GIS Laboratory has limited fixed role on notified Forest Land under the administrative control of the Punjab Forest Department.
3. The requisite information may be sought from Urban Unit Lahore or Survey of Pakistan being concerned agencies.
4. It is further pointed out satellite image given time line in the attached template is not available with Forest GIS Laboratory.
5. In addition, the Department arranged images only for selected forest areas not for cities as required through subject reference.
6. The data / information of selected forest areas processed by Forest GIS Laboratory is under process for verification / authentication by revenue department and survey of Pakistan. The same may be available after the authentication.

2. In view of above, the requisite information may kindly be obtained from the concerned agencies as mentioned above please.

7/9/2022
(MUHAMMAD JAVAID GILL)
CONSERVATOR OF FORESTS
DEV: & WORKING PLAN CIRCLE
LAHORE

No. /DWP, Dated Lahore, the 2022

Copy is forwarded to for favour of information to: -

1. The Director Budget & Accounts) Forests, Punjab Lahore
2. The Manager, Forest GIS Lab, Lahore.

7/9/2022
CONSERVATOR OF FORESTS
DEV: & WORKING PLAN CIRCLE
LAHORE

Fiscal Year	Project Description		Original Budget	Final Budget	Prog Releases	Progressive Exp
	Grand Total	**1**	**55.000**	**47.443**	**45.792**	**42.903**
LO16000186			**55.000**	**47.443**	**45.792**	**42.903**
LO16000186-Development of GIS based Forest Management System in Punjab.						
P62 - Forestry Wildlife & Fisheries			5301 - Chief Conservator of Forests (P&E) Centr Zone LHR.			
LE4219 - ADMINISTRATION			**0.000**	**1.651**	**0.000**	**0.000**
2017			0.000	0.000	0.000	0.000
2018			0.000	0.000	0.000	0.000
2019			0.000	1.651	0.000	0.000
LO16000186LZ-GIS Based Forest Management System in Put System in Punjab.						
P62 - Forestry Wildlife & Fisheries			5301 - Chief Conservator of Forests (P&E) Centr Zone LHR.			
LZ4651 - Conservator of Forests D&WP Lahore			**51.800**	**42.882**	**42.882**	**40.676**
2017			35.800	29.733	29.733	28.338
2018			12.002	12.002	12.002	11.191
2019			3.998	1.147	1.147	1.147
LO16000186 MO-Development of GIS based Forest Management System in Punjab.						
P62 - Forestry Wildlife & Fisheries			5301 - Chief Conservator of Forests (P&E) Centr Zone LHR.			
MO4437 - Conservator of Forests D&WP Multan			**1.600**	**1.505**	**1.505**	**1.433**
2017			1.600	1.505	1.505	1.433

LO16000186RS-Development of GIS based Forest Management System in Punjab.						
P62 - Forestry Wildlife & Fisheries			5301 - Chief Conservator of Forests (P&E) Centr Zone LHR.			
RS4437 - Conservator of Forests D&WP Rawalpindi			**1.600**	**1.405**	**1.405**	**0.795**
2017			1.600	1.405	1.405	0.795

Annexure-7

Office of the
DIRECTOR GENERAL AUDIT, PUNJAB
6th Floor A.G Office Building, 1 Turner Road, Lahore.
Phone No.0429210147,Excange Nos.0429210823&0429212459 Fax No.0429210166

No. DGA/Spl.Study/2021-22/CD-824 Dated: 01.08.2022

To

Deputy Commissioner
Sahiwal

Reminder

SUBJECT: **SAMPLE STUDY ON IMPACT OF URBAN GRWOTH ON ARABALE LAND IN PUNJAB**

Kindly refer to the subject cited above and previous earlier letter No. DGA/Spl.Study/2021-22/CD-824 dated 18-07-2022

2 It is intimated that office of the Auditor General of Pakistan intends to carry out a research and analytical study regarding impact of urban growth on arable land and inter-related aspects pertaining to Punjab province. The objective is to summarize, correlate and encompass all facts/data pertaining to the subject, incorporate viewpoints of field experts and relevant government departments and make plausible recommendations facilitating the provincial government as well as Federal Government in addressing issues relating to urbanization and its impact on arable land.

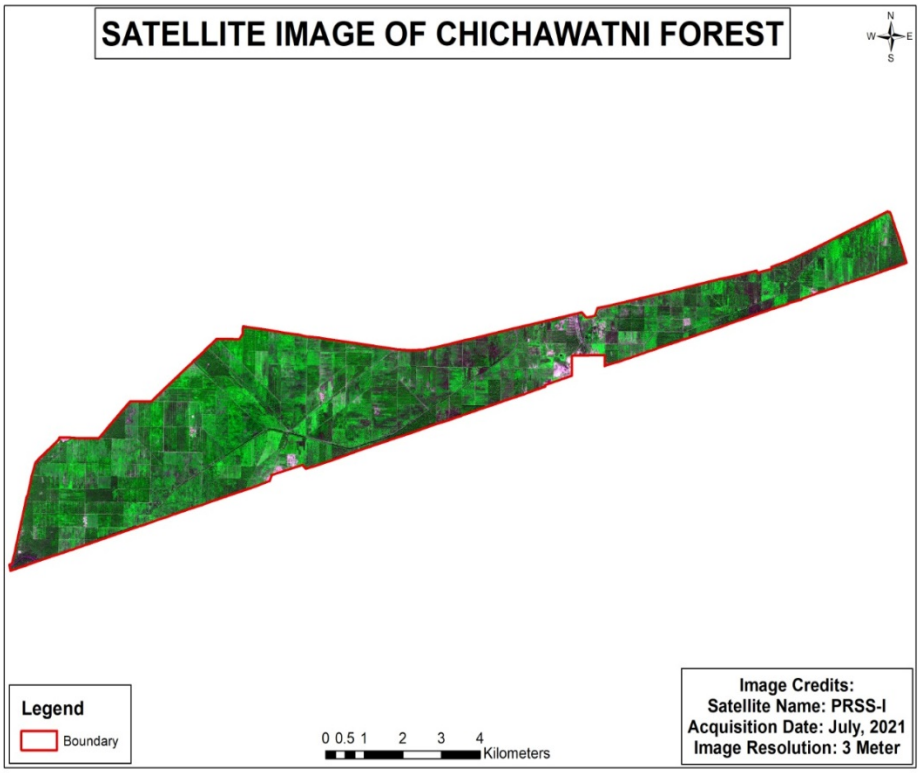
3 In this regard, provision of data and relevant record (as per format given in Annexure –A), from the offices under your jurisdiction would be critical towards successfully completing the subject study.

Director/Audit

Annexure -A

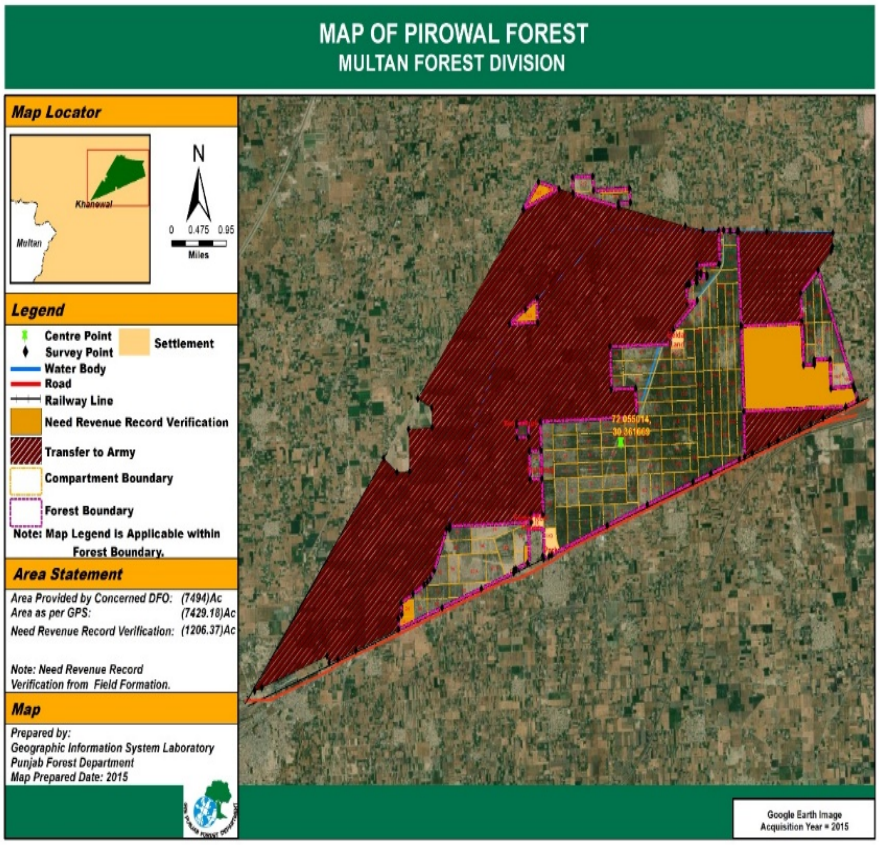
Sr.No	Punjab Land Use [Classification, Reclassification and Redevelopment] Rules, 2009	Uploaded documents to be posted on Website of Municipal Committee & Documents ancillary to above information
1	Rule no 24b sub rule 3 of Rules ibid prescribes that a City District Government or a Tehsil Municipal Administration shall publish the notified land use classification map on its website	• Notified spatial plans, master plans, zoning, land use plans, including classification and reclassification of land, urban design, urban renewal. • "master plan" means a land use plan of an area and includes a structure plan, an outline development plan, a spatial plan, peri-urban structure plan and a metropolitan plan. • "Land use plan" means a plan approved by a competent authority for reclassification, development or redevelopment of an area. • Agenda and deliberations of District planning & design committee as contained in the minutes of meeting. • Agenda and deliberations of district commercialization committee deciding the cases of change of land use from residential to commercial • Action plan for integrated system of water reservoirs, water sources, treatment plants, drainage, liquid and solid waste disposal, sanitation and other municipal services; • Horticulture and Arboriculture developments planned and executed • Implemented rules and bye-laws governing land use, housing, markets, zoning, environment, roads, traffic, infrastructure and public utilities: • list of the proposed road networks; • list of division of area into blocks; • The list of the proposed land uses for various blocks for last 20 years • Copies of guidelines, policies and strategies for guiding the future growth areas around the cities. • Structure Plan as a legally binding document acceptable to all the stakeholders. • Identification of City Boundary with respect to rural area, peri urban and urban area. • Allocation of land uses to blocks
2	Rule no 27 sub rule 1 (a) of Rules ibid prescribes that invite objections or suggestion by giving public notice indicating salient features of the draft peri-urban structure plan on its website and in at least two leading national and one local news papers	
3	Rule no 31 sub rule 3 of Rules ibid prescribes that a City District Government or a Tehsil Municipal Administration shall publish the notified peri-urban structure plan on its website.	
4	Rule no 35 sub rule 3 of Rules ibid prescribes that a City District Government or a Tehsil Municipal Administration shall publish the notified planning map on its website.	
5	Rule no 37 sub rule 3 of Rules ibid prescribes that a City District Government or a District shall publish the district planning map on its website.	
6	Rule no 44 sub rule 1 (a) of Rules ibid prescribes that invite objections or suggestion by giving public notice indicating salient features of the draft land use re-classification scheme of a project area on its website, to the key	
7	Rule no 48 sub rule 3 of Rules ibid prescribes that a City District Government or a Tehsil Municipal Administration shall publish the notified land use re-classification scheme on its website.	
8	Rule no 49 (A) sub rule 2 of Rules ibid prescribes that a City District Government or a Tehsil Municipal Administration shall, prior to submitting	

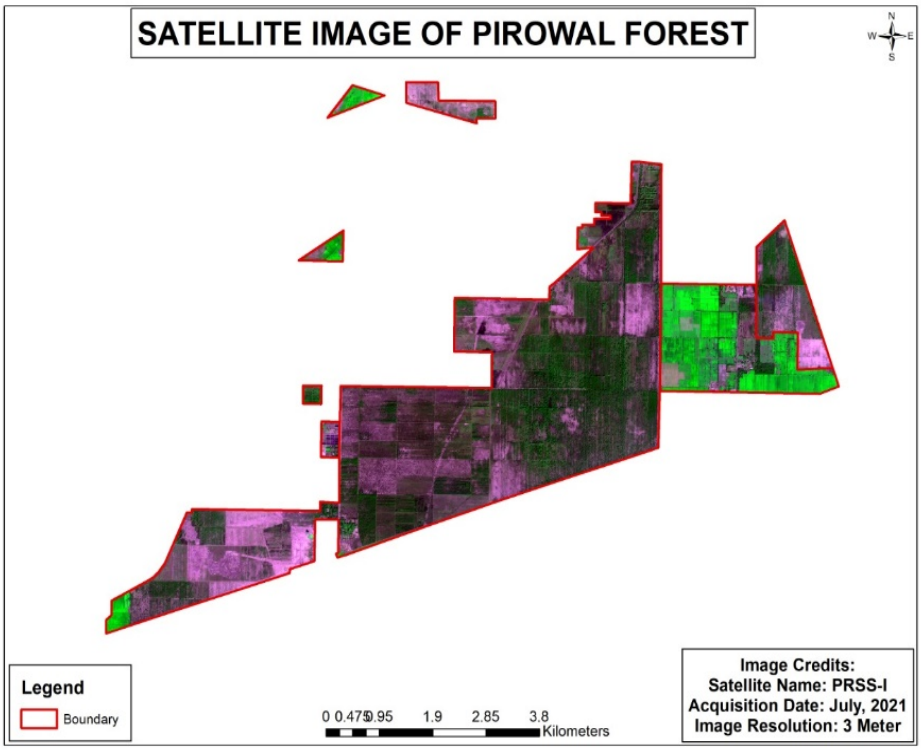
Annexure-8


SATELLITE IMAGE OF CHICHAWATNI FOREST
N
W
E
S
Legend
Boundary
0 0.5 1 2 3 4
Kilometers
Image Credits:
Satellite Name: PRSS-I
Acquisition Date: July, 2021
Image Resolution: 3 Meter

Annexure-9

Pirowal Forest satellite image




SATELLITE IMAGE OF PIROWAL FOREST
N
W
E
S
Legend
Boundary
0 0.475 0.95 1.9 2.85 3.8
Kilometers
Image Credits:
Satellite Name: PRSS-I
Acquisition Date: July, 2021
Image Resolution: 3 Meter

Annexure-10

Data discrepancies from source documents are placed in a link given below:

https://drive.google.com/file/d/1WFNWHvY2gBfQifYx1-pNUqef4rge8Ata/view?usp=sharing

16. Bibliography

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