REIMAGINING PLANNING OF IRRIGATED AGRICULTURE IN THE INDUS RIVER BASIN, PUNJAB, PAKISTAN

By

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Abstract

Faced with rapid resource degradation in the Indus river basin in Punjab, Pakistan, the provincial government of Punjab has identified 'integrated water resource management' as the guiding paradigm for achieving efficient, equitable and environmentally sustainable use of natural resources in the province. However, no clear roadmap for how multi-sectoral, 'integrated' resource management and governance can be operationalized exists. Focusing on irrigated agriculture in Punjab, this thesis uses a combination of historical, institutional and empirical analyses to investigate how 'integrated' food and water planning can be achieved in Punjab. The **historical** analysis traces how the idea of 'integration' in irrigated agriculture has evolved in Pakistan's colonial history and within the province of Punjab after independence. It reveals that both the departments of irrigation and agriculture have highlighted the need for vertical and horizontal integration within and between the departments throughout their existence. They have experimented with various institutional configurations and many reforms, like the creation of the On-Farm Water Management directorate and introduction of participatory irrigation management, have been implemented in an effort to achieve this integration. The **institutional** analysis explores how planning is done within and across the provincial departments of agriculture and irrigation. It finds that currently only the provincial tiers are responsible for planning *within* the two departments while the sub-provincial tiers are responsible for management and operational functions. Coordination *between* the departments happens by way of the provincial Planning and Development department as the final approver of their proposed plans. Finally, the **empirical** analysis uses annually collected departmental data to develop metrics that can enable integrated planning of irrigated agriculture. In conclusion, this thesis uses the idea of boundary spanning organizations and objects and builds on the historical, institutional and empirical analysis to propose recommendations for how planning in the Indus River Basin of Punjab can be re-imagined.

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Contents

CHAPTER 1: LOCATING INTEGRATED WATER RESOURCE MANAGEMENT IN PUNJAB'S POLICY LANDSCAPE

Pakistan Vision 2025 was published by the current national government in 2014 as a blueprint for the country's development, with the goal to set Pakistan on the path to becoming one of the ten largest economies in the world by 2047 (Pakistan Vision 2025, x). The document identified seven key pillars for achieving this goal, of which Pillar IV was 'Security', described as "sufficient, reliable, clean and cost-effective availability of energy, water and food security – for now and the future"(p58). However, the report goes on to recognize that "these sectors have suffered historically from severe failings of integrated policy and execution" (p58) and while it identifies the problems, it does not have concrete suggestions for how this integration in policy and execution may be achieved. Focusing on irrigated agriculture, interactions between food, water and energy most clearly manifest at the farm level since agricultural output (or food) is a clear outcome of water (in the form of surface irrigation) and energy (used in pumping ground water). While the farmer constantly weighs the trade-offs involved in prioritizing one sector over another (e.g. using energy for ground water extraction costs substantially more than the nominally priced canal water), relevant government departments function in sectoral silos which has resulted in severe natural resource degradation and inefficient, unsustainable practices within Punjab.

The province of Punjab is well cognizant of the hurdles in the way of sustainable resource management in the Indus river basin and is striving to address these challenges through continuous reform efforts. The latest thinking, as Member Infrastructure, Planning

and Development Department (PND), Abid Bodla summarized, focuses on achieving integration in water management by rationalizing water use between sectors and reducing inequities in water access: "On the macro scale, we want to understand how to allocate water between different uses, and on the meso and micro scale, we want to look at the food-water-energy nexus and understand how to reduce head-tail inequities to address rural poverty." The macro scale refers to the provincial level, where the major planning problem PND foresees is competing demand for water between agricultural, domestic, industrial and environmental uses. The meso and micro scale refers to the sub-provincial district, tehsil, village and farm tiers where head tail inequities in water conveyance are commonly understood to be the biggest causes of the yield gap and poor agricultural output in Punjab. In order to address these problems, after over a decade of consultations and reiterations, a Punjab Water Policy is near finalization and expected to be approved nationally and provincially. This document has put forward a coherent, multi-pronged approach to water resource management that seeks to combine ideas of Integrated Water Resource Management, food-water-energy nexus thinking, cutting edge water informatics tools and deliberate thinking around water governance and institutional reform to tackle the challenges confronting Punjab today.

Historically, there has been a tradition of responsive natural resources management nationally by the country's top water, agriculture, energy and irrigation departments. This includes the negotiation of the Indus Water Treaty in 1961, the green revolution between the 60s and 80s to gain self-sufficiency in food production, infrastructural reform efforts with

donor support, addressing issues of salinity and water logging in the 90s by encouraging deep drill tube well usage in targeted areas, and the creation of the on-farm water management wing in the 80s to improve water efficiency in canals and on farms. Since devolution of power to the provinces in 2010, this role has been taken over by the provincial government. However, as the concerned provincial departments have reacted to one problem after another, new challenges have emerged requiring more innovative and responsive planning, governance and management. The draft provincial water policy is the first document that seeks to put together a coherent, holistic vision for achieving the goals of sustainable natural resource management, resiliency in the face of climatic unpredictability, and reduction of inequities between upper and lower riparian farmers. As the document summarizes succinctly: "While the Irrigation Department has served well the initial need of developing and maintaining the irrigation infrastructure, a transition is now required from building to managing, from development to conservation, from supply to demand, for which institutional reforms, strengthening and capacity building are now required not only in line departments but also a new approach towards implementation of Integrated Water Resources Management (IWRM) methodology is required." (Punjab Water Policy, p6)

I) Integrated Water Resource Management (IWRM)

This thesis looks at the question of food and water planning in Punjab, Pakistan, to understand how better integration across departments horizontally, and different scales vertically, might improve planning outcomes to help achieve goals of food and water security in the province. A focus on integration between different water uses and with a focus on the

food-water-energy nexus has been identified by the province of Punjab in various policy and planning documents (Pakistan Vision 2025, National Water Policy (draft), Provincial Water Policy (draft)). Integrated Water Resource Management and food-water-energy nexus have been explicitly called out as paradigms guiding the way forward for provincial policy and planning. The government of Punjab has begun giving an institutional shape to this idea with the creation of a water resource management wing. A technical assistance grant from Asian Development Bank is being used to hire water experts and consultants to delineate how an IWRM approach may be implemented institutionally using the key features identified in the provincial water policy.

However, given the lack of clarity around how IWRM may be implemented or the food-water-energy nexus operationalized, translating these ideas into implementable plans is no easy task. Both approaches particularly fall short in specifying what 'integration' among different water uses or between food, water and energy might look like or how it might be implemented. However, they come with unique principles that have significant implications on water use, food production, and users of these systems. For example, the key features of IWRM identified by the provincial water policy come straight out of the donor cookbook of the principles that IWRM embraces. These include "...river-basin planning based on IWRM and the creation of river-basin organizations, ...decentralization of decision making, transferable water rights, cost recovery and pricing, and participation of farmers in agricultural water use through participatory irrigation management." (Giordano and Shah, p366) But in terms of integration, as Giordano points out, "though IWRM is meant to provide

integration across sectors, it is typically pushed primarily by water professionals. Thus, actual implementation often neglects the integration of land with water rights." (Giordano and Shah, p367) In Punjab, this is taking the shape of the Water Resource Management Wing which will put water management hierarchically above other departments, e.g., agriculture, which limits agriculture's ability to be a part of the discussion on irrigation and agriculture planning on an equal field.

In 'Water Governance in a Comparative Perspective', Benson et al identify five elements to understand how IWRM and WEF differ: "*policy integration*; *governance*; *scale*; *participation*; *resource efficiency* and *sustainable development*." Benson finds that while IWRM is silent on institutional aspects of 'integration' focusing on principles of 'good governance' such as "transparency, collaborative decision making and the use of specific policy instruments" (Benson et al, p760), the nexus approach "treats different sectors – water, energy, food and climate security – as equally important (i.e. multi-centric)". This has important implications for consideration of multi-sectoral integration and joint decision making, however, even nexus conceptualizations "provide few normative principles on how governance should occur." (Benson et al, p760) Furthermore, integration raises "'institutional challenges' with both 'opportunities and impediments to joint decision-making'", and "because 'resource coupling' is played out at different institutional levels, 'multi-tiered institutional arrangements' are required to govern it." (Benson et al, p 760). In spite of the broad body of work present on the need for integration within the IWRM literature and the

more recent idea of WEF nexus, there is little guidance on what integration means or how it might occur in a governance framework.

II) What is integration?

Given the number of stakeholders and geographical and administrative tiers involved in irrigated agriculture in Punjab, Pakistan, coordination between everyone involved is challenging to say the least. Integrated planning across food, water and energy is even more difficult without well-established mechanisms. The interaction between food, water and energy in Punjab is most clearly acknowledged by all stakeholders at the farm level where food is produced through investment of surface water and energy usage in ground water extraction (by way of tube wells). 95% of the total water flow in Punjab's irrigation system is used in agriculture and over 20% of the primary energy used in Punjab contributes to ground water abstraction in agriculture (Wescoat and Siddiqi, p580). The provincial water policy recognizes that a number of key institutional and legislative reforms are needed in order to better manage the food-water-energy nexus and integrate water resource management. And while it seeks to establish IWRM in Punjab, it does not develop clear mechanisms for integration of planning and decision making at tiers below the provincial level and the approach remains water-centric. As Giordano points out in his analysis of IWRM's success: "IWRM is flawed because it puts water at the center though it is only one aspect of holistic problem management." (Giordano, p365)

This thesis seeks to understand what the benefits of horizontal and vertical integration might be in Punjab and provide guidelines on how it might be achieved based on

the provincial water policy draft and initial thinking with regards to establishment of a water resource management entity at the provincial level. Ultimately it seeks to answer the question: why is integration beneficial in the planning of irrigated agriculture and how can an integrated planning framework be operationalized in the province of Punjab? It will do this by investigating three aspects of the institutional mix as it exists in the province today:

a) Integration across departments

The provincial water policy highlights: "The IWRM approach moves away from single sector water planning to multi-objective planning and integrated planning of land and water resources, recognizing the wider social, economic and development goals and entailing cross-sectoral coordination. It is a dynamic approach." (Provincial Water Policy, p33) However, there is a clear hierarchy in the departmental operations based on their functions and management paradigms. Irrigation is supply based and therefore sets the water allocations for agriculture. The agriculture department follows more of a market-based, demand-driven approach to incentivize farmers to adopt water conserving measures or improve agricultural productivity. The new water policy highlights irrigation efficiency, water productivity and cropping patterns as means by which water use effectiveness in agriculture can be improved and recommends measures like agro-ecological zoning, extensification over intensification, addressing head-tail inequities as ways to manage demand for water (Provincial Water Policy, p29-31). However, given the clear delineation between irrigation and agriculture departments, assumptions about what the two departments can achieve hinder coordination between the two for more effective problem solving. It needs to be investigated what an

integrated planning framework may require to encourage more active coordination in planning between the irrigation (and future water resource management wing) and agriculture departments.[1]

b) Integration within departments

The irrigation and agriculture departments of Punjab function along geographical and administrative boundaries that do not align. The irrigation department follows a canal command based hierarchical structure[2] while the agriculture department[3] follows traditional administrative structures along district, tehsil and union council boundaries[4]. Given this misalignment of geographical boundaries, current mechanisms for coordination between departments exist predominantly at the provincial level. This fits within the IWRM paradigm because it encourages a basin based approach to water resource management. While Punjab does not contain the entire river basin for the Indus River and the remaining four rivers passing through the province, this approach embraces a provincial level centralized management of the basin area that falls within the provincial boundaries. This is evidenced in

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[1] The departments are also looking at notifying agro-ecological zones as a way to address the boundary mis-alignment issue between agriculture and irrigation. Identifying a system to decide optimal cropping patterns for different agro-ecological zones is another area of interest.

[2] The irrigation system is divided among 5-6 Chief Engineers (CE) and each of these units is called a zone. Each zone is split into 2-3 canal circles headed by a Superintendent Engineer (SE). Each circle is a unit with a complete canal system. The circle is further divided into divisions along major distributaries coming out of the canal system which are managed by the Executive Engineer (XEN). The division is further divided along minor distributaries into sub-divisions which are headed by the Sub-Division Officer (SDO).

[3] The province of Punjab is divided into 9 divisions and 36 districts. Each district is further sub-divided into tehsils and union councils where each union council tends to be between 25,000 and 40,000 in population. Most government departments follow this population based structure for administrative and management purposes.

[4] Organograms for both departments can be found in Appendix 1

the provincial water policy that clearly recommends the establishment of basin/sub-basin authorities for the implementation of IWRM in Punjab. The water policy also suggests development of decision support based tools using GIS, and extensive water and environment databases for knowledge based management of the basin: "Punjab currently lacks an integrated database for water and environment, water balance and real time simulation models, the use of which could tremendously enhance in *[sic]* resolving water allocation and equity issues" (Provincial water policy, p6). The focus on the basin as the unit of governance and the use of technically developed tools for management are factors that encourage a centralization of management and concentration of decision-making and planning powers at the provincial level. However, this might result in atrophying of management abilities at the sub-provincial institutional tiers. There is, thus, also a need to investigate what role can be played by the sub-basin and district level authorities in planning and resource management for improved vertical integration across institutional tiers.

c) Role of the meso-scale in improving water and food governance

Punjab provides an interesting case study of water and food governance with a clear case of centralization of expertise at the provincial level, while simultaneously trying to adopt participatory management at the farm level by creating Farmer Organizations. There is acceptance within the provincial irrigation department (PID) that participatory management experiment has not been a success to date and needs more reforms before it can be fully operational: "In reality two parallel systems of management of canal irrigation are now in

place – 5 canals managed under PIDA[5] and 20 canals under the Department of Irrigation. Therefore, the desired objectives of reforms could not be achieved and the experiences are of mixed nature. It is the right time to review the lessons learnt from the institutional reforms in the five Pilot AWBs[6] and develop a system of reforms which suits the socio-political situation of the province and acceptable to the Department of irrigation and the water users." (Provincial water policy, p35)

Part of the difficulty in a multi-scale institutional analysis is that the provincial water policy treats the irrigation department as a single province-wide entity, whereas conflicting incentives and localized political economy factors impact farmer's ability to act and resolve water conflicts and make agricultural decisions in their particular context. Elinor Ostrom highlights in her studies of cooperative management of common pool resources like canal and underground water is best managed by understanding the 'rules of the game' set up by the particular institutional mix in an area. Scott, Kurain and Wescoat Jr. summarize: "for successful environmental outcomes at the level of watershed to be replicated at the basin scale would require robust feedback loops that support both vertical and horizontal institutional linkages that can respond to vagaries of both socio-economic heterogeneity and also bio-physical change and variability." (p32) Much of the interface between government institutions and users of the irrigation system occurs at the meso/district/water distributary scale. This is also where political forces, problems of elite capture and farmer rivalry manifest

[5] Provincial Irrigation and Drainage Authority
[6] Area Water Boards

most explicitly. However, the water policy does not explicitly call out the meso-scale of governance and what its role may be in setting up an integrated water management structure. Part of the reason for this is that mid-tier administrative structures are seen as extensions and implementation arms of the provincial administration and not envisioned as planners. The role of the meso-scale or the district/canal command managers thus remains under-studied. However, this tier provides the key link between the micro and macro, setting up the local context within which farmers and other actors function. A provincial approach also may not allow for sufficiently customized management of variations of socio-economic heterogeneity and biophysical variability. Delineating what planning and management occurs at each of the institutional levels and what role the meso-scale might play in it is also a key aspect of investigation in this thesis in setting up an integrated planning framework for water management in Punjab.

III) Planning Irrigated Agriculture in Punjab

This thesis seeks to reimagine some of the principles and institutional roles guiding planning in the Indus river basin in Punjab to achieve outcomes of efficiency, equity and environmental sustainability. The investigation of these questions is guided by Elinor Ostrom's thinking around how complex socio-ecological systems should be studied, understood and designed: "An irrigation system is a social ecological system involving complex interactions between human actions and physical-biological dynamics. The usual assumption is that only after improved engineering works have been put in place, could 'appropriate' institutions be molded." (Ostrom, 2005, p6) However, as she goes on to

elaborate, "Engineering works are but one of many components that constitute a socio ecological system." (p6-7) A well thought out, context based institutional template that allows for stakeholders to work together for collective management of common pool resources is necessary for the development of robust, sustainable systems. As Ostrom explains, "We need to ask how diverse polycentric institutions help or hinder the innovativeness, learning, adapting, trustworthiness, levels of cooperation of participants, and the achievement of more effective, equitable, and sustainable outcomes at multiple scales." (Ostrom 2009, p436)

While the province of Punjab has explicitly selected IWRM as its guiding paradigm for water resource management in Pakistan, it is unclear if this approach will help or hinder the qualities highlighted by Ostrom above. This thesis will focus specifically on planning in irrigation and agriculture to understand the problems and potential of vertical and horizontal integration within and between the departments of agriculture and irrigation from a historical, institutional and empirical lens. One chapter each is dedicated to these three dimensions and a concluding chapter proposes a way forward towards achieving integrated planning with the ultimate goal of imagining an institutional design that enables farmers and concerned institutions to develop robust and adaptive systems. Within the broader framework set-up above, the thesis seeks to address two key questions: 1) Why integrated planning? Or phrased differently; what benefits might integration offer in better planning of irrigated agriculture in the province of Punjab, and 2) Can a case be made for elevating the role of the meso-scale in creating improved vertical and horizontal linkages for stronger planning within the province of Punjab?

Chapter 2 will set up the institutional context by tracing how the idea of 'integration' in the planning of irrigated agriculture in Pakistan has historically evolved prior to decentralization and after it. This chapter will identify centralization of natural resource management at the provincial level as a key outcome of decisions around management of water infrastructure; and explore how ideas of bottom up participation through farmer organizations developed in the province. Chapter 3 will explore the current institutional make-up of and planning processes in the agriculture and irrigation departments. It will demonstrate that the meso-scale has been a historically neglected tier from a planning perspective and a weak connector between the provincial and lowest tier of farmer organizations. Chapter 4 will develop the importance of considering multiple scales in planning through empirical analysis of key agricultural data in the province of Punjab, and try to quantify benefits of more integrated planning across the province. The concluding chapter will build on the historical, institutional and empirical analysis to propose recommendations for how a more integrated approach to planning irrigated agriculture might be operationalized in the province of Punjab so that IWRM becomes means to achieving improved natural resource management within the province instead of becoming the end in itself.

CHAPTER 2: EVOLUTION OF WATER-FOOD-ENERGY PLANNING IN PUNJAB, PAKISTAN

In her book 'Improving Irrigation in South Asia', Elinor Ostrom identifies an 'interventionist mentality' to be a key problem in developing robust and responsive irrigation systems. This mentality sets up a power dynamic where engineers see themselves as help providers and farmers as 'help recipients', resulting in a flawed accountability system where engineers are accountable to goals set by superiors rather than engaged in problem solving to serve the farmers (Ostrom, 2009, p8). In such a situation, government engineers and bureaucrats become focused upwards rather than downwards, prioritizing checking off deliverables rather than solving actual problems. Users then may perceive the intervention to be a game where they have to compete with each other to benefit (p9). To a large extent, a similar narrative captures the evolution of irrigated agriculture in Punjab as well. This chapter argues that a combination of the 'rule of experts' and systematic dismantling of linkages between community and developers of the agriculture and irrigation infrastructure, has encouraged a centralized, top down and siloed approach to food, water and energy planning in Punjab and Pakistan. Recent reform efforts to amend this have focused on participatory management of the irrigated agriculture system, identifying the village as the unit where integration across water and energy sectors for food production may be achieved. However, these efforts have stemmed from the top or through international donor efforts instead of from the grass-roots level, and without correct institutional arrangements in place, it is unlikely that such integration can be achieved successfully.

I) Key Stakeholders in Irrigated Agriculture

Food, water and energy in the province of Punjab, Pakistan, are managed by a wide range of actors and institutions. Departments of Agriculture, Irrigation and Planning and Development are the most directly responsible governance entities. Each, however, has several sub-departments and connected authorities that are responsible for a multiplicity of functions. For example, the provincial Planning and Development department assigns budget and approves development projects, Department of On-Farm Water Management pushes technologies for higher water productivity, Agriculture Extension Department helps knowledge dissemination to farmers, the Irrigation Department manages infrastructure development and irrigation system operation and the Provincial Drainage Authority supports the maintenance of irrigation and drainage system through creation of farmer organization at the behest of donor organizations encouraging participatory systems. Among all this, the Farmer Organizations have to talk to the Irrigation Department, which only interacts formally with the Agriculture department a few times a year while the Agriculture department's On-Farm Water Management wing limits its jurisdictional mandate to farm level water usage and efficiency, quite separately from the Irrigation Department. Meanwhile, donor organizations bring in local and international expertise, and facilitate research and innovation in integrated modelling and grand multi-sectoral plans - even as the farmer on the ground remains six degrees removed and the agriculture economists and irrigation engineers claim monopoly of technical knowledge as a hurdle to including mid to low tier managers into planning and decision making.

Integrated food-water-energy planning requires that the existing insitutional framework supports the alignment of all these stakeholders to work towards similar goals and contains built-in mechanisms for cross-departmental coordination. However, analysis of the development of these departments and sub-departments shows that such coordination, while considered frequently, has rarely been practiced. This chapter traces the evolution of the departments of irrigation and agriculture since colonial times to understand how they historically understood the need for integration in food, water and energy sectors and why coordination between these departments is difficult to achieve.

II) The Problem of Resource Management

Agriculture accounts for more than 40 percent of the Pakistan's employment and roughly 21 percent of the GDP[7] (Bennmessaoud et al., 2013, p10). The irrigation system plays an integral role in maintaining the agricultural sector since majority of the agricultural land in Pakistan obtains water through irrigation. Furthermore, due to expansion of the irrigation infrastructure, the cultivable area has gradually increased from 25 million acres in 1947 at the time of independence to roughly 40 million acres in 2004 (Qamar and Briscoe, 2005, p40). Pakistan's crop yield levels remain well below what has been achieved globally and regionally (Qamar and Briscoe, 2005, xx), and due to a shortage of water storage for food production, farmers are relying on ground water to supplement canal water supplies, leading to falling water tables (Qamar and Briscoe, 2005, p41). This is also the main source of energy usage in agriculture in Pakistan, with 20% of the Punjab's energy usage being consumed in agriculture

[7] Based on 2010 figures

by way of tube wells (Siddiqi and Wescoat, 2013, p580). Furthermore, the use of tube wells and inefficiencies in the surface canal water infrastructure has also been found to be related with issues of water logging and salinity, to the point that now poor water quality is leading to loss of cultivable land. Thus it is clear that canal water and energy usage in ground water, as managed by the department of Irrigation, are directly related to food production, which is supported and managed by the agriculture department. The two departments have historically had clearly separated jurisdictions to prevent overlapping responsibilities, which has made integration across sectors, and aligning goals and coordinating on development quite difficult.

III) Emergence of Irrigated Agriculture in the Indian Subcontinent

The development of irrigation infrastructure and settled agriculture was systematically used by the Mughals and the British to establish connections between the state and local communities. A basic canal infrastructure was developed during Mughal times depending on the state's ability to "mobilize local elites and their followers in canal digging" so as to produce 'communities' of sharers and maintainers of waters; and also as a way of linking the state with local elites (Gilmartin, 1994, p1132). The British used irrigated agriculture as a tool for incentivizing nomadic populations to settle and to provide employment to disbanded soldiers. While those were the immediate reasons, a larger philosophical reason behind situating the Indian population within a property rights regime based on agricultural settlement was to locate them within a local social order of 'community' and 'custom' associated with the colonial state. As David Gilmartin explains: "On one level, of course, this

was because of the close connection in this arid region between the local control of water and settlement on the land. But on another level, it reflected the fact that control of irrigation was a hinge between the power of the local "community" and that of the state." (Gilmartin, 1994, p1134) Gilmartin terms this the 'science of empire' rooted in the British practice of linking the colonial state to the local community through settling land within "a framework of local relationships" and "by the legal and administrative language of the colonial state." (Gilmartin, 1994, p1133)

The British 'science of empire' sought to study, classify and order alien cultures and communities – and build on this process to develop connections with local elite and communities. This had two possible consequences. Some argued that it "tended to legitimize the exercise of local 'privilege' in the management of irrigation water, even though this often undercut effective water management..." which led to "oppression on the part of the headmen of villages." (Gilmartin, 1994, p1136) I.e. inequalities were hard coded into the physical nature of the irrigation infrastructure as it was developed by certain local elites to their own advantage under the British. However, a conflicting argument was made by some British officials for recognizing the importance of local knowledge and custom to encourage self-governance. Gilmartin points out that most of this discussion was based around the use of *chher* labor provided by irrigators during winter season for silt clearance. Some among the British administrators considered the use of such labor without due compensation coercion while others took it as an important part of self-government of the irrigation infrastructure. This struggle represented the ultimate push and pull between a cross-sectoral management

of the irrigation infrastructure that included the farmers in a form of self-governance, and an engineer based view of management that prioritized efficiency and ideas of mathematical calculation to ensure equity (Gilmartin, 1994, p1136). In the early 19th century the *cherr* system of labor was abolished, marking a clear win for the scientific empire and the engineers versus ideas of community based self-governance. Gilmartin identifies the Canal and Drainage Act of 1873 as the ultimate codification of the bureaucratization and centralization of canal network management, and explains that "the achievement of British Indian engineers in the late nineteenth and early twentieth centuries was...to define a new, 'scientific' way of looking at the problem that would justify excluding local 'communities' from a role in the administration of major canal channels." This meant relying on science to address problems of silting in canals, eliminating the role of irrigation headmen from local communities and establishment of irrigation schedules defined by the engineer (p1137). There was resistance from local communities and landlords, who were not warm to the idea of being at the mercy of engineering expertise for access to water, but the engineers won and were able to create a separation of irrigation management from agricultural production prioritizing efficiency over including farmers in the governance of food, water and energy resources.

Around the same time that the Canal and Drainage Act of 1873 institutionalized the bureaucratization of irrigation management, the British Indian government also set up the Department of Agriculture (established in 1871). Similar institutions had been created before the British by different Indian Emperors to encourage better crop production and assess and collect revenue on land value and agricultural production at different times. But the British

science of empire systematically institutionalized agricultural management in science and research through departments like that of Agriculture, Forest, and the Famine Commission. This was followed by the establishment of a number of different crop research institutes meant to research and solve problems in Indian agriculture brought to their attention (Gill and Mushtatq, 1998, p3-4).

The Irrigation department was officially created in 1905 after separating the responsibilities of civil works and canal development from the Planning Works Department and handing them over to Irrigation. Its primary responsibility continued to be the development of irrigation infrastructure until 1958, when the Water and Power Development Authority (WAPDA) was created for the implementation of the Indus Basin Project (directed by technical and financial assistance from foreign donors) and many of the senior engineers from the Irrigation department were reassigned to WAPDA for the timely delivery of the Indus Basin Project (Gill and Mushtatq, 1998, p10-11). Even while several administrative changes to the structure of the Irrigation department and its relationship with WAPDA took place over time, the creation of WAPDA at the national level for implementing the Indus River Basin Project in the after math of the 1960 Indus Water Treaty solidified the legacy of the British scientific approach of large-scale, top down, infrastructure based approach to water management across Pakistan, and especially in Punjab.

The combination of the British 'science of empire', which developed a large scale canal infrastructure by co-opting the local elite to embed the state in local community relations; the imperialism of 'science', which emphasized scientific research and organization

to solve problems of agriculture through scientific research and engineering; and the British reliance on local communities to manage their farms using local knowledge and customs, created a unique configuration of settings under which irrigation and agriculture departments emerged as separate entities from the very beginning; even while both were trying to affect food production. This basic set-up became the basis for all future discussion and decisions of how governance around irrigated agriculture is to be arranged in the future Pakistan after it achieved independence in 1947.

IV) Integration across Irrigation and Agriculture Departments

The issue of integration across the Departments of Irrigation and Agriculture was recognized from the early history of Pakistan, as highlighted especially in a 1960 report by the Food and Agriculture Commission (FAC). The report succinctly captured the tone of the split between the two departments that can be found echoed through their corridors even today. It explained: "Irrigation, of course, increased agricultural production, but one of the first points to note about the Irrigation Department is that it is essentially an engineer's affair, supplying water at field outlet point and leaving the farmer to distribute and use it as he likes. The best agricultural usage of water is not the department's business. Its staff are purely there to supply the water in the canals, see what crops are grown and collect the water charges. (Gill and Mushtatq, 1998, p16-17)" The report went on to identify, that "Unfortunately, none of this contributed to the increase of production..." and that the "The engineers were not agriculturalists and the agriculturalists had not applied themselves sufficiently to the problems of irrigated agriculture. Very little research had been done on the

interrelation between crops and irrigation in the different parts of the country, and no extension service is provided to advise farmers on the subject." (Gill and Mushtatq, 1998, p17) The report stressed that given the rising problem of salinity, the current irrigation and agriculture jurisdictional boundaries should be reconsidered to decide "where to draw the line between Irrigation and Agriculture" (p17).

General consensus was that either the irrigation department staff that inspects the farmer's field to collect revenue related information can be given the additional function of improving water usage at the farm level, or that this function should be added to the existing agricultural extension services since on-farm water distribution is "more a matter of agriculture rather than engineering" (p17). The FAC suggested that since the biggest issues confronting farmers at the time (salinity and drainage of storm water) were best addressed at the farm level, these functions should be handed to the Department of Agriculture so the irrigation staff can focus on decreasing canal head-tail discrepancies for impartial distribution of water. This theory was put into practice in the 70s after a few years of research on how to improve water efficiency at the farm level and reduce conveyance losses in watercourses, resulting in a series of on-farm water management and watercourse improvement pilot projects through the late 70s and early 80s, culminating in the formation of the On-Farm Water Management Wing within the Agriculture department. However, in spite of the envisioned role of the On-Farm Water Management wing as solving the problems of irrigation at the farm level, and a general appreciation of the big strides it had made in improving watercourses and encouraging technology use for laser levelling etc., the 1998

case study of the Agriculture department goes on to argue that the sharp separation between the Irrigation and Agriculture departments at the watercourse level remains a 'great divide', "which runs through the framework from field level operators to provincial level departments, and to federal level ministries." (p86) For example, the case study explains, the efficiency of the Agriculture department is severely affected if irrigation supplies are not made available to growers. Even today, if interviewed, senior officials of the Agriculture department relate that the largest hurdle to improving agricultural yield remains water provision to farms, especially for farms that are based towards the tails of the canals network. In spite of this, when asked about coordination between the Irrigation and Agriculture departments, a senior bureaucrat at the Agriculture department replied that day to day coordination between the departments might happen informally, and annually when deciding water allocations, but did not explicitly vocalize the need for closer integration between the two departments.

V) Coordination Within and Across Departments

As reforms were introduced gradually in both the Irrigation and Agriculture departments; a move towards pushing power downstream ensued in order to conduct participatory management of irrigation infrastructure and address some of the operation, maintenance, development and financing problems confronting irrigated agriculture in Punjab. On-Farm Water Management was considered a key component of pushing power downstream; however, it resulted in a move away from extension activities towards construction efforts with the involvement of community members. Unfortunately, this meant

that instead of being 'bottom up', the water user associations meant to enable involvement of community members were mostly active for fixed development projects incentivized by donor funding and not often functional beyond that. However, this did mean that yet another stakeholder in the myriad of actors within the agriculture department had to be incorporated in planning and implementation decisions for managing the increasingly complex agricultural sector. While Water User Associations were created for management of water courses through an ordinance in 1981, all other agriculture directorates and wings remained provincial entities with implementing wings and officials present at the district and tehsil levels but without much autonomy or discretion in terms of planning or decision making.

In the 1998 case study of the Agriculture department, the authors point out the need for integration within the department as well as across departments: "The reorientation of various wings of the Agriculture Department is imperative, not only to ensure a coordinated approach, but also to optimize the strength of the department, which at the moment, seems excessive due to inadequate planning and coordination. For the purpose, the Agriculture Departments may be divided into two parts, i.e., one dealing with supplies, and the other with education, research and extension services. Wings of On-Farm Water Management, Field and other ancillary organizations may be included under the umbrella of supplies. Education, Research and Extension should be covered under the umbrella of services." (Gill and Mushtatq, 1998, p99) The report further juxtaposed the need for better coordination within the department of Agriculture with the need for better coordination with other departments helping manage irrigated agriculture: "An effective way

of ensuring an integrated approach to facilitate agricultural services (including mechanical, chemical, biological water and other facilities), can be the introduction of 'One Window Operation (OWO)' at tehsil/union council level. Under the one window concept, the Agriculture Department, Irrigation and Power Department and the Farming Community participate equally to ensure sustainable agricultural production in their respective area." (p100) The report goes on to suggest that such a multi-disciplinary approach to irrigated agricultural management is 'urgently' needed with the ultimate goal "to increase per capita yield" (p100).

The Irrigation department case study of 1998 similarly highlights the lack of inter-agency coordination as a major hurdle to improving the irrigation system performance. The report included coordination with the Agriculture department as well as WAPDA, Punjab Revenue Department and Finance and Planning and Development departments in the list of relevant departments. It also highlighted the need for farmer participation in irrigation management for "efficient operation of canal systems, control over water theft, and transparency in revenue assessment and collection." (Israr Ul-Haq, 1998, p97-98) While most of the irrigation department case study focused on the difficulties in achieving infrastructural improvements to the canal and drainage system, as is considered the main responsibility of the department, the agriculture department and need for participatory management emerged as aspiratory goals that had been challenging to achieve. The report highlighted two efforts to realize inter-agency cooperation: the Revised Action Plan of 1979 and the Water Sector Investment Planning (WSIP) Study of 1990 by the World Bank, and went

on to conclude that neither were very successful at realizing the goal of better coordination among the concerned departments. The World Bank WSIP study, almost entirely focused on developing the original Indus Basin Model that became the basis for future modelling efforts, and made barely any mention of institutional arrangements or how the model might be implemented. On the World Bank website, the abstract for the report on the model essentially declares it useless at the time, explaining: "In 1986 the model was revised extensively and updated for the analysis of the Kalabagh dam. For several reasons, the [Indus Basin Model] heretofore has not been transferred to the Government of Pakistan. First, the model, particularly in its early manifestations, was so large and cumbersome that it required the very latest computer technology to solve, technology that was only available in the U.S. Second, the software system in which the model was defined was a highly complex, specialized routine which only a handful of experts could operate. Third, there had been no provision for training Pakistani staff in the understanding and use of the model."[8] Even while the departmental analyses highlighted the need for coordination within and between the concerned departments, the nature of models used and their complexity, especially in the field of water management, made such coordination with other agencies or with farmers quite impossible. Later efforts to streamline the model have addressed some of these challenges but it remains a tool available to the provincial departments only.

[8] From the World Bank website, accessed December 19th, 2016: http://documents.worldbank.org/curated/en/946011468154460456/Water-sector-investment-planning-study-guide-to-the-Indus-Basin-model-revise

VI) Participatory Management for Irrigated Agriculture

In his 2015 book, 'Blood and Water: The Indus River Basin in Modern History', David Gilmartin cites the publication of the landmark Indus Water Treaty of 1960 as an *annexure* to the World Bank Development Fund Agreement a reflection of the role of the Pakistani state vis-à-vis the farmers: "...in the process, the role of the Pakistani state itself was transformed from being the voice of the Pakistani irrigator in a struggle for 'national' justice against India...to the redefinition of the state as essentially an official conduit for foreign technical and financial aid for assimilating Pakistan to an international, Cold War development order – the price tag, in the eyes of the donors, for bringing geopolitical stability to South Asia." (2015, 228-229) Gilmartin summarizes that this set the stage for bureaucratization of the Indus river basin's reconstruction led by national engineers and the centralization of irrigation planning, development and management by the Water and Power Development Authority (WAPDA). In the 1950s when waterlogging and salinity emerged as a challenge to agriculture, a project for Salinity Control and Reclamation (SCARP-1) was initiated to test the use of deep tubewells to lower the water table. (p237) The 60s saw a massive expansion of the SCARP program with the installation of thousands of state managed deep tubewell, often located at the head of a tertiary canal, to supplement surface water supply and simultaneously address problems of water logging. With the SCARP project, the irrigation engineer was forced to step outside of irrigation's "technical system of system flows" (p239) to developing a technical vision for ground water management located at the smallest village level and community. Unlike in the pre-independence British years when a more piece-meal strategy

was followed to manage water logging issues, the SCARP projects were developed through a state lens of apolitical, '*systematic* science' by developing a comprehensive waterlogging strategy. (228-229)[9] What neither the national government, nor the donor organizations foresaw, was the explosion of private tube well usage that followed in the next few decades as a result of rapidly rising cropping intensification and availability of inputs that allowed growing of crops year round. For the first time since the British times, the engineers were confronted with a demand driven system "rooted in the independent actions of the individual irrigators themselves" (p240) as opposed to a supply driven system based on large scale infrastructure.

Faced by waning interest in financing large scale infrastructure projects by donor organizations and financial constraints, the focus of the irrigation and agriculture department shifted to increasing efficiency of existing infrastructure and resources. The World Bank responded to the challenge by encouraging the departments to develop local community organizations at the village level as a "critical strategic resource" (p240). It was as a result of this thinking that the Water User Association Act was promulgated in 1981 based on initial pilots with On-Farm Water Management that found farmer involvement helpful in delivering watercourse infrastructure improvement. While the irrigation department was initially reluctant to adopt such an approach for minor and distributary canal management, the

[9] He explains; "This was because the dominant colonial engineering ethos, focused on maximizing 'acreage per cusec of water rather than to get the maximum yield per acre,' tended to strongly mitigate against any comprehensive waterlogging strategy that might impinge on the larger structure of surface-flow development, which in the eyes of most engineers defined the systemic contours of the river basin."

creation of Provincial Irrigation and Drainage Authorities at the behest of donor organizations in 1997 also created an obligation for the Irrigation department to create Area Water Boards at the canal level for participatory irrigation management. The Participatory Irrigation Management (PIM) program sought to gradually phase in ground water and surface water management by Farmer Organizations and Area Water Boards formed along relevant Canal Commands at multiple scales. These organizations could then be the interface for farmers to coordinate with the irrigation department, and emerge as important stakeholders in the management of the irrigation agriculture. This participatory framework was then expected to create a space for bottom up management of irrigated agriculture in Pakistan. As explained by development experts in the 90s, "It is not enough to try to create a *sense* of local ownership in WUAs...The organizations must *belong* to the water users in fact."[10]

In this way, the development experts and the provincial government set about on the mission of setting up bottom up governance from the top down. Perhaps it is unfair to term this implementation of participatory irrigation management as bottom up governance; its goals often did not seem to exceed beyond checking off whatever deliverable the World Bank or ADB sponsored development project required. In the case of WUAs, the goal was to line watercourses and reduce conveyance losses at the farm level. This was achieved rapidly and quite successfully with the direction of the department of On-Farm Water Management. However, beyond this, the WUAs were barely active and rarely involved in the actual

[10] Quoted by Gilmartin in Blood and Water, p245

management, distribution or allocation of water. Gilmartin summarizes: "And this reflected, at least in part, the reluctance of engineers to formally involve them in playing such roles." (p243)

The top-down nature of participatory management had direct impacts on possibilities of integration and coordination between the increasing numbers of stakeholders now involved in management of irrigated agriculture. For example, even while one development project after another has been introduced since the 90s to improve farmer involvement in groundwater and drainage management, overall consensus is that there has been little success in actually transferring power to farmers or involving them in planning or decision making. Studying the bureaucratic ethos of irrigation engineers in Pakistan, Daanish Mustafa writes in a 2002 paper that trained engineers of a certain management level today can "be described as modern-day carriers of the imperial science discourse," (p42) who cannot imagine a participatory irrigation system managed by the farmers as a reality. As one Sub-Division Canal Officer explained: "...if farmers could distribute water themselves why would they come to us for every single problem? If they cannot amicably distribute water at a watercourse, how can they do it for a canal distributary?" (p46) For another engineer, it was farmers' lack of capacity to manage technical systems that was the problem: "I agree that it (the irrigation system) should be decentralized, but the farmers cannot run the system on their own... I say simplify the legal procedures, let the low level employees take decisions, and let them have those powers till the literacy rate of the public exceeds 50%. If we decentralize the system before hand, there are likely to be murders every day."

Functionally, thus, the introduction of participatory management just resulted in another layer of actors and stakeholders that had to be involved, coordinated with and integrated in planning decisions around irrigated agriculture. As long as the imperialism of science continues to focus power at the provincial level in the hands of highly trained engineers, the attempts to manufacture participation from the top seem misguided at best. However, in the analysis of the question of integration across and within the irrigation and agriculture departments, an important scale is completely missing from the equation. This is the scale at which 'lower employees' function, who are currently left to implement the scientific plans of international designed reform projects, or to fulfill the whims of local influential. It is this scale which needs to be strengthened if integration across the multiple administrative scales and tiers of the departments of irrigation and agriculture is to be realized to truly encourage multi-sectoral, multi-tier integration of food-water-energy planning. While this scale has been strangely missing from new and recent reform projects, the 1998 case study of the agriculture department hit the nail on the head when it suggested: "Problems, like assured irrigation supplies and inequity in the distribution system, are the most serious constraints in the way of increasing agricultural production. To address this issue immediately, institutions, such as Canal Councils, ought to be assigned an active role to the farmers in assisting the Irrigation Department for operation and maintenance for the canal system. Therefore, it is proposed to set up a committee comprising of a Public Representative, SDO[11] of Irrigation

[11] Sub-Division Officer, head of an Irrigation circle

Department, Water Management Specialist, EADA[12] of Agriculture Department and Assistant Commissioner, to strictly monitor the operation and maintenance activities of the canal network. The same will help to ensure equity and reliability of irrigation water to every water user." (Gill and Khurram, 1998, p102)

While many of the functions mentioned in this proposal do not exist with the same titles and in the same form today, the need for such a boundary spanning organization like a 'Canal Council' continues to exist today as a platform where all stakeholders may have a 'seat on the table' for management of irrigated agriculture in Punjab.

VII) Devolution and Decentralization

The 18th amendment to the Pakistani constitution was promulgated in 2010 and devolved majority of the powers that were previously with the federal government to the provincial government. Since then, there has been a national struggle to further decentralize power to local governments with varying degrees of success in different provinces. Punjab with one of the strongest bureaucracies in the country has showed the most resistance to any downstream movement of power, keeping most of it centralized at the provincial level. The district and local government administrative tiers thus mostly function as line departments responsible for implementing provincial decisions at the lower administrative tiers. The technical nature of the agriculture and irrigation departments has a further centralizing effect. With most reform efforts and planning models being developed in the corridors of donor

[12] Extra Assistant Director Agriculture, head of a tehsil

organizations, the provincial government is ideally placed to have a say in the reform program development; and there is no need to include the districts agriculture officials in this process. An investigation into the impact of devolution on Agriculture extension in central Punjab, for example, found that the District Coordination Officer remained highly involved in financial matters, implementation of work plan and monitoring and supervision of extension staff, but the head of agriculture at the district level (the Executive District Officer) was found to be 'behind the scene' (Saeed et al, 2006, p20). The district, therefore, acts as the site for processing finances and budgets for implementation of development plans devised at the provincial level, but does not have much autonomy for district specific planning.

Spatial misalignment between agriculture and irrigation administrative structures also means that the district is not involved in decision and development plans made by the irrigation department While this geographical and administrative misalignment is not mentioned in any of the reform efforts, anecdotal evidence indicates that the district plays a key role in responding to the needs of local community, even in irrigation matters. The floods of 2010 were a key example of this where the districts were the avenues which local political leaders influenced to affect which constituencies were affected by breaching protective levees (Mustafa, 2002, p746).

Political interference and influence of irrigation officials by local elites is also identified as a significant factor inhibiting the ability of irrigation engineers to achieve equitable distribution of water through the canal infrastructure. As one Superintendent Engineer explained: "Today I admit that miles of lower reaches of watercourses and distributaries are

dry. However, today you get the politicians off my back and I can assure you that no tail section would go dry." (p45) At the mid-tier scale of the district or the irrigation circle, the engineers find themselves pitted against the political elite in a zero-sum game: "I believe that there are hundreds of these spurs in Punjab which were built on the basis of political influence...We basically make the forces of nature worse by messing around with them through these spurs which typically have no technical justification. I think that in terms of floods the politicians have disempowered the engineers, whereas engineers should be brought to the top. We violate principles of geomorphology because politicians pressure us to, and the public ends up suffering for that."(p45)

VIII) The Need for Boundary Spanning

The tussle of where power in the irrigation and agriculture departments should reside at the various institutional ties is in a constant state of flux. While the provincial tier remains the strongest, irrigation has also pushed some operational and management functions to the bottom most tier in an effort to empower farmers for self-governance. With the reversion to the Local Government system in Punjab in 2017, the divisional tier has once again been strengthened within the agriculture department as the bridge between the district and provincial levels. Given the shifting levels of power and influence at different government tiers, and the spatial and geographical misalignment between irrigation and agriculture boundaries, a clear need for boundary spanning organizations has been consistently recognized in the departments. Boundary spanning organizations or objects "link the producers of knowledge with decision makers and generally facilitate flows of information in

both directions." (Buizer, Jacobs and Kash, 2009, p1) Canal Councils that incorporated both agricultural and irrigation experts had been suggested with a very similar function as far back as the 1998 case study of the agriculture department as discussed earlier.

In one of the most recent development project supported by the Asian Development Bank which focuses on establishing conjunctive water management, introduced, another very similar boundary spanning organization has been proposed to strengthen participatory irrigation management. This is the Irrigation Management Unit (IMU), which will support "farmer organizations in undertaking O&M and engineering, groundwater management, OFWM support, agricultural support services, and administration and financial management." (Asian Development Bank, 2006, p (ii)) If successful in enabling the role of integrated management in irrigated agriculture, the IMU will be scaled up to all of Punjab in later legs of the ADB project. However, the IMU is imagined primarily as a 'management' organization to enable farmers to optimize resource use within the framework of the substantial infrastructural investments being made in the irrigation system in the ADB targeted project areas. Planning functions and decisions very much remain within the domain of provincial tiers. The next chapter explains how planning is currently carried out in the province of Punjab and why 'integrated' planning is particularly lacking in its processes and outcomes vis-à-vis irrigated agriculture today.

CHAPTER 3: IRRIGATED AGRICULTURE PLANNING IN PUNJAB TODAY

This chapter investigates the role of the sub-provincial institutional tiers in planning to identify how coordination between irrigation and agriculture departments currently happens with a focus on integrated planning. Specifically, three aspects are looked at closely through a combination of interviews with government officials and institutional analysis of Planning and Development Department (PND) and the irrigation and agriculture departments: 1) the process of planning as it exists currently in the three entities under analysis (PND, irrigation and agriculture), 2) mechanisms for incorporating sub-provincial input into the provincial plans for vertical integration and 3) mechanisms for coordinating planning between the irrigation and agriculture departments for horizontal integration. In conclusion, this chapter will make the case that while efforts at decentralization over the last two decades have shifted focus from federal planning to provincial planning, the sub-provincial tiers remain marginalized in the planning process imagined more as information gathering or executing arms of the provincial departments; and this comes in the way of vertical and horizontal integration of irrigated agriculture planning in the province of Punjab.

I) Planning in Punjab

In thinking about integrated water resource management, it is important to unpack the term 'management' and identify what it entails. Conversations with members of the agriculture and irrigation departments reveal three different types of decision-making

categories in the day to day functions of the departments: planning, management and operation. Planning is the least clearly defined and the most difficult to investigate without a clear and consistent definition across departments and institutional tiers. The most explicit outcome of planning in the provincial bureaucratic structure, however, is in the form of mid-term and annual development plans. Elaborate manuals for how the annual and mid-term programs are to be produced by the National Planning Commission and the provincial Planning and Development department exist (Appendix 1 has the different stages of plan formulation). They provide clear deadlines, departmental obligations and annual guidelines based on priorities identified by the government of the day. The outputs of this planning process are development plans with lists of projects are implemented by concerned departments. A quick perusal of the annual development plans shows that for irrigation, the plans primarily consist of list of physical infrastructural projects noted by location. Agricultural department list items in comparison consist of subsidies and micro-credit schemes for the province with location listed as 'All Tehsils'. Location specific plans are often related to building research facilities or constructing demonstration farms. The most clearly identified host for planning functions is the Planning and Development Department (PND) of the Government of Punjab. PND serves as the central node and coordinating agency for compiling all departmental plans and the final decision making entity on which projects will be approved given provincial financial capacity (Aberman and Noora-LisaWielgosz, p16).

Given its central position, PND also serves as a key link between irrigation and agriculture department plans as a way of 'integrating' their priorities and goals. Further, as

the hub for coordinating all donor programs since all projects executed with donor support have to go through PND in terms of project development as well as finances, it is also responsible for ensuring all provincial projects fit within the larger development agenda envisioned by the provincial government. Since devolution, the provincial planning departments have grown in significance considerably as the key agency for coordinating all donor activities (Aberman and Noora-LisaWielgosz, p17); however, the Punjab government continues to take its guidance from national strategy plans like the Pakistan Vision 2025 in addition to provincial documents like the Punjab Growth Strategy 2018. PND has in recent years also asked each department to develop a sectoral plan which guide the way forward sectorally and provincially. Sectoral plans exist for both the departments of agriculture and the department of irrigation, however only the agriculture sectoral plan is publically available.

While clear guidelines and manuals exists for how annual and mid-term development plans are to be developed, planning at sub-provincial levels gets more murky. When asked at the district level what planning documents exist, district departmental officials reference the district budgets or their contribution in the provincial annual development plan. Districts compile information on current and development project expenses from tehsils and union councils which is then forwarded up to the province and compiled by departments at the provincial level to inform the provincial development plan.

Within the water sector specifically, planning is seen as top-down and donor drive. As Bandaragoda highlighted in a 2006 analysis of water sector reforms in Pakistan, "sporadic changes were introduced to the irrigation management organization, based on ad-hoc

project-based requirements, making the management structure rather ineffective in a fast changing socio-economic context." (p56) Combined with the absence of a coherent planning vision with the impetus for the reforms coming from donors instead of the farmers and primary system users, these reforms lacked the necessary institutional support to achieve their objectives. Bandaragoda goes on to summarize this discrepancy: "...efforts to achieve stability through enhanced physical infrastructure and technological inputs were mostly subverted by poor institutional support, resulting in low agricultural yields, widespread irrigation misconduct, severe tail-end deprivation, low productivity of manpower and financial resources." (Bandaragoda, p56)

While Bandaragoda's analysis precedes 18th Amendment devolving most powers and finances to the provinces, his analysis continues to stand true even after, with power and influence focused now at the provincial level instead of the federal level. A detailed network mapping and analysis exercise conducted by IFPRI in 2013 focusing on irrigated agriculture in Pakistan shows that the provincial government continues to be the central policy making and decision-making body "[allocating] and [coordinating] the flow of resources from the central government to the province." (Aberman and Noora-LisaWielgosz, p16)

The network analysis[13] also found Punjab Irrigation Department (PID) to be described as "the powerful owner of the water in Punjab" by interviewees (Aberman and Noora-LisaWielgosz, p16) even while in terms of centrality and influence, Punjab Agriculture

[13] The network analysis consists of four types of links: formal authority, technical information, informal pressure and funding.

Department (PAD) showed one more degree of influence than PID in the network analysis. (Aberman and Noora-LisaWielgosz, p12) The network map for Punjab has been replicated below and it can be seen that all entities influencing PID and PAD are the same except for one difference: while PAD influences farmers, PID influences the Indus River System Authority (the national authority responsible for implementing the Water Apportionment Accord among the provinces). This shows a critical difference between PID and PAD: PID is an upward pointing entity while PAD a downward pointing one.

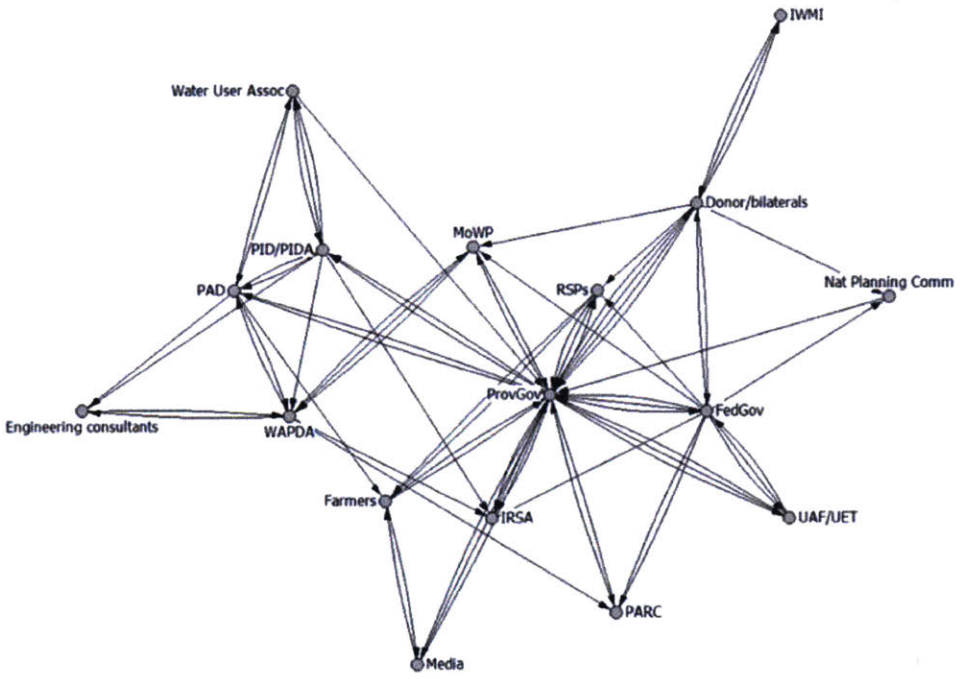

Figure 1: Complete Multiplex Network for Punjab (Source: Aberman and Noora-LisaWieglosz, p11)

II) Multi-Scale Planning

An analysis of planning decisions made at the different institutional tiers in PID and PAD reveals that planning remains concentrated at the provincial level with poor mechanisms for

integrating meso and micro level stakeholders[14] within and outside the departments in the planning process. Sub-provincial tiers of the provincial government are taken largely as information gathering, implementation arms for the provincial departments without many strategic or planning functions. Understanding integration of planning vertically within PID and PAD requires understanding: 1) how input and data for planning decisions is collected from the sub-provincial scales for making provincial plans, 2) what planning, management and operational decisions are made at the different institutional tiers within the irrigation and agriculture departments.

a. Irrigation

The flow of influence within irrigation is upwards with the lowest tier officials (SDO, XEN etc.) identifying gaps and need for rehabilitation within the irrigation infrastructure, acting as arbiters for water conflict resolution, and working to ensure that allocated canal water requirements are met by influencing PND, donors and other reform agendas. As explained a senior official of PID, "Everything comes from down to up, rarely is it going top-down." For irrigation department, this means that the Chief Engineer and Superintending Engineers identify problematic areas and projects that are required to address them based on input from the lowest tiers of the irrigation department, i.e. the sub-division officers (SDO) and the executive engineer (XEN). The projects identified by PID are then pitched to donor

[14] Since PID and PAD have different organizational structures, the terms meso and micro are used to refer to similar institutional levels. For PAD, the meso-scale can be taken to refer to the division and district levels with micro-scale referring to the farm and village level. Tehsil and union councils are connectors between the micro and meso scales for the PAD. For the PID, the zone and circle tier may be taken as the meso-scale and the farmer or watercourse can be taken as the micro-scale.

organizations for funding, and once approved these are incorporated in Mid-term Development Framework and the Annual Development Plans by PND. Talking about planning, he explained further, "We don't have proactive planning. Most of our projects come from field formations. We are moving in project mode – generally it's reactive planning and mostly focused on maintenance of existing canal system." Efforts at developing a proactive planning mechanism within irrigation department have been on-going since 2006 when the Strategic Planning and Reform Unit (SPRU) was set up. SPRU conducted a detail system requirements analysis for irrigation infrastructure and identified the need for a billion dollar worth of investment required to upgrade the irrigation infrastructure. The donor organizations in this narrative act as asset financiers necessary to raise funds to implement these projects. As the senior irrigation official explained, "We were able to plan big projects but were not able to go down to root level and that's what needs to be done."

The establishment of Area Water Boards (AWB) at the canal level and Farmer Organizations (FO) at the distributary levels at the behest of donor department's encouragement was meant to create a formal institutional linkage between the irrigation department and the farmers on the ground. While the AWBs and FOs are considered a largely unsuccessful experiment the PID, the AWBs and FOs remain entirely irrelevant to the planning process as the role of AWBs and FOs was primarily imagined in operation of the canal system for ensuring fairness in water distribution, resolving disputes and collecting revenue. Referring to the On Farm Water Management program responsible for creating the FOs, Bandaragoda explains: "Farmer involvement in the management of the irrigation system

was not as expected in the project design stage. The World Bank's post-project evaluations later confirmed that the projects achieved their physical components (water losses in watercourses were reduced from about 40% to 25–30%), but failed in most of their institutional objectives (World Bank, 1996)." (p57) Not unexpectedly, officials of PID showed skepticism in the idea of participatory irrigation management as set up under the Punjab Irrigation and Drainage Authority (PIDA) since it was set-up as a parallel system to the PID rather than imagined as a way for the irrigation department to build a strong mechanism for closely working with the farmers it is supposed to be serving. A provincial irrigation official explained, "PIDA's slogan was that in five years irrigation department will have no responsibility or role where Farmer Organizations are managing the system. This is why it failed."

Current revision of the participatory irrigation management system seeks to reimagine the role of AWBs and FOs in the irrigation system. However, their role remains limited to operational management only. Same holds true for the zone and circle levels of the irrigation department which play a key role in management and identification of needed projects, but have more marginal roles in planning which continues to be done at the provincial level rather than for zones and circles. Table 1 below shows a rough distribution of decisions made at different tiers of the PID. It can be seen that planning and plans continue to exist at the provincial level without specific breakdown for individual zones and circles. As Arif Nadeem, Ex-Secretary Agriculture and Irrigation explained, "The executive engineer's (XEN) role is to operate the system as it exists at optimal efficiency. The Superintendent

Engineer (SE) is the supervising authority of the XEN. He makes development decisions on canal structure changes, water course development, silting etc. The Chief Engineer (CE) is the morale booster or policy formulator. It is at the CE or SE level that planning should happen."

Table 1: Typology of decision types at different scales in the Irrigation Department.

		Decision type		
		Planning	Management	Operational
Tier	Provincial (CE)	- Identify projects development of annual and mid-term plans for the province. - Develop policies and plans to address issues of ground water extraction, water logging and salinity. - Align PID's plans with provincial development objectives and other sectoral plans and policies.	- Allocation of water between seasons and among crops/adjustments based on climatic variations - Allocate water between different uses (e.g. agricultural, energy, domestic)	- Negotiating with WAPDA and IRSA on timing of water release - Resolving theft complaints for influential farmers and landlords
	Zone (SE)	- Identify infrastructural projects for development and push upwards (with XEN's support)	- Manage execution of development projects that have been approved at the zonal level.	- Supervision of XEN and support in resolving water disputes when needed.
	Circle (XEN/SDO)		- Execute development and maintenance projects at the circle level (e.g. silt clearing, structural maintenance)	- Head/tail equity; supervising fair operation of rotational schedule; dispute resolution; water theft prevention - Participate in Advisory Committee meetings - Manage elections for Area Water Boards where they exist. - "Maintain system as it exists to optimal efficiency"

b. Agriculture

For the purpose of this research, investigation of planning within the agriculture department has been restricted to its functions involved in agricultural production, support and management. Departments that deal with agricultural markets, price setting and procurement play an important role in incentivizing farmers to grow particular crops through price based signals, but do not play a direct role in providing technical or physical inputs for agricultural production.

Punjab Agriculture Department (PAD) is distinct from PID in that its sub-provincial tiers are structured along administrative boundaries of district, tehsils and union councils. Like other departments with a similar administrative budget, planning in PAD follows the traditional budget formulation and ADP development process. As relayed by Mahmood Akhtar Rana, Chief of the Planning and Evaluation Cell, PAD, a Budget Call letter is issued by the finance department at the behest of which all departments ask their subordinate directors for concept notes and proposed projects on water management, agriculture extension etc. The office of the departmental head then "compiles, deliberates, prioritizes based on estimated availability of resources and developmental budget." Once the list of ongoing and proposed projects is compiled, the Secretary Agriculture, in coordination with PND and the Chief Minister, will determine which projects for the department are finally approved with donor input. The budget is finalized with approval from the Punjab Assembly. Unlike PID which still has a sectoral plan in draft stages, PAD has a detailed sectoral plan that determines departmental priorities for the next five to ten years. For the agriculture

department, according to Akhtar Rana, two prioritizes help determine future priorities: 1) import substitution and export enhancement, and 2) productivity enhancement and food security. For example, Rana sb explained, "It was noticed that the import bill for pulses had gone up rapidly, so we decided to start a project on this." The departmental sectoral policy has now also clearly identified the need for developing value chains for horticulture and fruits and vegetable exports as other agricultural products that will play the dual function of higher incomes for farmers and generating foreign currency through exports. (Agriculture Department, 2015, p30)

A similar process is followed at the district level except an effort is made to involve local stakeholders like chambers of commerce, farmer groups etc. through consultations. Since agriculture in Pakistan is controlled through the market, the agriculture department has limited control on what crops farmers choose to plant except to use support prices to incentivize the growth of certain crops. Wheat is overwhelmingly grown in the province since it is used for both subsistence purposes and also has a government established support price.[15] Difficulties for smaller farmers to invest in more lucrative crops that also require heavier investment and more land often prevent farmers from responding to PAD's efforts to diversify and encourage other crops like horticulture. PAD relies on market based mechanisms or its extensive Extension Directorate field formation to incentivize farmers to change their behavior or adopt better technologies and farming practices for improved productivity. Biophysical elements determine the crop options available to farmers and the

[15] Per 40 kg support price for wheat in Punjab is PKR 1300 where it can be bought for PKR 950 internationally.

PAD sees its role as enabling the farmer to make the most of the inputs and resources available to it. The vision for the sector is therefore, set provincially, and transferred downwards.

At the district level, where the Agriculture officials historically reported to the District Coordinating Officer (DCO) as well as the provincial agriculture department, the Executive District Officer for Agriculture's responsibilities were limited to supervising and approving field plans for extension staff and supporting the DCO in district wide activities. Arif Nadeem explained: "Nine times out of ten, agro priorities clash with DCO's priorities. Districts are not given any target for agriculture production and no one is asking DCO about agriculture," adding further, "When has the Executive District Officer (Agriculture) been told what his budget and resources are, what crops he is producing, how much livestock does he have?" While data and information might flow upwards in PAD in the form of crop assessments and output estimates, not much is flowing downwards except for details of how a provincial project might be implemented at the district level. Even though the PAD's field formations are more closely associated with and working with the farmers, given the current institutional set-up, PAD limits its role to one of information and technology dissemination or trouble shooting problems as they are confronted (e.g. the cotton pest outbreak of 2015). Planning, therefore, exclusively remains the domain of the provincial tier (Table 2).

Table 2: Typology of decision types at different scales in the Agriculture Department.

		Decision type		
		Planning (annual plans, 5- year plans, reform)	Management (execution of these plans)	Operational (the day to day navigation)
Tier	Provincial	- Develop sectoral policy and long-term, mid-term and annual plans. - Determine crop prioritization and incentivization schemes. - Develop subsidy/technology pushing schemes - Set crop prices and targets	- Manage execution of subsidies, ensure targets are being met, procurement is being done etc.	- Troubleshoot emergency problems (e.g. cotton pest epidemic)
	Division (new tier)		- Supervise execution of subsidies through on-farm water management program - Oversee execution of extension program	- Participate in Advisory Committee meetings - Develop relations with farmer fertilizer and crop organizations
	District			- Participate in Advisory Committee meetings - Execute ag extension field plan - Execute delivery of subsidies - Maintain model farms - Develop relations with farmer fertilizer and crop organizations - Provide technical support to help farmers improve productivity.

With the latest move on the part of the provincial government to enact the local government, commiserate system, two broad changes have taken place: 1) the division level between the district and province has been strengthened with the Executive District Officer (Ag) now situated at the divisional scale as Director Agriculture (Division) under the

Commissioner,[16] and 2) individual directorate officials of the agriculture department will only report to their respective provincial counterparts and not the DCO. Touted as a good thing by the PAD district officials since too much of their time was dedicated in carrying out field work for the DCO, the sub-provincial tiers of the agriculture department are now better connected with their provincial department both in terms of departmental structure and flow of funding.[17]

III) Multi-Scale and Cross-Sectoral Planning

Before thinking about institutional integration between PID and PAD, it is important to understand that the largest hurdle to integration between the two departments at sub-provincial levels is the geographical misalignment between their jurisdictional boundaries. PID functions on a canal command based jurisdictional structure while PAD is structure on traditional administrative boundaries. This means that there are no clear counterparts for the district level PAD at PID even while operational interaction exists between the two departments at the district/circle scale (refer to figure below). While at the provincial level PND acts as the planning coordinator for both departments, no similar mechanism exists to facilitate coordination in planning at the district/circle level. Interviews with the district staff reveal that planning is taken to be the responsibility of the province, and so is integration of planning goals between the two departments. At the sub-provincial levels, only mechanisms

[16] The DCO has now been rebranded the Deputy Commissioner.

[17] Previously funding flew through the district government and district agriculture department expenses were a line item within the district budget. Now funding will go to the district agriculture department directly through the provincial department.

for operational coordination between the two departments exist in the form of Advisor Committee Meetings which are primarily held to resolve issues of water theft and disputes in the presence of all stakeholders (farmers and representatives of PID and PAD)[18]

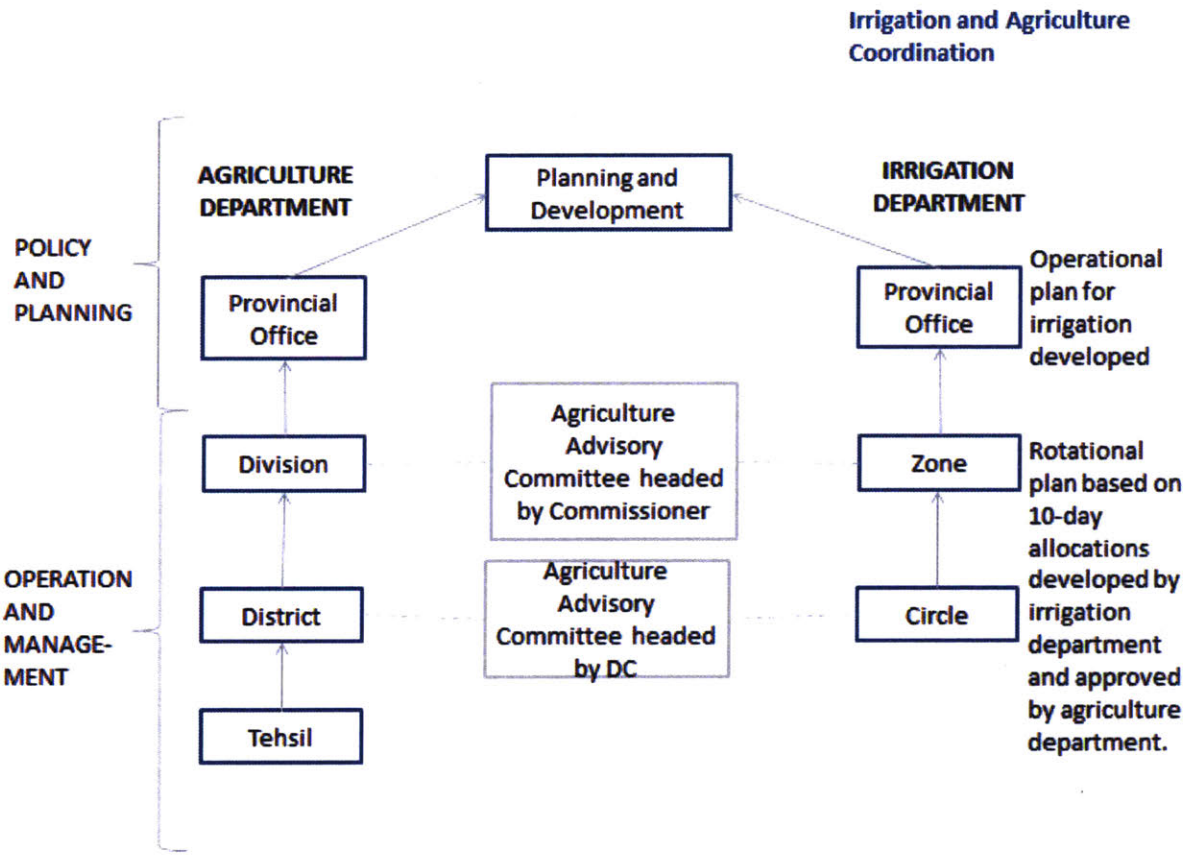

Figure 2: Multi-scale representation of roles and linkages between the irrigation and agriculture departments.

Overwhelming consensus at all tiers of the PID and PAD is that integration in planning between the two departments can only happen at the provincial level and is not needed at

[18] Although as one senior PID official said about the Advisory Committee meetings, "Sure those meetings happen but whether the irrigation representatives shows up or not is another matter."

the levels below. As Chaudhry Ashraff, former Director General On-Farm Water Management Program pointed out, "The separation between irrigation and agriculture is very clear. Irrigation has all canal infrastructure up till the water course. Agriculture has the water course and the farm. There is no need for more coordination than that." However, at the provincial level, there is an attempt to rethink institutional arrangements to develop more formal mechanisms of coordination between the different water users in the province. A senior irrigation official explained: "Currently there is no mechanism to supervise what the agriculture department is doing with the water and the irrigation department is doing use management not resource management. A new legal entity will be designated that the agriculture department can reach out to suggest water requirements. This new entity will do resource management and not use management as is the business as usual."[19] With the establishment of a water resource management entity, a policy for ground water regulation can also be developed. He elaborated further that the idea of a water resource management entity is crucial to bringing conjunctive water management within the jurisdiction of the government: "Currently no one owns ground water so it cannot be managed. The new policy under development[20] gives government the right to manage groundwater but ownership will continue to belong to the land owners." A future ground water management framework might then take the shape of reallocated surface water (instead of the current fixed time-

[19] There is also an attempt to make PND better suited to support this water management role by creating a designated post of 'Member Water' as opposed to the current system where the 'Member Infrastructure' looks after irrigation infrastructure projects as well as all others in development in the province.

[20] This refers to the groundwater policy under development

based allocations) or stricter regulation for tehsils especially suffering with rapid ground water abstraction.

Once established, the water resource management wing will be crucial to conjunctive water use management, however, due to the 'water' centric nature of its formulation, agriculture will continue to find itself at a hierarchically lower plain in planning and management decisions. As the irrigation official explained, "We have a supply driven system with the aim for equitable distribution. That is a constraint. In other countries, irrigation is demand based; water provided at outlet is given on the basis of demand. Farmers provide their demand on 10-daily basis for the amount of water they will need. In Pakistan, cultivator manages whatever water is being supplied." PAD's responsibilities are thus nested within and hierarchically below that of PID. Farmers are reliant on irrigated water to carry out farming or use tube wells to make up for irrigation water shortage. He continued: "Relevance of agriculture department is in operations only as information disseminators. What more can be done with agriculture at this point? Unless if PAD decides to implement some sort of cropping patterns, that's when coordination with PID will have to happen." He explained that irrigation was not devolved in 2002 because of the discrepancy in boundaries between irrigation and agriculture: "Agriculture does not have its own infrastructure. Compared to that irrigation has a huge infrastructure that cannot be integrated at district level. You can develop agro-climatic zones but how will those be implemented? Integration has to be at the provincial level and its composition will be an art".

A number of hurdles at the provincial level, however, are still imagined by PAD in the way of integrated planning between the two departments. A senior agriculture official identified the reasons for segregation between PID and PAD: "No agriculture expert or social scientist is present in the irrigation department. It is managed by civil engineers who are managing water, not irrigation. The need is for PID to have agricultural experts and for PAD to have irrigation experts. Agriculture added a water management sector with agricultural engineers but irrigation department *can't* have agricultural engineers because they deal with infrastructure. This is a technocratic hurdle." He went on, "The second is a bureaucratic snag. While previously, all agricultural directorates (like food, irrigation, environment, livestock, forest, fisheries) were coordinated within one department, now they have been separated into more and more departments. For example, marketing separated so now there is a tension between extension and marketing."

At the district scale, similar misgivings about integrated planning with the irrigation department exist. "The irrigation infrastructure requires a lot of work but no one is taking it seriously," explained a district government official, "Without new reservoirs, canal lining cannot achieve much. There is no solution to theft. Tail end is not getting any water and advisory councils are unwilling to take action." He pointed to challenges in coordination both vertically and horizontally in current planning processes: "There is a lack of ownership of irrigation infrastructure by stakeholders because no feedback is asked from them. I am unaware of all projects running in the irrigation department so what will a common farmer know of what projects are going on?" Even within PAD, a number of ongoing programs

provide subsidies on seeds, implements, inputs etc., however, he explained, "There is a top to bottom sort of implementation. Allocation of subsidies is on the bases of crop acreage, we are not given or asked for any feedback." The role of the meso-scale tiers in PID and PAD, therefore, remains limited to implementing provincial schemes and projects as guided, leaving cross-sectoral coordination to the province.

The only way to achieve true integration, in the opinion of one irrigation official, is through integrated farming and very precise watering requirements. The PND can then calculate food requirements for the country and then work backwards to calculate water requirements and how climate change might be managed. However, such a framework requires a completely different ecosystem with large land holdings, and commercial scale agriculture where the government has more levers in hand to direct agricultural production. Given the small size of farmer land holdings in Punjab and their dependence on subsistence wheat farming for consumption preventing them from switching to more profitable crops, there isn't much space or capacity for planning irrigated agriculture in Punjab at sub-provincial levels. It is precisely for this reason, there is a case to be made for lifting up the agriculture department and the sub-provincial scales in the provincial planning framework in a way that they are able to fill the gaps in the way of integrated vertical and horizontal irrigated agriculture planning in Punjab, Pakistan.

IV) Meso-Scale as the Boundary Spanning Scale

The institutional analysis reveals that not only is there a sharp geographical and jurisdictional divide between agriculture and irrigation departments, there is also a sharp separation between the functions of institutional tiers. Planning is clearly identified and accepted by all institutional tiers to be a provincial function. In fact, key structural issues have been identified by various government officials with regards to why integrated planning cannot happen at sub-provincial levels. These include the fixed supply, time-based water allocation system in irrigation, the lack of tools available to agriculture department to notify cropping zones. However, this simplification ignores the point that informally a number of planning decisions are made at the meso-scale. PID clearly considers the zone and canal level and Chief Engineers and Superintendent Engineers to be ideally located for identifying planning projects. In PID, even while planning remains largely a top down affair, the provincial department inevitably relies on district level administration and field formations to identify priority areas. For example, Chaudhry Abdul Hameed, Director Agriculture for the Division of Faisalabad explained, "We realized that pulses in Faisalabad are very expensive and none were being grown here. We told the (provincial) department that farmers did not get seeds so a new project was started to subsidize seeds and seed drills and teach farmers the method to use them."[21] As a result, the amount of area where pulses are grown in Faisalabad has grown substantially. Another way that the districts and divisions contributes to planning, he

[21] It was not clear from his account where the plan to promote pulses started, from the province or the district.

further explained, is that agriculture extension officials identify research problems that are shared with the province in monthly meetings and become the impetus for future projects.

Similarly, ground water management in Punjab is imagined to be absent at the moment leaving it to the farmers to make their own judgement on how much ground water to rely on. Another divisional official of PAD explained that as a policy they ask farmers to use as much groundwater as they need for their crops. The decision by the department to not regulate groundwater abstraction for now is in itself a policy decision that has been taken keeping farmer welfare in mind. Recognizing that informal planning decisions are taken at all tiers is extremely important in developing planning mechanisms that can be truly integrated. As this same division office explained, "In Pakistan, the PC-1[22] demand comes from the top. The secretary orders, experts are called overnight and figures are derived and planned. Political influence is over bearing. What is needed is for farmers to be included in any planning process (small, medium, or big)." While such participation has been attempted in the form of Farmer Organizations, Water User Associations and Area Water Boards, it has fundamentally proven inadequate for two reasons. First, these organizations were only imagined in an operations and management role, and second, they were imagined as independent self-governing groups that could be substitutes for the existing irrigation and agricultural institutions.

[22] PC-1 = Project Concept. This is the proposal document for a project developed by departments to request funding.

What has been lacking in the reform efforts up to date, is an attempt to fully integrate planning within the institutional vertical tiers. Recognizing that planning decisions are made at all tiers automatically highlights the absence of the meso-scale in current planning processes. However, given the existing function of the meso-scale in the irrigation and agriculture departments as the connecting link for flow of information from the farmers to the provincial tiers and flow of policy and planning decisions from the provincial tiers down to the farmers, it is ideally located to be a boundary spanning scale within the departments (Figure 3).

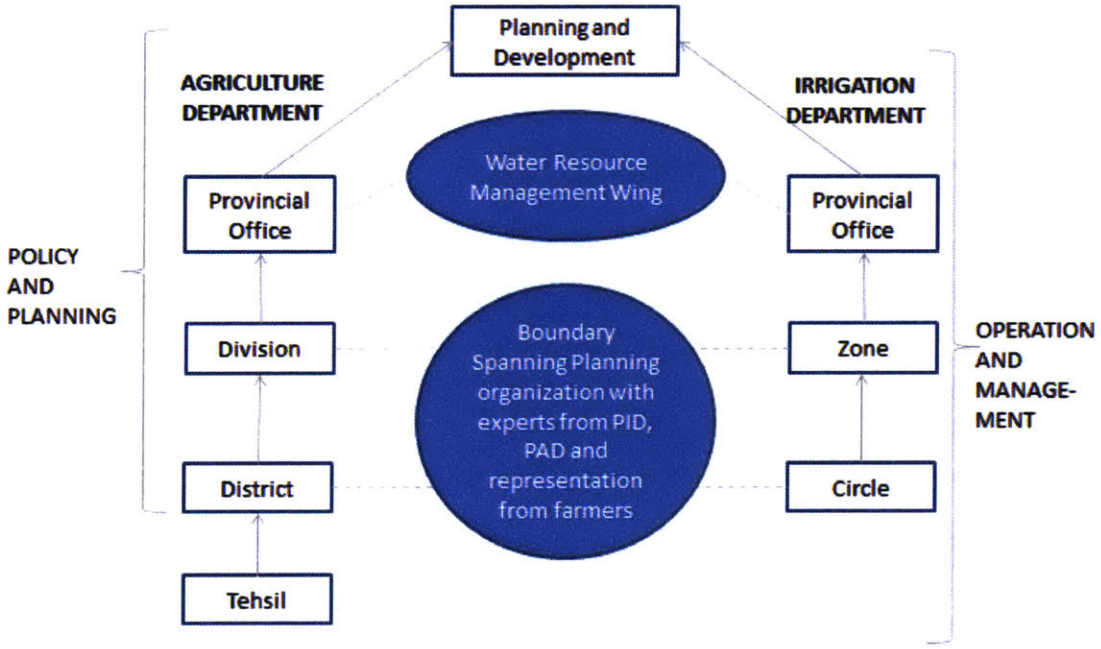

Figure 3: Integrating planning between PID and PAD with (proposed) boundary spanning organizations.

District and division officers as well as the circle and zonal officials are uniquely position to be eyes and ears of the provincial departments while simultaneously acting as the government-farmer interfaces. In this unique dual role, the meso-scale can be imagined as a boundary spanning scale which can play a crucial role in planning catering to the particular socio-ecological variations within that particular division or zone, while simultaneously including farmer voices in the planning process and connecting them to the macro or provincial tier. Reimagining the boundary scale as a 'boundary spanning' scale, thus, will allow planning to be reconfigured in the institutional set-up as a multi-level process happening simultaneously at the provincial and district/division or circle/zone levels. Imagining planning occurring at the 'meso-scale' instead of just departmentally will enable thinking of it as a dynamic multi-sectoral process. Plans for irrigated agriculture in Punjab can then developed for divisions or zones, instead of just the province, and a divisional scale can fully embrace multi-sectoral goals, instead of simply being departmental. In this way, a boundary spanning approach at the meso-scale can be an innovative way of reimagining integrated planning within Punjab.

CHAPTER 4: BOUNDARY SPANNING ANALYSIS FOR INTEGRATED PLANNING

In a recent paper on modelling the agricultural food, water, energy nexus in the Indus River Basin in Pakistan, Yang et al use the World Bank developed Multi-Year Indus Model Basin Revised to evaluate the impacts of alternate water allocation mechanisms. They find that more flexible surface water allocation policy inter-provincially and intra-provincially would increase surface water use in the basin, while groundwater and energy use would be lower. (Yang et al, 2016). Enabling such a flexible water allocation process with a focus on food production as the output of water and energy (as used in ground water extraction) requires multi-level planning. Boundary misalignment between agriculture and irrigation departments makes integrated analysis of irrigation and agricultural metrics difficult. Given the additional problem of ground water over abstraction, adding conjunctive water management to an integrated irrigated agriculture analysis even more challenging. However, the complexity of such integration partially stems from the current siloed approach to planning of irrigation and agriculture. Combining disparate indicators in one model and understanding their trade-offs becomes difficult when related variables are analyzed individually.

As boundary functions can be institutionalized in boundary organizations, 'boundary objects' based on integrated analyses can be developed as key unifiers for irrigation and agriculture experts to align their view points towards similar goals. As Cash explains: "... 'boundary objects' are collaborative effort outputs that 'are both adaptable to different

viewpoints and robust enough to maintain identity across them'. (2003, p8089) One such object in enabling boundary spanning functions can be integrated analysis developed in collaboration bringing "multiple types of expertise to the table" and "[enhancing] legitimacy by providing multiple stakeholders with more, and more transparent, access to the information production process." (p8089) This chapter attempts to build a similar integrated analysis that a) highlights the variations in agricultural productivity and water usage at the meso-scale and b) develops integrated metrics using annually collected departmental data that can enable irrigation and agriculture experts to sit on the same table and engage in integrated planning.

The biggest challenge in integrated irrigation and agriculture analysis at the meso-scale is the spatial and geographical misalignment between the boundaries of the two departments. A number of attempts have been made to map agriculture output measured on district boundaries to canal command areas so that water discharges can be included in agricultural output and yield analyses (Tahir, Habib, 2001 and Kirby and Ahmad, 2016). Since 2012, the Crop Reporting Services (CRS) department of the Provincial Agriculture Department has also formalized crop yield and production estimation methods with detailed data on inputs from district level representative sample of 1200 villages all over Punjab. Since this dataset includes information on the amount of water used by farmers and expenditure on tubewell usage, it provides a straightforward way to roughly estimate water availability and energy usage at the farm level.

This chapter uses CRS dataset of wheat from 2013-2016 to explore the relationship between yield and water with a focus on multi-level planning. While provincial cropping data is available by districts, this is not mapped to irrigation data in annually published provincial statistics. However, using the input data collected by CRS, integrated water input and agricultural output metrics can be developed to enable cross-sectoral thinking and decision-making. The sampling of villages done by the CRS is representative at the district level only, however, for this analysis, data from 2013-2016 has been merged to collect enough data points for a tehsil level analysis. Conducting this tehsil level analysis for all of Punjab is a key contribution of this thesis in highlighting the intra-provincial variations of irrigated agricultural performance in the province, and thus the need for a more locally focused planning process. The chapter will start with a brief overview of some key variables in the crop reporting data, go on to explore some bivariate relationships at the district and tehsil level, and finally, use the analysis to identify winners and laggards in wheat production in Punjab.

I) Single Variable Analysis

Since the focus of this analysis is on integrating agriculture and irrigation performance, treating yield or agriculture production as the outcome variable and water and energy (as used in ground water pumping for agriculture) the single variable analysis focuses on some key variables including yield, irrigation water applications and land size. The summary statistics in table 3 show that most variables are normally distributed except for net land and

the total cost of using tube wells to extract water. Both are substantially skewed to the right with extreme outliers as also visible in the histograms below.

Table 3: Descriptive Statistics for Key Variables

	Yield <dbl>	No. of Waters <dbl>	Urea <dbl>	DAP <dbl>	Net Land <dbl>	Total TW Cost <dbl>
Minimum	0.000	0.000	0.00	0.00	0.00	0
1st Quartile	7.195	2.000	50.00	50.00	4.00	600
Median	9.074	3.000	100.00	50.00	8.00	1600
Mean	8.845	3.144	79.08	45.65	18.44	1922
3rd Quartile	10.720	4.000	100.00	50.00	15.00	3000
Maximum	25.050	10.000	200.00	175.00	1450.00	45000

The agriculture department's recommendation for number of irrigation applications for wheat is conventionally three. Both the median and the mean for this distribution are around 3 so broadly this advice seems to be followed.

While the average yield for the province is roughly 8.8 kg/300 s.f.[23], this varies quite a bit within the province from district to district. Maps of average yield (figure 5) and average number of irrigation applications (figure 6) show the relationship between climate and number of irrigation applications. While the southern Punjab districts, which have hotter climates seem to have the highest applications of irrigations, maximum yields are located more towards central-eastern Punjab around the Okara, Vehari, Pakpattan belt.

[23] Yield is measured for a sample plot of 300 s.f. per sample field.

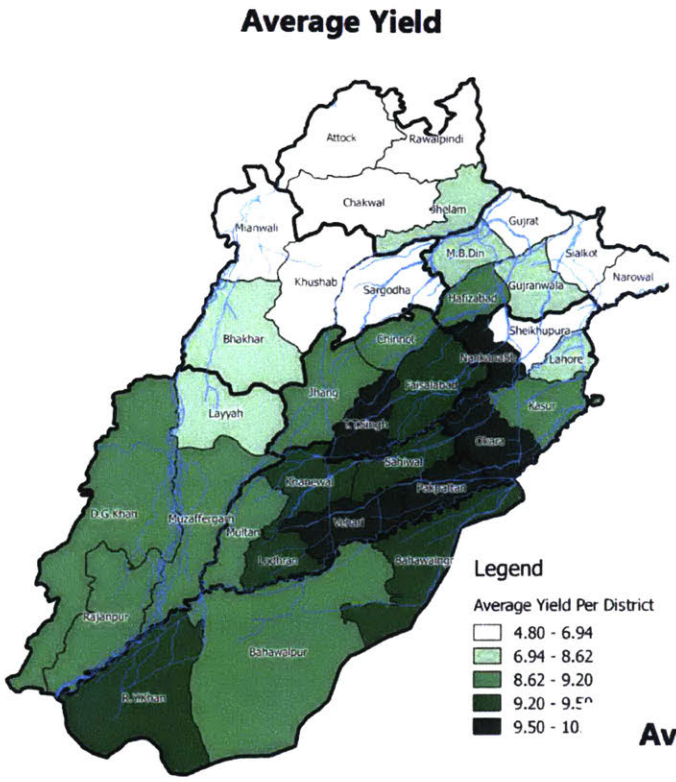

Figure 4: Average yield by district in Punjab

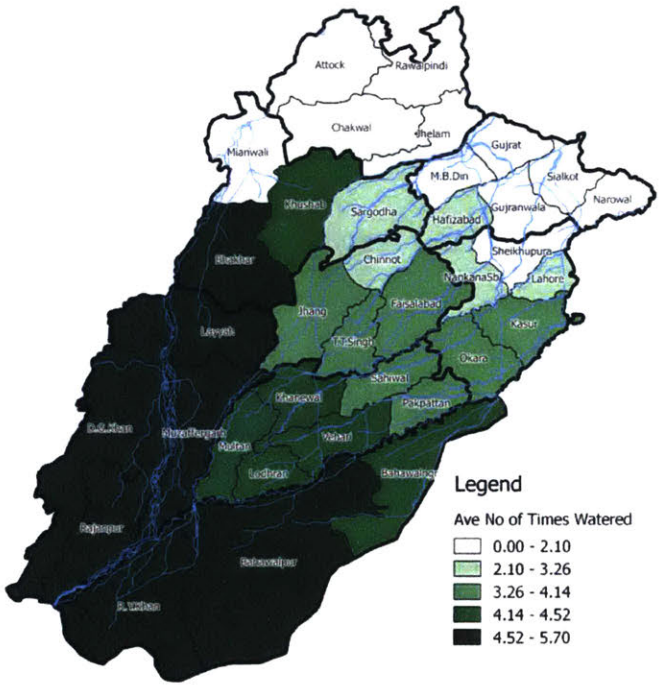

Figure 5: Average number of irrigation applications by district, Punjab

A closer analysis of distribution of net land ownership (below) shows that most land holdings are less than 20 acres in size with the median for the variable as low as 8.

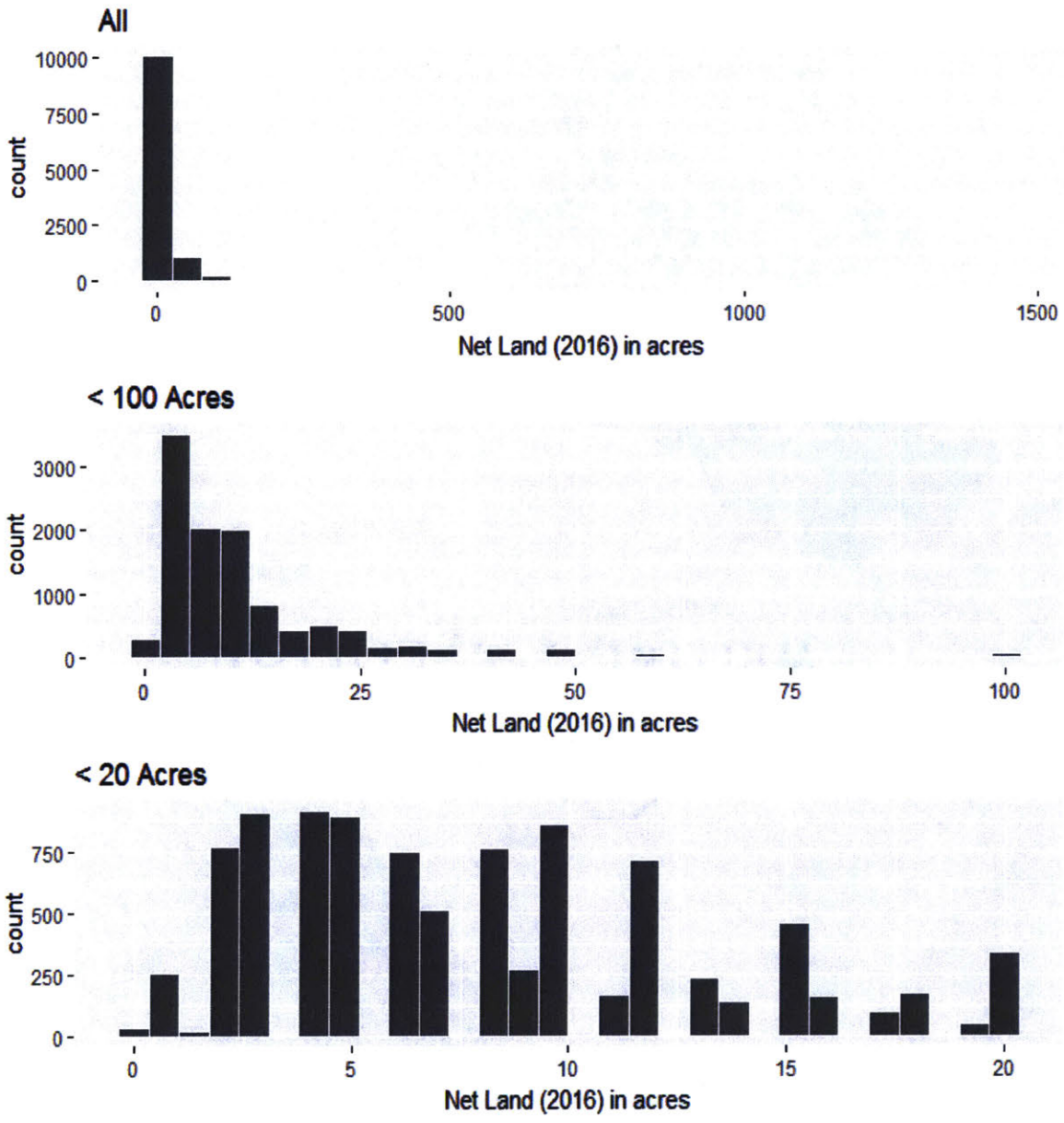

Figure 6: Distribution of Land Ownership by Size

A distribution of the mode of irrigation shows that farmers overwhelmingly use a combination of canal and groundwater, indicating the insufficiency of the irrigation water supply. A substantial one third rely exclusively on ground water, while a much smaller 14% use only canal. This is reflected in the tube well usage cost (calculated as the sum of tubewell expenditure on electric and diesel powered tubewells for each farm) with the first quartile of the farms paying 600 RS for tube well usage, and the median farmer paying 1,600 RS. Some farmers report charges in tube well usage of above 20,000 RS. However, there were only 19 such incidents in the entire dataset so those values have not been included in the histogram below.

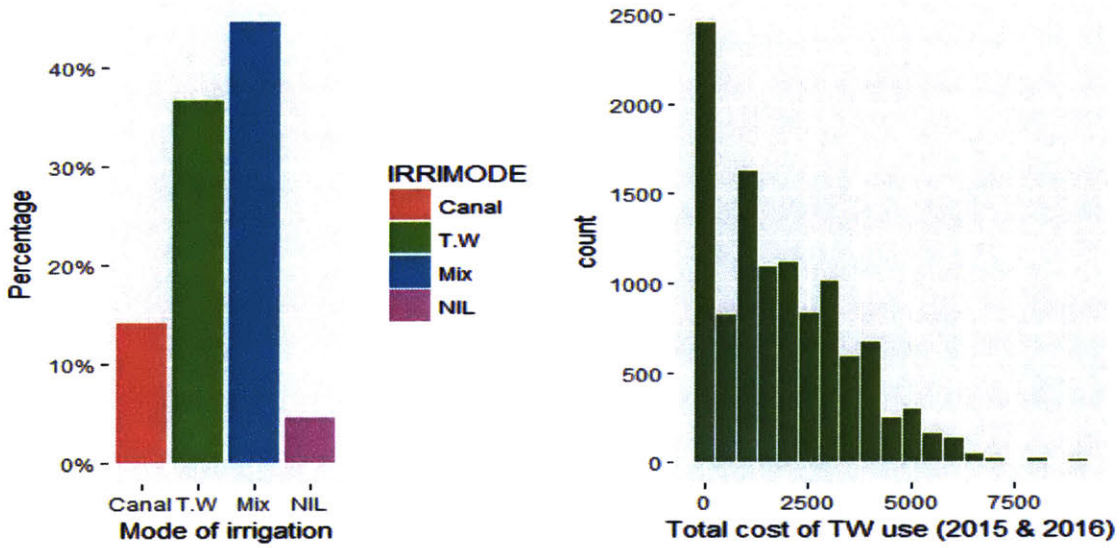

Figure 7: (Left) Distribution of modes of irrigation for agriculture in Punjab. (Right) Distribution of total cost of tubewell usage in Punjab (Rs).

II) Spatial and bivariate analysis

This section tests a number of hypotheses about bivariate relationships in Punjab regarding wheat growth. One is the impact of net land ownership on yield since it is suspected that farmers with smaller land holdings are unable to invest in the right inputs or leverage economies of scale. An analysis of yield against net land across divisions for net land ownership smaller than 20 acres shows that the size of land has negligible effect on yield. Linear regression lines plotted through each division are almost completely horizontal only varying in height which seems to indicate a more spatial division level effect rather than a land size impact.

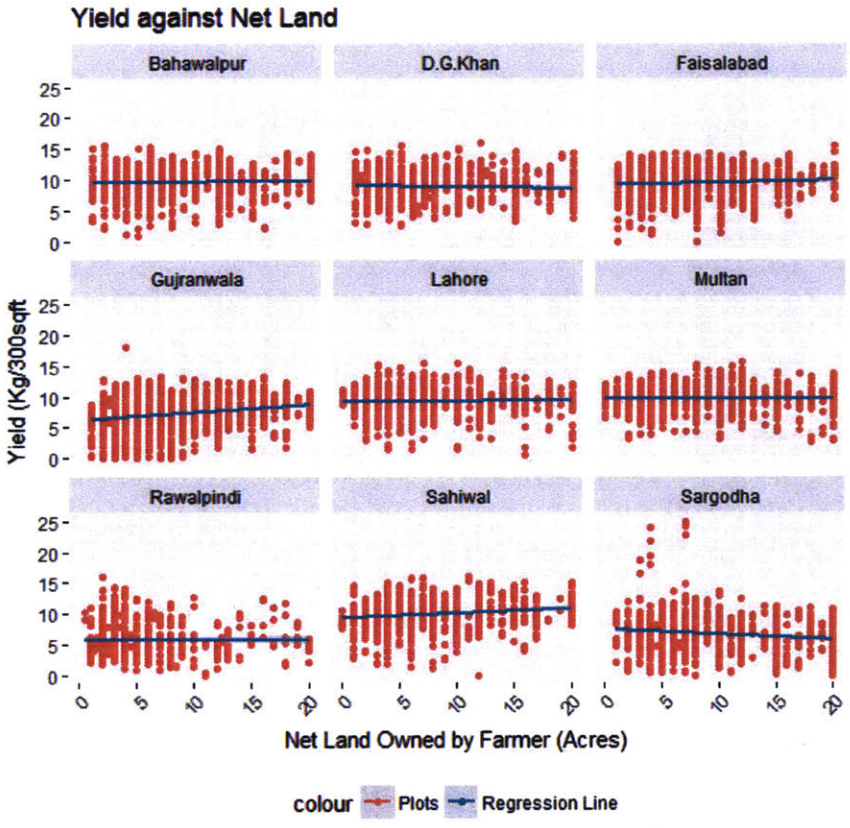

Figure 8: Relationship between yield and net land owned by a farmer by division.

Plotting yield against number of irrigation applications by district (figure 8) confirms the pattern observed in the maps above, i.e. while there is a positive relationship between water applications and yield, maximum water application does not result in highest yield. Pakpattan and Okara which have the highest average yield also have average irrigation applications of slightly above 3, the departmentally advised number.

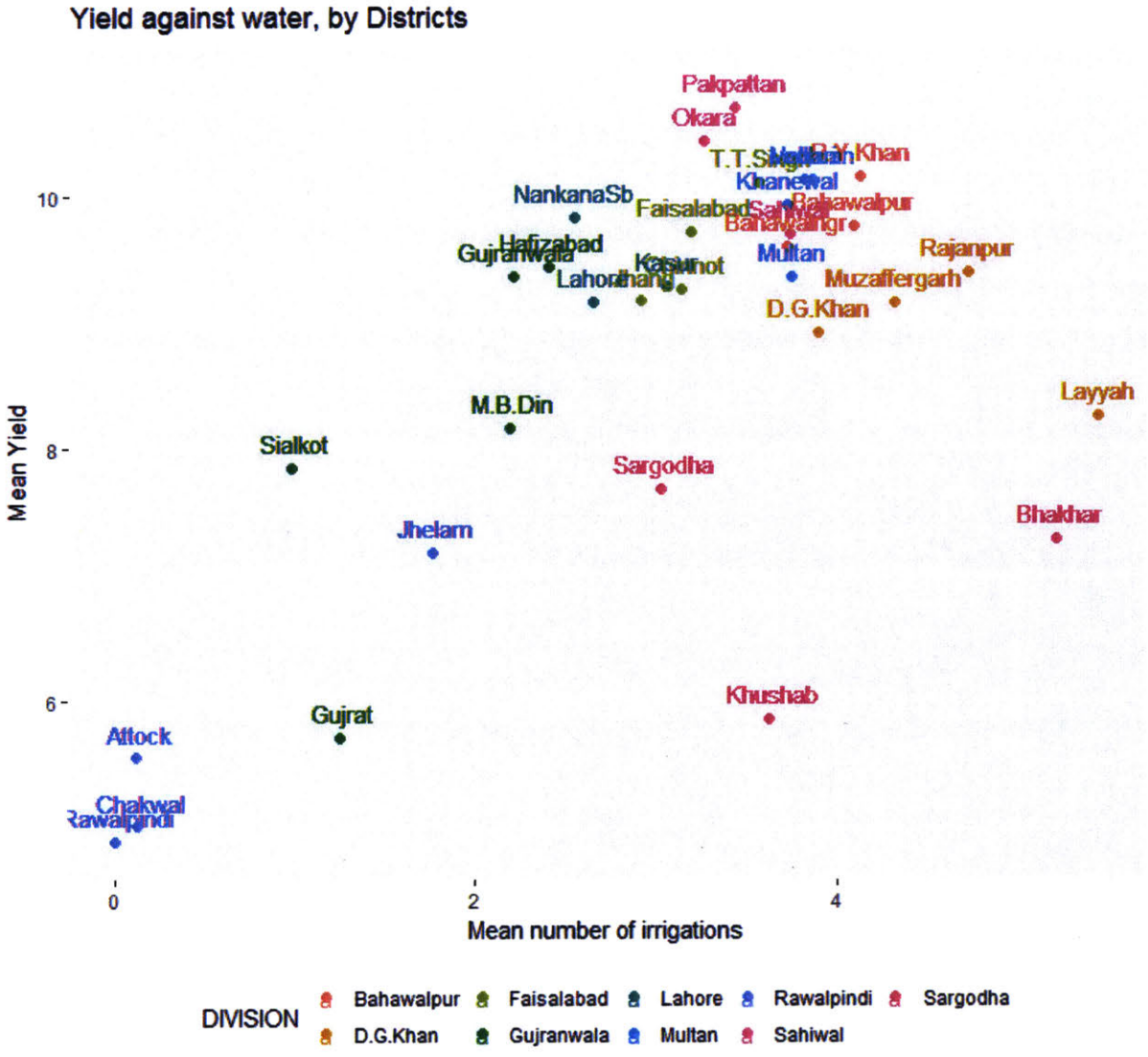

Figure 9: Average yield plotted against average number of irrigation applications, by district.

To investigate variations of yield and water usage within divisions, average of yield and number of irrigation applications was taken at tehsil level and plotted. Points of the same color within a division represent tehsils within the same district. Bahawalpur and Sahiwal divisions immediately stand out as high performers, while Sargodha has one of the lowest average yield figures in the province. Rawalpindi division stands behind other divisions since its agriculture is rain-fed in nature and not supported by the irrigation network. Gujranwala division seems to show the most variation in average yield between tehsils with some of the lowest averages as well as the highest in a pretty linear positive relationship between irrigation applications and achieved yield.

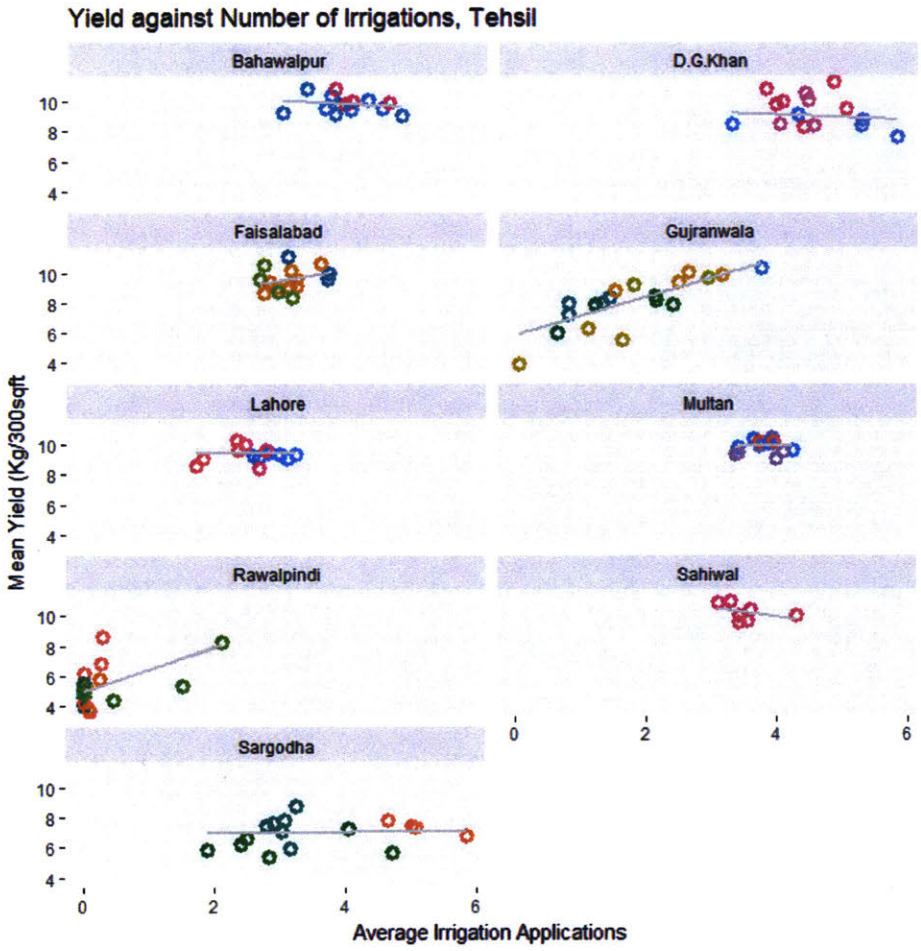

Figure 10: Average yield plotted against average number of irrigation applications, by tehsil.

With high yield districts and divisions identified, a bit more investigation into the mode of irrigation is relevant. Gujranwala and Sargodha divisions show the highest reliance on ground water usage, which might also explain the high variance in average yield and number of irrigation applications as a result of variations in abilities of farmer to afford tube well usage. D.G. Khan, Sargodha and Faisalabad all show a higher average yields and a good mix of all modes of irrigation illustrating that farmers optimize whatever mix is available to them to attain maximum yields.

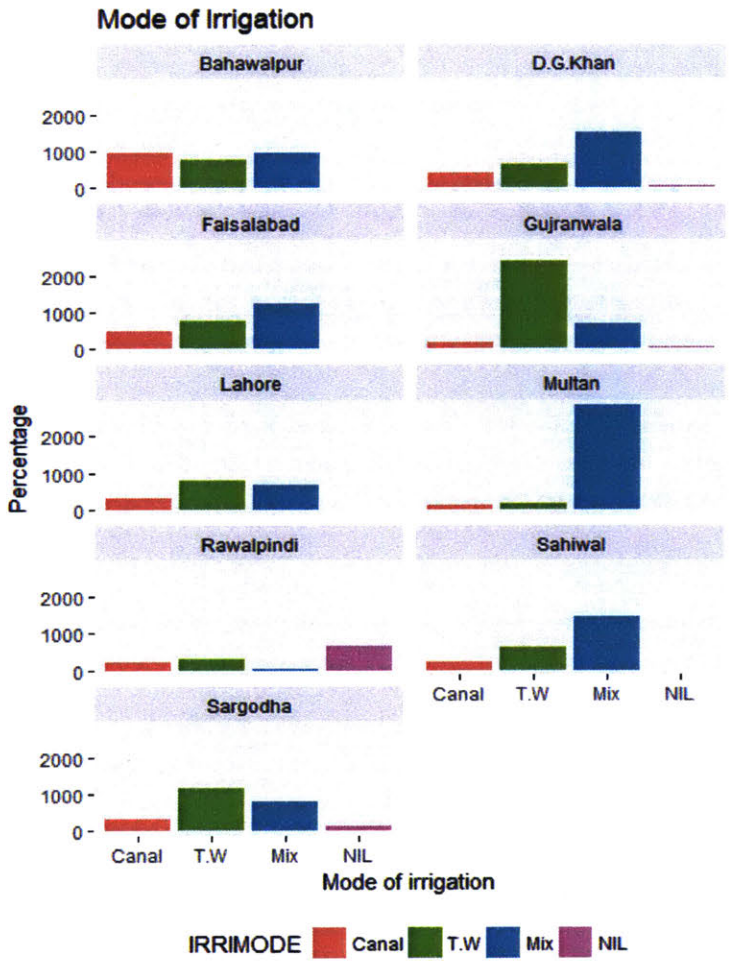

Figure 11: Distribution of mode of irrigation by division.

III) Multivariate Analysis

With a clear sense of the current performance of different districts and divisions in agricultural productivity and water usage, this section utilizes multivariate analyses to develop integrated indicators for identifying leaders and laggards in irrigated agriculture. Indicators that can act as a proxy for water productivity are ideal in this regards since they can encapsulate the relationship between agricultural productivity and water usage in one metric. Based on the CRS data, this can be done by dividing Yield by Number of Irrigation applications to roughly approximate which districts and tehsils are able to achieve highest yields per irrigation application.

A district level plot of average yield per irrigation (figure 11) shows that while Pakpattan and Okara stand out in terms of absolute yield, districts in Gujranwala division like Gujranwala and Sialkot are able to achieve considerably higher yield per unit irrigation application. The three barani districts (Rawalpindi, Attock and Chakwal) unsurprisingly show the poorest performance. However, Bhakar, Khushab and Layyah stand out as laggards by this metric.

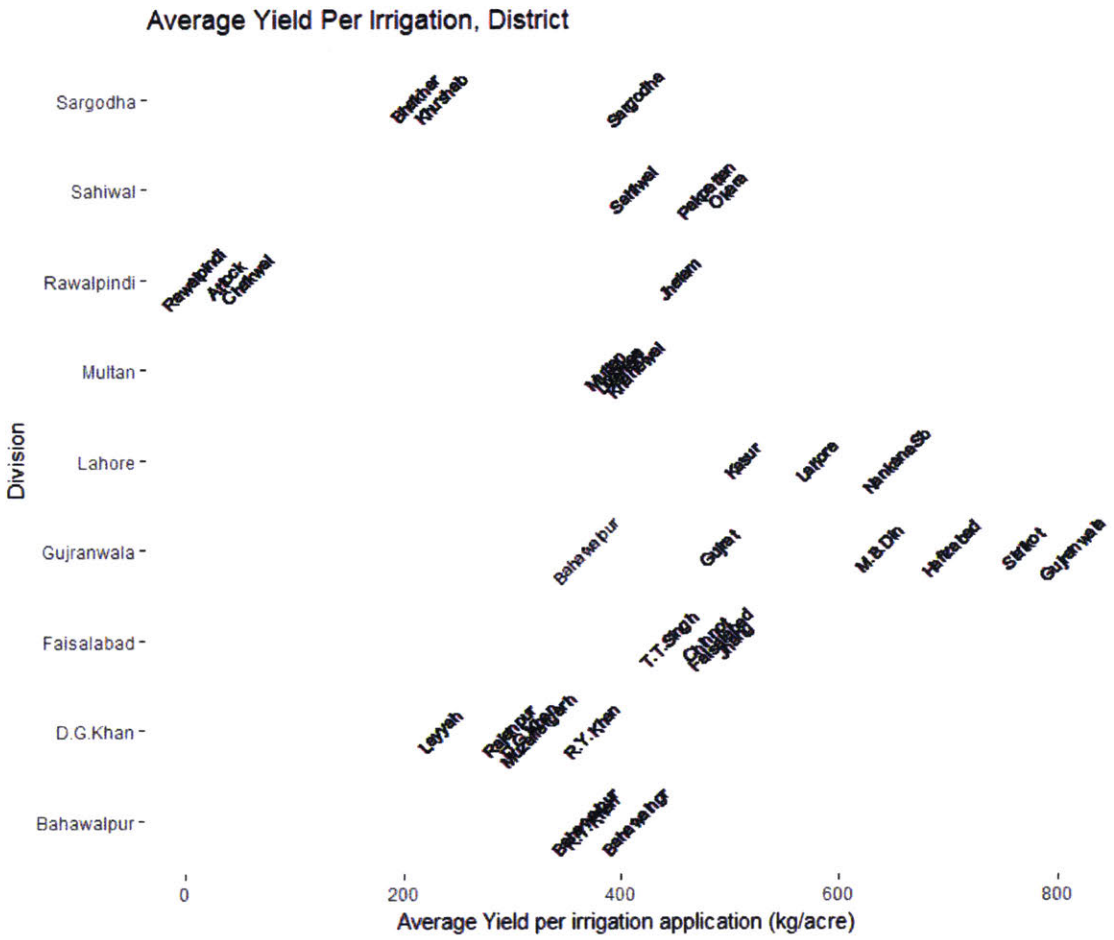

Figure 12: Average yield per irrigation application, by district

This analysis can be broken down further to obtain average yield per irrigation by tehsil to identify leaders and laggards for each division (figure 12).[24] Nurpur, Mankera, Sarai Alamgir and Karor are clear laggards that need to be focused on for improving yield. Three tehsils of Gujranwala, including Hafizabad, Sambrial and Wazirabad stand well ahead of the rest as leaders.

[24] The Tehsils are colored by district within each division.

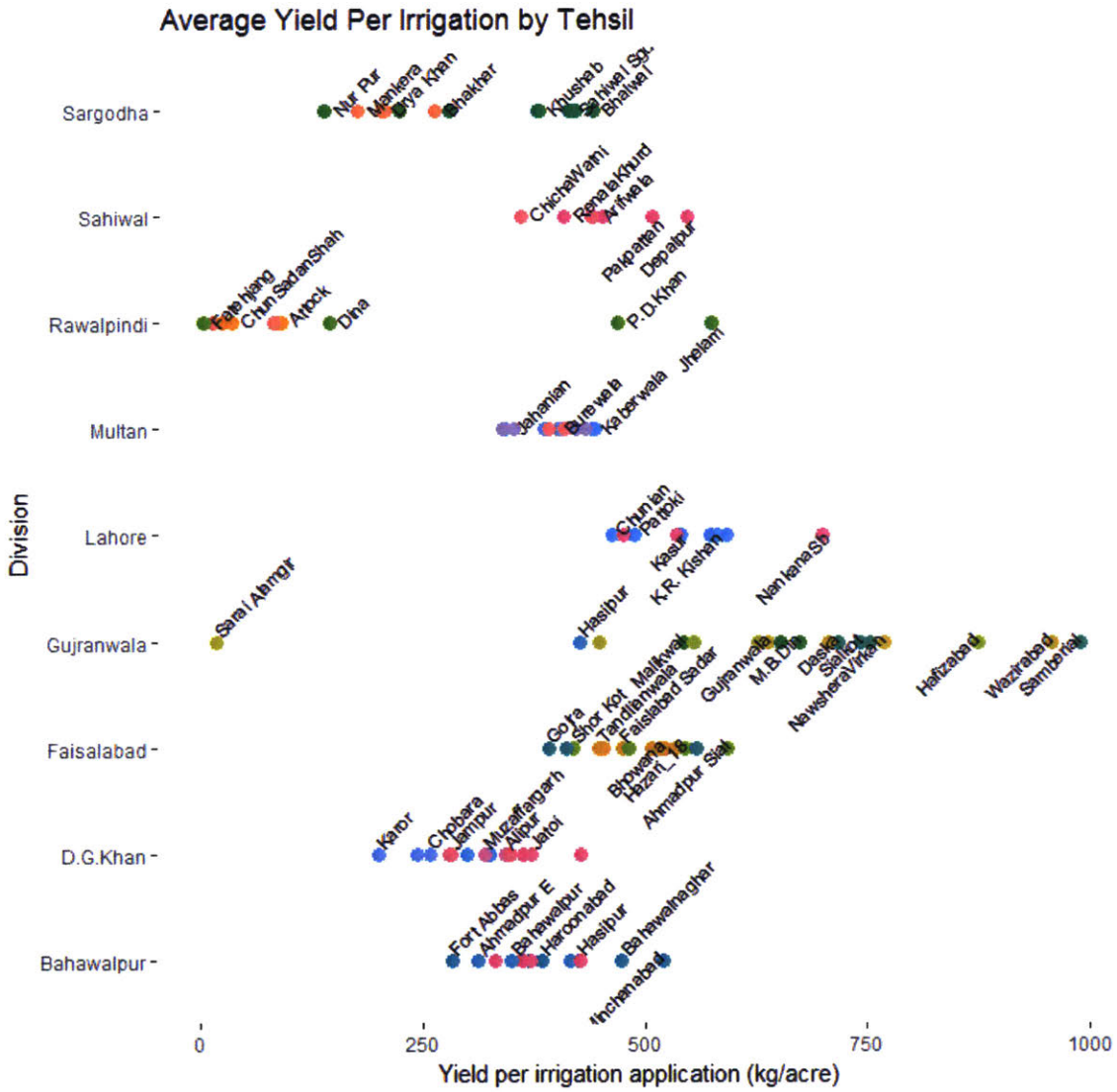

Figure 13: Average yield per irrigation application, by tehsil

A similar analysis can be conducted to investigate the relationship between yield and tube well usage (figure 13). Identifying which districts and tehsils are deriving the least in terms of yield gain per unit rupees investment in tube well usage can help inform planning alternate, less costly solutions for water provision.

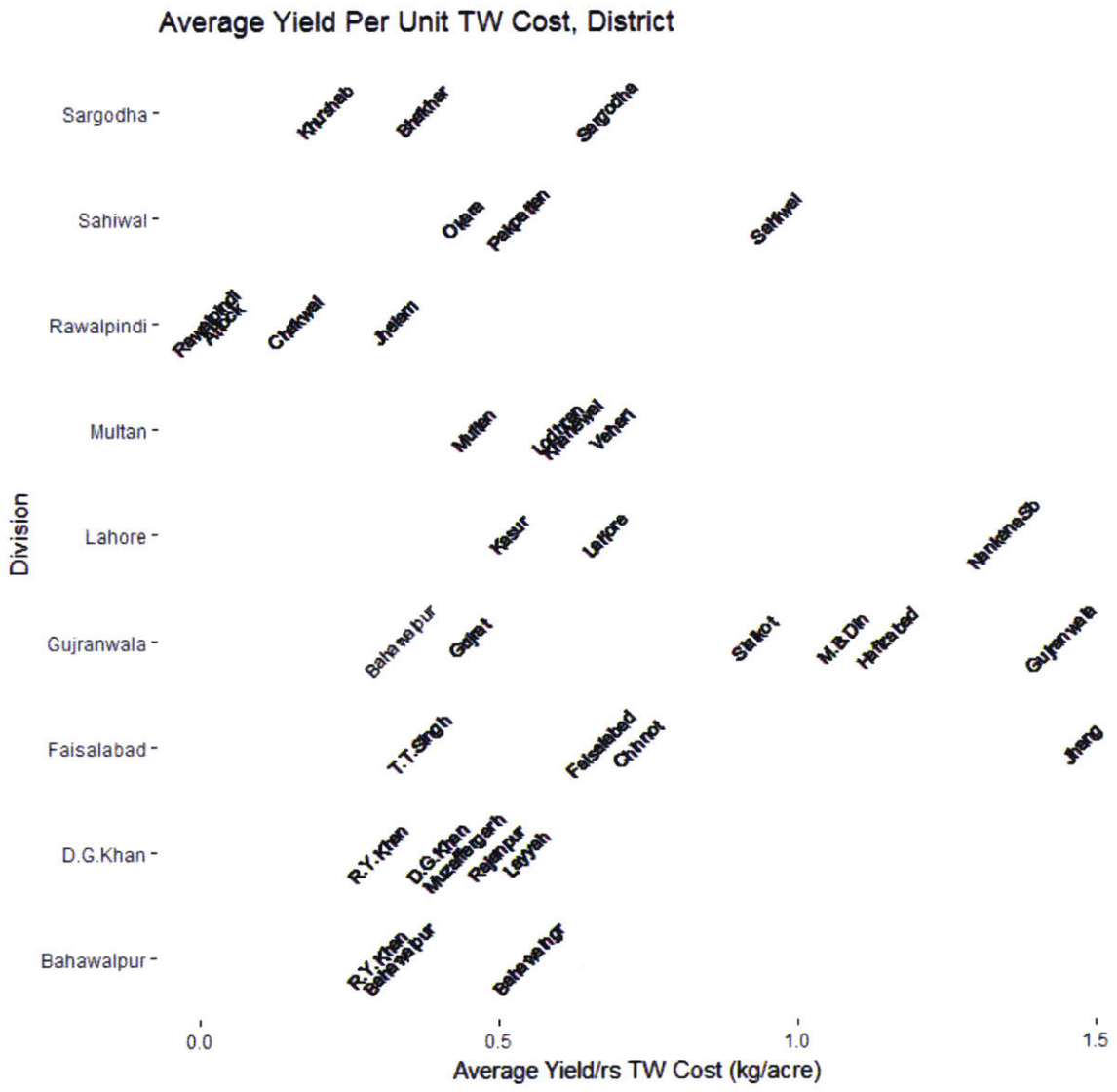

Figure 14: Average yield per unit expenditure on tubewell usage, by district

The district level analysis of average yield per unit cost in tube well usage shows that districts in Gujranwala continue to be leaders in optimizing groundwater use for higher yield. However, here Jhang and Nankana Sahib also emerge as significant leaders. The *barani* areas continue to show very low yields per unit cost of tube well usage. Bhakhar and Khushab as well as the districts in Southern Punjab emerge as the least efficient in converting ground

water to achieve higher yield. A tehsil level analysis using a similar indicator of yield per unit cost of tube well usage (below) separates out the leaders and laggards at the tehsil level (figure 14). This disaggregation shows some clear stand outs. While most of the tehsils are located on the left side of the center towards the lower end of yield per unit tube well usage, some tehsils in Lahore, Gujranwala and one in Chichawatni stand out with much higher yields per unit expenditure on tube well usage.

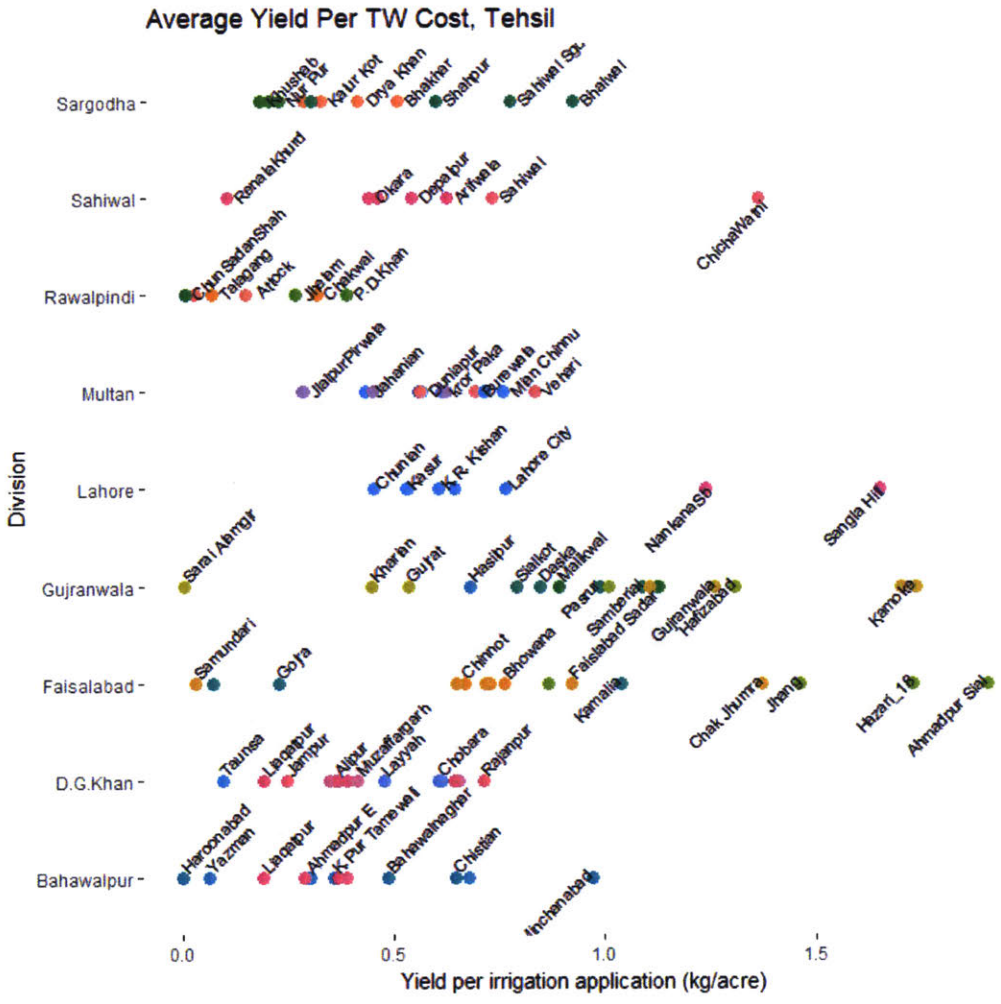

Figure 15: Average yield per unit expenditure on tubewell usage, by tehsil.

Further investigation into understanding the differences between the leaders and laggards will need to include analysis of ground water quality, precipitation information and other inputs to disentangle why certain tehsils have been more successful at achieving higher average yield than others. However, this analysis shows that using existing, annually published data, and indicators that capture not just agricultural productivity but water productivity can be used to identify high performing areas and low performing areas, allowing both agriculture and irrigation to together plan how the areas that are lagging in performance might be supported to come up to the level of the leaders.

Using such an empirical analysis as attempted here as a 'boundary spanning object' can allow the irrigation and agriculture departments to develop multilevel plans that allow for variations across and within divisions and districts to be appropriately addressed at a provincial and district or divisional level. For example, a program that has been supported by the irrigation department is the small dams project. With empirical analysis that can help identify where groundwater extraction levels are high and canal water available, small dams and reservoirs can be built for ground water recharge through the small dams project. More developed versions of this analysis can also incorporate multiple crops instead of looking at wheat alone such that trade off analysis of different crop can be done to develop multi-pronged plans for addressing areas suffering from water scarcity. With irrigation and agriculture departments working together, they will have a variety of tools available to 'problem solve' creatively, from infrastructural investments to pushing new technologies and incentivizing crop substitution. Pushing planning downstream to the meso-scale will allow

adaptation of provincial policies to the needs of the local context and for institutions to dynamically respond to the needs of the farmers.

CHAPTER 5: RECOMMENDATIONS

In an iconic lecture summarizing the key lessons of how complex economic systems may be governed using diverse institutional arrangements, Elinor Ostrom highlighted that no standard principles of good institutional design exist. In systems such as that of irrigated agriculture in Punjab, there are many different centers of decision making that function with varying degrees of independence and interdependence. Ostrom highlights: "Building trust in one another and developing institutional rules that are well matched to the ecological systems being used are of central importance for solving social dilemmas." (2009, p435) Achieving such a set of institutional configuration and rules remains a challenge with no easy solutions. This research used three different methods of analysis to investigate the potential and relevance of integrated water resource management and food-water-energy nexus thinking in the province of Punjab, Pakistan. Both within the departments of agriculture and irrigation, and in the halls of provincial and federal planning and economic development departments, a need for reforming current planning and decision making processes with regards to irrigated agriculture is recognized. With the first drafts of the national and provincial water policies nearing official approval, integrated water resource management has been identified as the way forward with nexus thinking informing decision making at the sub-provincial levels.

Using three different types of analyses, this research sought to understand the existing institutional mix from a historical lens and develop a data analysis approach that might help

sectoral departments achieve integrated planning. It found that there is a need to address fragmentation between and within the departments of irrigation and agriculture by thinking of integrated water and food production planning not just as a provincial subject but also as a sub-provincial responsibility. To achieve such a multi-level, well-integrated planning framework, literature on boundary spanning organizations and objects provides a way forward. Some key highlights for the way forward are as follows:

1) Integrated Planning with Boundary Objects**:** Planning with a focus on variations at sub-provincial levels within Punjab will allow management of biophysical variations in agriculture, climate, surface and ground water management throughout Punjab in a more customized and targeted manner. However, without empirical analysis that integrates food, water and energy informing government planning and decision making at all institutional levels, integrated planning cannot be achieved. Metrics and boundary spanning analyses that use combined water and land productivity instead of simply agricultural output or yield can be integral to helping irrigation and agriculture departments talk to each other to address problems together. Without all stakeholders basing their plans on the same sets of information, coordination is not possible.
2) Planning for Context: Strengthening planning analysis based on the sub-provisional district and division scales will allow challenges of landholding sizes and poor yield to be captured at a more localized level so they may be addressed in a targeted manner instead of through province wide schemes. However, this requires fundamentally

reimagining sub-provincial scales to be more than simply executing bodies for the provincial government. Institutional development of planning mechanisms at the sub-provincial levels to both include the division and district offices in planning processes and to empower the departments to laterally approach each other to address problems is one way to imagine the way forward. Thus, there is a case to be made for strengthening the meso-scale by creating boundary spanning planning organizations between the irrigation and agriculture departments. A Water Resource Management wing at the provincial level is a step in the right direction as a move away from water allocation to water management. However, the current thinking on IWRM still imagines it to be a provincial subject even while vastly varying relationships between sectors of food, energy and water are recognized at sub-provincial levels. Without strong capacity at the divisional and district levels, these citizen interfacing government tiers cannot be the necessary linkage between farmers and the provincial government as is required for participatory irrigation management to succeed.

3) Boundary Spanning Organizations as the Way Forward: The idea of boundary spanning organizations that allow agriculture and irrigation experts (traditionally experts who have little coordination between each other) can be an innovative but game-changing approach for achieving integration within and across PID and PAD in Punjab. Such an idea will enable policy makers to re-imagine the role of sub-provincial levels not only at a decision-making level but also from a technical, legal, financial and jurisdictional capacity point of view to truly reorient PID and PAD

towards solving farmers' problems rather than simply fulfilling provincially set deliverables. Such boundary planning organizations will be integral to multi-scale planning as a link between the farmers and the provincial government to enable inclusive farming that is bottom-up instead of top-down.

4) Conjunctive Water Management for Irrigated Agriculture: While currently no mechanism for regulating ground water exists, the complexity of ground water usage vis-à-vis surface water irrigation and its impact on agricultural productivity is well accepted. A standardized province wise policy to manage ground water extraction will be simply inadequate given the variation in the usage of ground water throughout the province. A push for downstream planning, with the groundwater piece as missing link to connect food and water planning, can provide innovative solutions for conjunctive water management. More context specific localized thinking will enable boundary spanning organizations to bring together irrigation and agriculture experts and farmers to adopt, complex multi-pronged strategies for water management (varying from smaller interventions like laser levelers to larger ones like creating local reservoirs for ground water recharge) to solve the problem of ground water over abstraction. Such a detailed and flexible planning strategy can only be achieved if planning is thought of as a multi-level process rather than simply a provincial one.

The government of Punjab is at an important transitional point willing to rethink current institutional structures to achieve better integration in water uses. This thesis attempted to show that benefits of integration are best seen not by planning at provincial level but by

being more deliberate about integrated planning at sub-provincial levels with the aim to be focused downwards to responsively solve farmers' problems. This requires different decisions makers to work collaboratively with each other as well as the users of the system to attain desired objectives of efficiency, equity and environmental sustainability. With such high aspirations, there is a case to be made for the government of Punjab to be even more ambitious in its reform agenda to elevate the meso-scale and reimagine the role of the agriculture department vis-à-vis irrigation to truly achieve integrated planning in the province.

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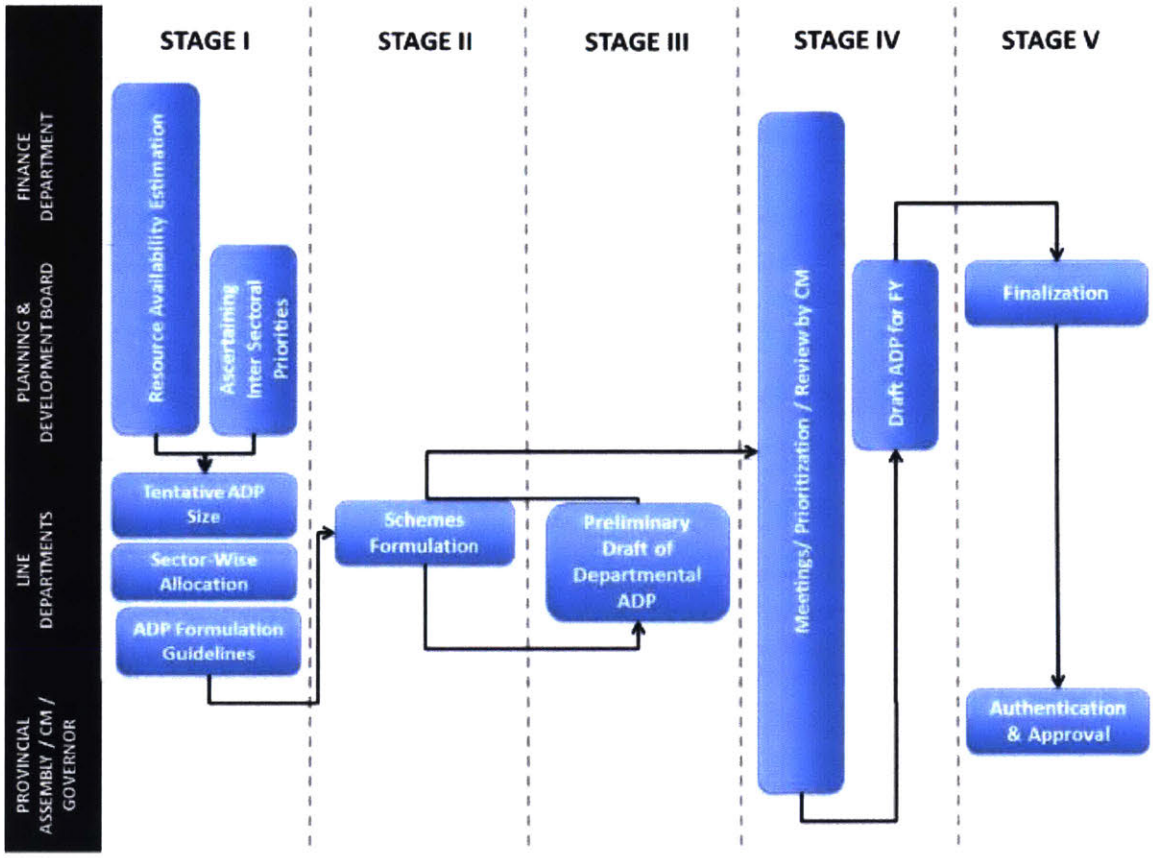
Appendix 1: Planning Process and Organograms



Stages of creation of the provincial Annual Development Plan
Source: Punjab Planning Manual

Acronyms:
ADP = Annual Development Plan
FY = Fiscal Year
CM = Chief Minister

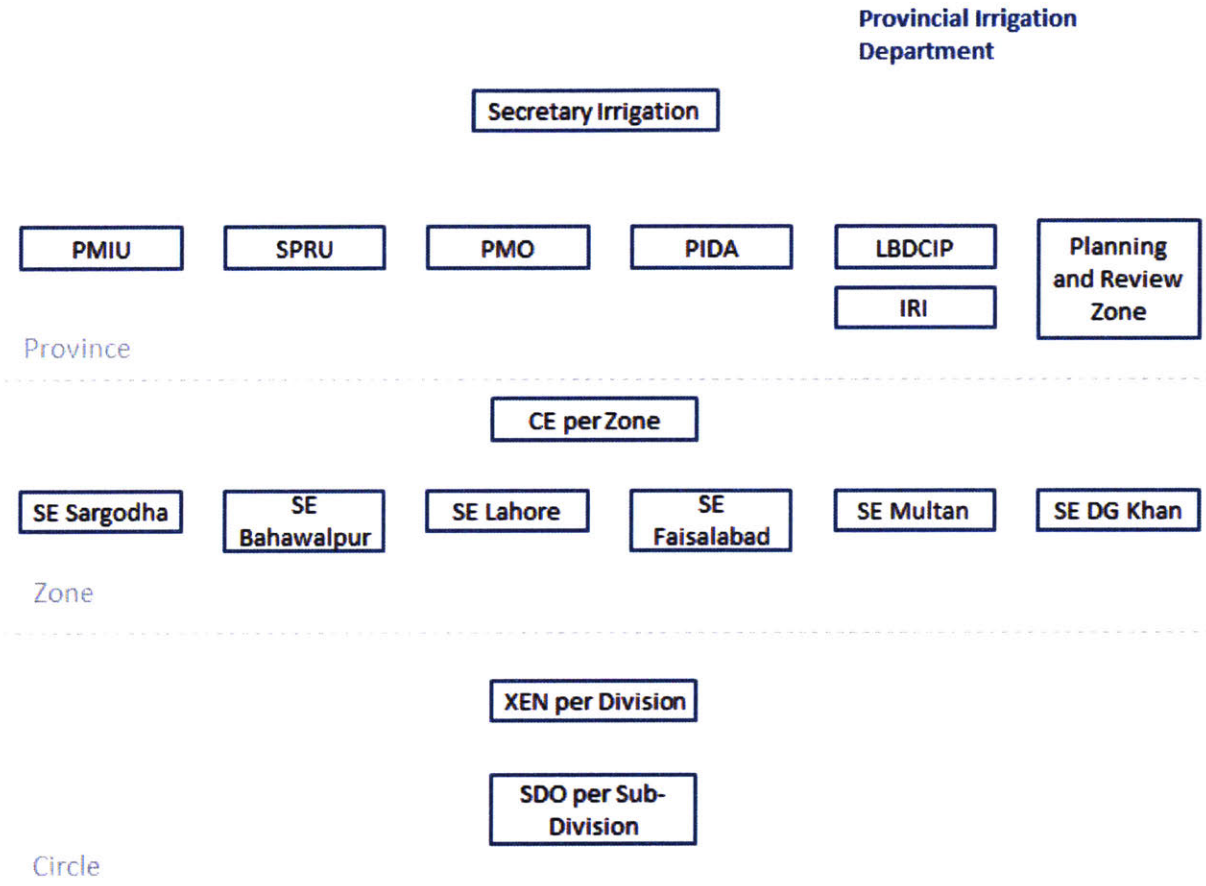


Figure 16: Organogram for Provincial Irrigation Department

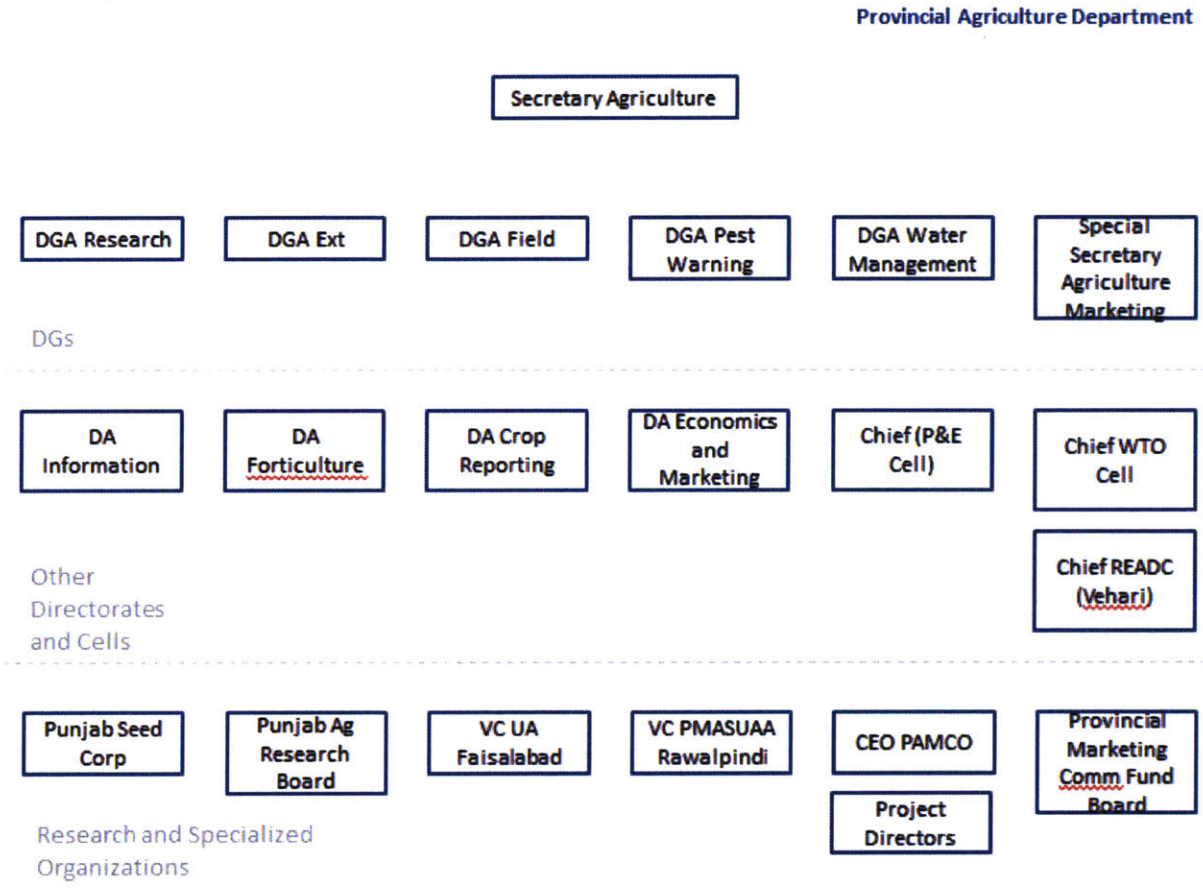


Figure 17: Organogram for Provincial Agriculture Department

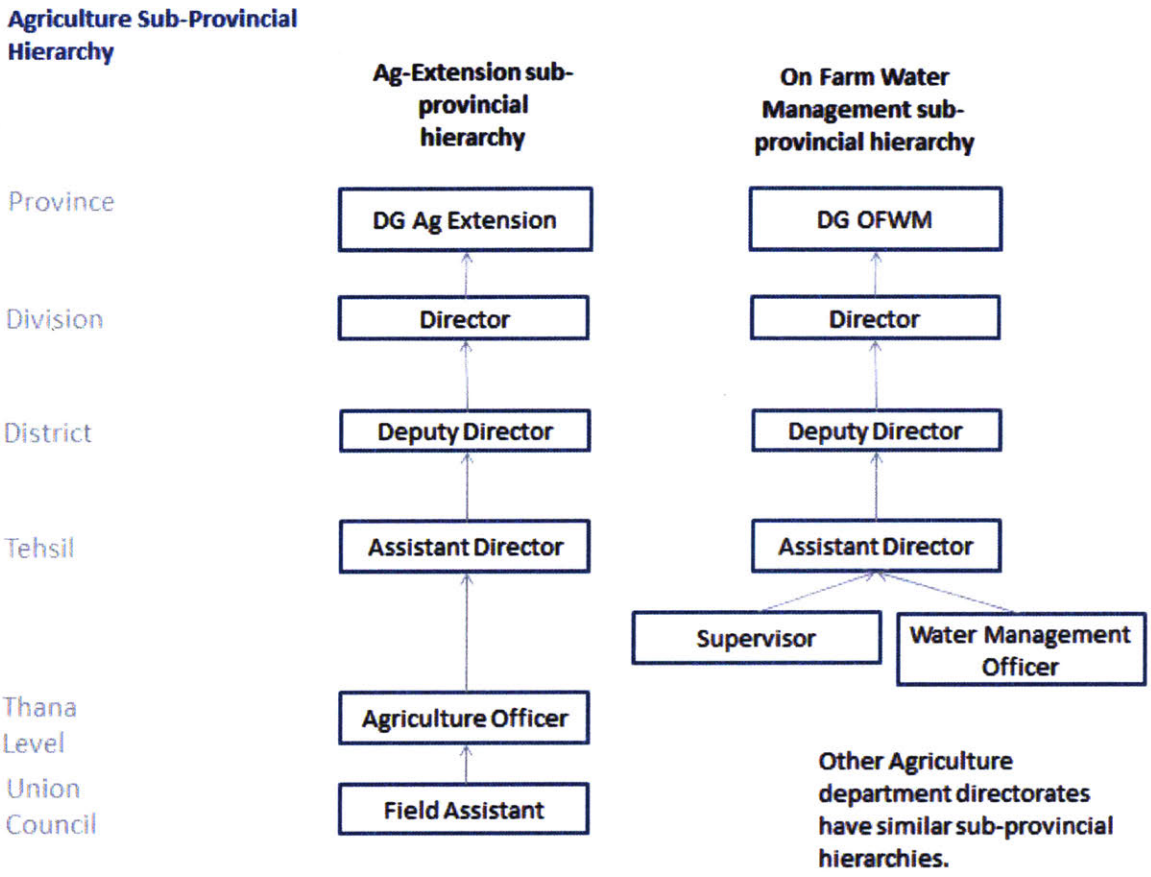
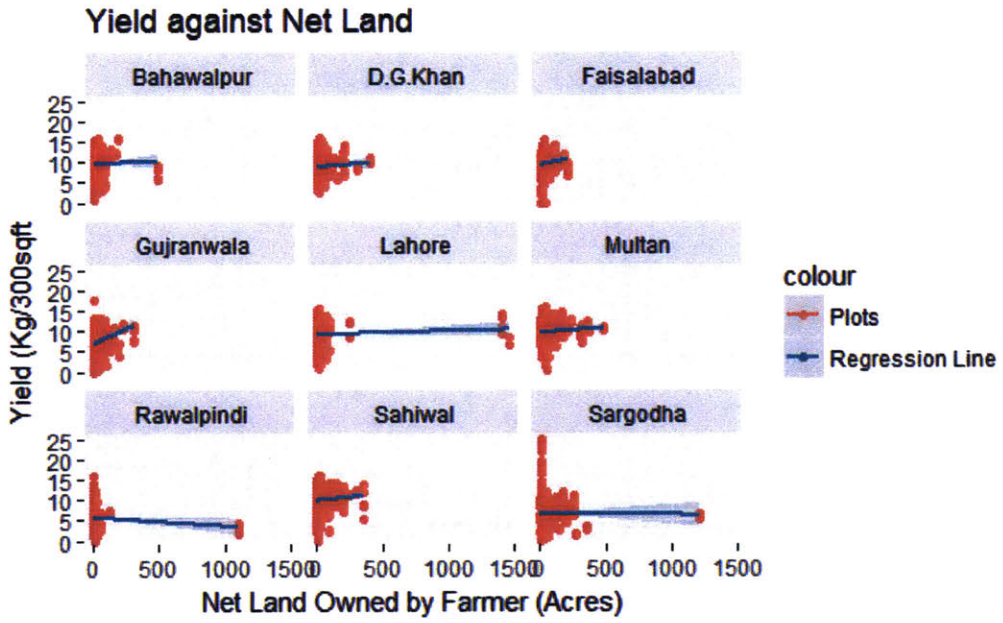


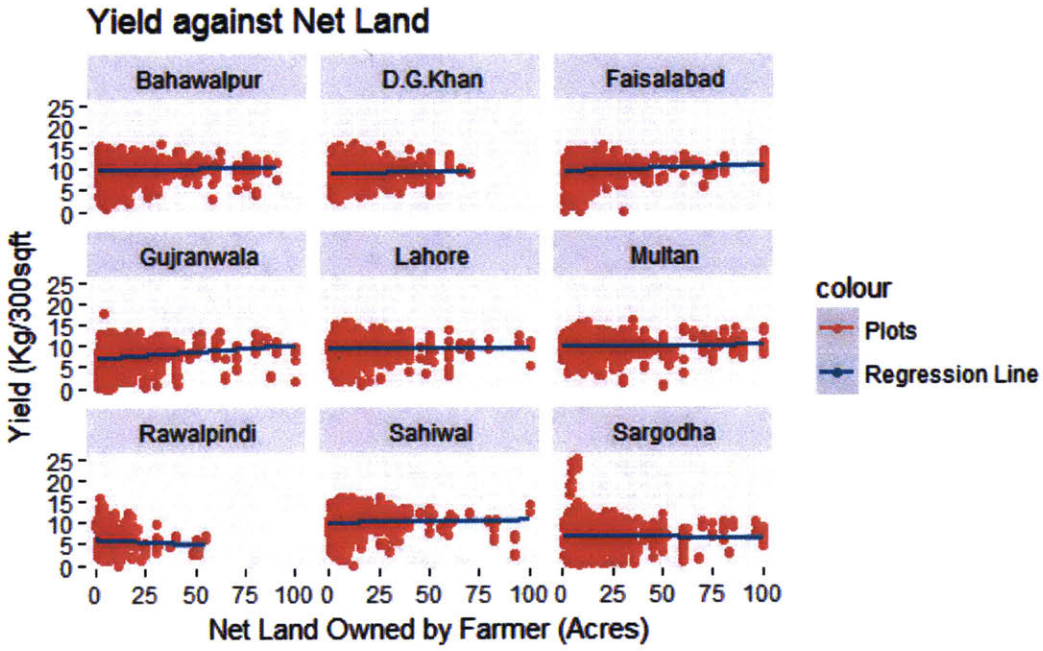
Figure 18: Sub-provincial hierarchy for the agriculture department.

Appendix 2: Additional Analysis

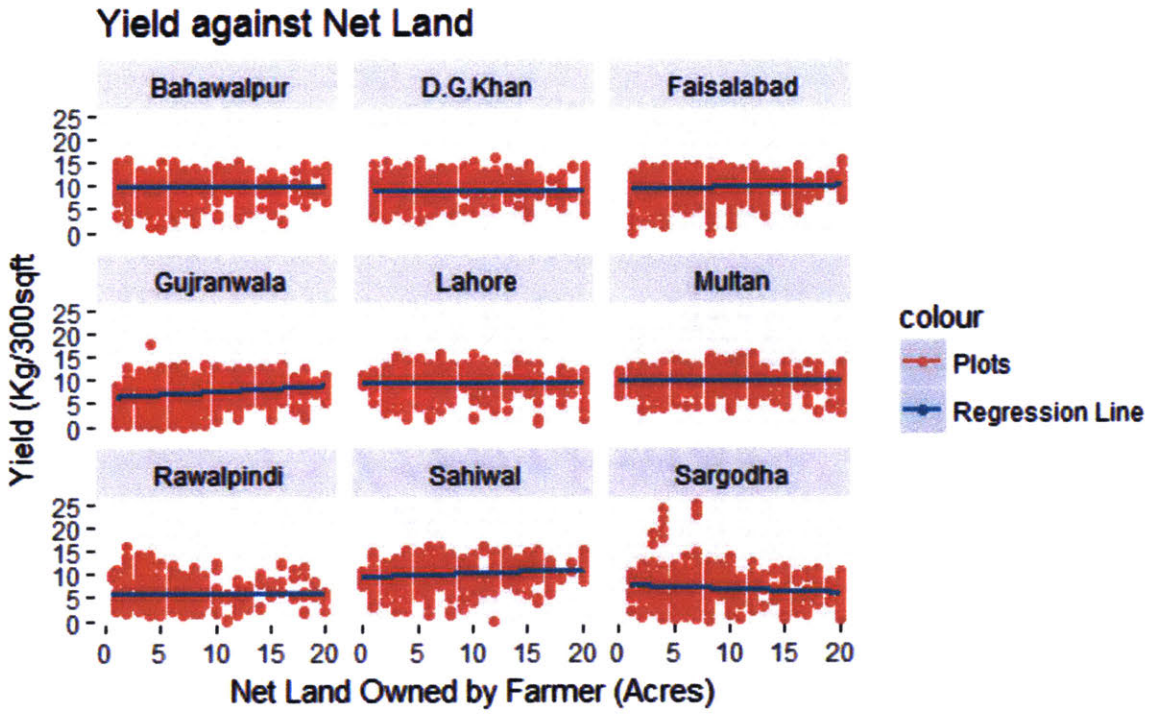
Yield against Netland (entire dataset)



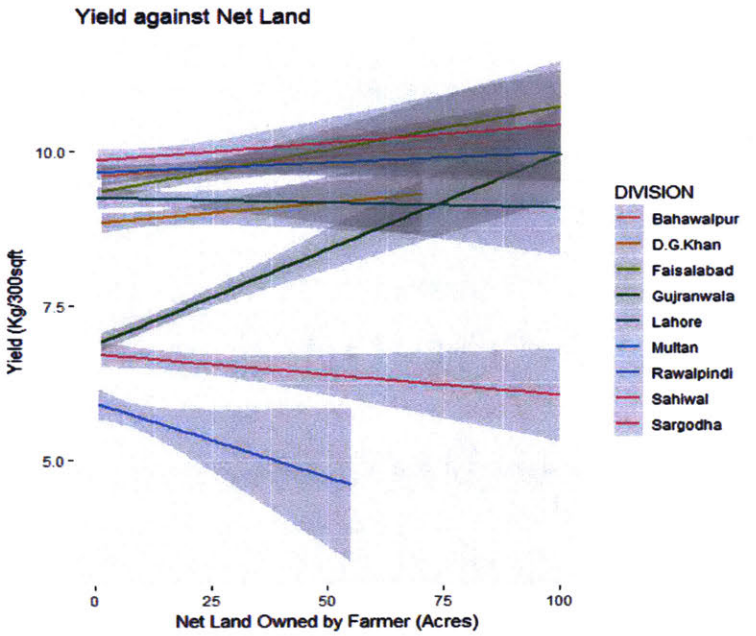
Netland < 100 acres



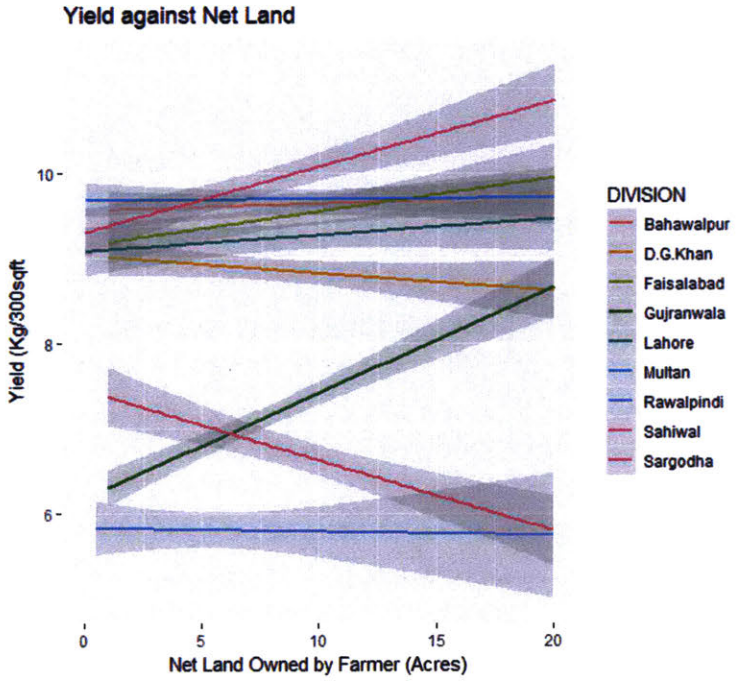
Netland < 20 acre



Netland < 100 acres

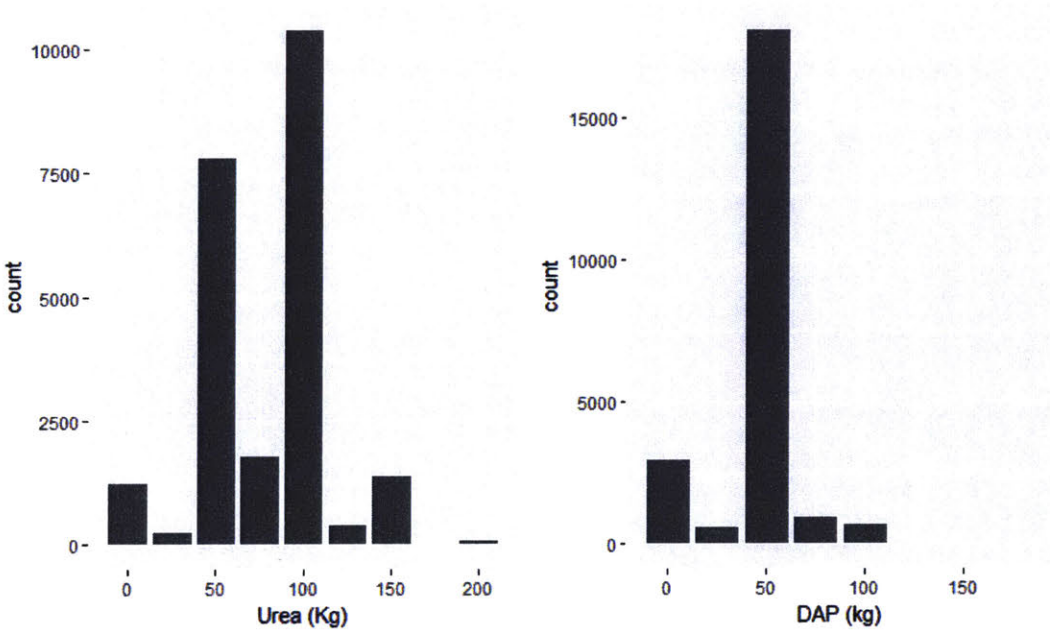


Net Land <20 acre



District Colours and Labels:

Histogram of Urea and DAP:



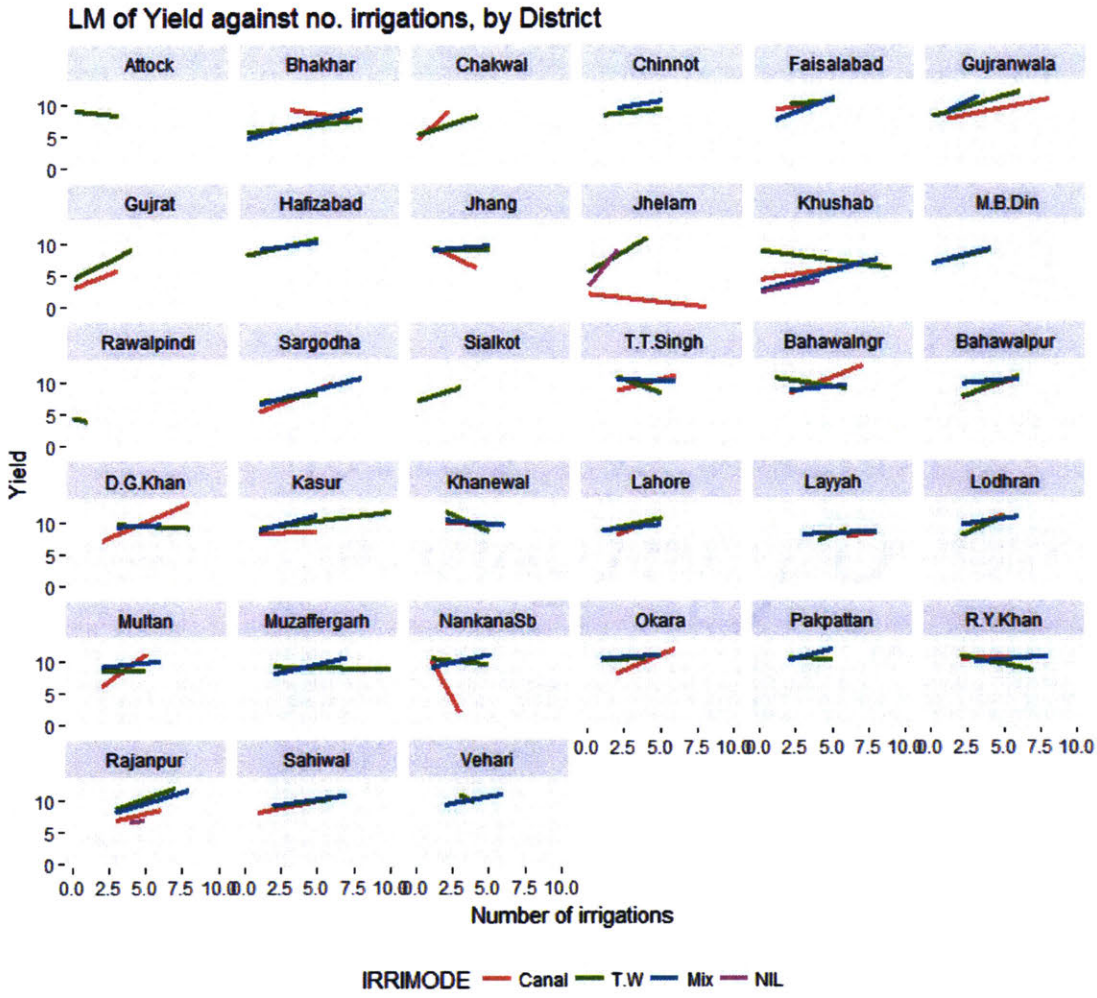


Figure 19: Linear Regression Model Yield against Irrigation applications