Swedish University of Agricultural Sciences
Faculty of Natural Resources and Agricultural Sciences
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Unit of Environmental Communication

Analyzing Feasibility of Pricing in Sustainable Irrigation Water Governance Reform in Punjab, India

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Abstract

India faces water management challenges. The agriculture sector is the largest user and polluter of water but the water resource management has had a duality of good design and poor implementation. The agricultural water management is in a conflict between institutional and political priorities in ensuring security for food and rural livelihood. In Punjab, a concern is growing about sustainability among farming community over income and production of rice and of freshwater for needs of farmers and increasingly for non-agricultural sectors. The political pressure for efficiency of water use and for conservation and allocation is growing but necessitates a critical analysis as to whether this constitutes the most effective and only prescription to overcome the challenge Punjab faces. There is an ambiguity in the concept of economic efficiency especially of defining cost and value of water and conditions surrounding production and livelihood of individual farmer in the state complicate rather than simplify the question of appropriateness and validity of application of optimal water and/or electricity pricing in Punjab. Various findings and discussions show how this may be the case and indicate very broad issues such as international trade that requires coordination among wide ranging departments and stakeholders to identify suitable mix of options available for Punjab.

Acknowledgements

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Tatsuhiko Sato

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Table of Contents

1.Introduction

Pricing water for irrigation is one of the policy interventions which have been discussed controversially for many years in the context of sustainable management of both water resource as well as agricultural economy. Experiences of Punjab state in the northwest of India is perhaps an illustrative example of precarious groundwater condition which exhibits the conflicting need to restructure public policies for reliable and sustainable management of surface and groundwater resource for irrigation supply and the economic benefits they have brought to farmers.

A juncture of the policy reform lies in a revision of supply side technological solution; dams and canals to maximize economic returns [1]. Those who advocate promotion of demand side management point to supply side approach which failed to ensure efficiency of irrigation water use and irrigation service sector and argue for robust changes for Indian agricultural water management from the Green Revolution era. The shift entails wide ranging measures and a need for a framework to embrace very wide and diverse aspects associated with water resource use. Integrated Water Resources Management (IWRM) could be one way to present a conceptual framework, but ultimate importance continues to lie with a concrete structural reform; whether optimal pricing and a removal of distortion to service price via subsidies made to water and electricity for irrigators in Punjab has any appropriateness and feasibility to address

[1] OECD 2010:34

the problems on irrigation water sustainability while maintaining and restoring strength of Punjab's agricultural economy. These represent hard measures to swallow for users and policy makers in the context of a political agenda for food and farmer livelihood security. It is important to understand effectiveness of other non-pricing approaches to the problem more accommodating to the region's socio economic reality. Particular aspects such as Indian national rice policy on which international trade regime lurking a shadow influence should also be considered. Since major changes in Indian national food security policy is not likely, author stands for a position that impact mitigation has to be considered both for environment and farmer livelihood when a structural reform is sought. Due to Punjab's idiosyncratic condition such as saturation of land area under irrigation and conscious and proactive farmer community, moderate strategy can be as much effective and buy time to avert social and economic distress of weaker farmers while tackling structural issues.

1.1 Problem statement and Research question

Rice and wheat cropping system in north western part of India which was brought by the Green Revolution has seen stagnation in productivity growth and has not kept pace with faster population growth[2]. Economic growth and climate change uncertainty would mean a potential change in the current pattern of allocation and availability of water.

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[2] Erenstein, 2009:1799

The public irrigation policy in canal systems and development of groundwater have both resulted in salinization, waterlogging and over withdrawal [3]. It is Punjab's agricultural water management systems this thesis raises questions with regard to the system's institutional capacity to cope with rising pressure to use water more efficiently.

This thesis aims to test the research question as to whether demand side management measures, especially economic optimization of pricing is a right and realistic prescription or at least a right path to promote efficient and sustainable use of irrigation water and agriculture in Indian Punjab. It is important to note that this analysis has a boundary. While water covers wide ranging elements; physical, political, legal (incl. human right), social and economic, main focus is on a relationship between the local agricultural institutions and policies into which the notion of optimal pricing is tested. Hence discussions and conclusion in this thesis do not necessarily imply applicability to contexts outside of the studied region.

Chapter two introduces the complexity of the idea and tries to show a relative nature of the value and costs of water and various pricing methods are conceptually challenged in a context of irrigation. Chapter three deals with the Indian policy, legal and institutional systems of water management for irrigation and analyzes critically for adoptability of pricing in developing an efficient mechanism such as trading through

[3] Erenstein, 2009:1800

market and for cost recovery. Chapter four aims to gain familiarity with a particularity of Punjab's agricultural economy, irrigation patterns, and individual farmer welfare and how they are "fixed" with a food security policy of India which includes price supports and input subsidies. In chapter five, a detailed and critical analysis of the contexts of previous chapters is made. This chapter invokes a designing of pricing in two tiered structure such as attempted in France because of farmers' strong inclination for reliability of water supply and low price elasticity of farmers for water. However with absence of alternative choice, the single volumetric price increase may be too damaging in the current irrigation water arrangement in Punjab. Chapter six tries to discuss effectiveness of two possible alternative demand side management measures available for Punjab. Water amount and energy cost saving techniques and long term, but targeted structural reform on electricity subsidy to pave way for progressive introduction of (two tiered) pricing for better allocation efficiency and cost recovery in the future.

In Chapter seven, the author concludes with a suggestion of conditions which appear to be conducive to implementing a more robust reform which can accommodate economic pricing of water.

1.2 Scope and methodology

This thesis is primarily a theoretical review from existing literature on irrigation water pricing and institutional aspects of water management in Punjab (and in India). The discussion relies on analyzing economic concepts on water pricing policies and social and institutional setting in Punjab and India. Sources are drawn from case evidences both empirical and non-empirical (i.e. based on simulation data only) and drawn from cases in other countries, notably in France, for a comparison. Physical analysis of hydrology, water quality, or geology of aquifer, though equally essential subjects in water management, is not a scope of this thesis.

2. Conceptual Discussion for Water Value and Cost

Before the discussion over what constitutes an optimal policy of pricing, the basic conceptual differences between water charging and pricing and value and cost first needs to be clarified. Charging encompasses all the policies and actual instruments required such as the appropriate level of cost recovery, basis on which the charge is made, and implementation both for levying and collecting the revenue, whereas pricing refers to price per unit quantity of water[4]. The latter is often interpreted as volumetric evaluation which increases political and cultural sensitivity in some countries that instead opt for the use of charging for the service of water supply to disconnect it from the value of water itself[5].

It is more important to highlight that there are no agreed principles in terms of how in practice costs and value should be applied in price to various uses. Economic values are indications of human preferences for service and products and are not inherent in them[6].

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[4] FAO 2004:4

[5] Ibid. FAO:4

[6] Natural Research Council, US, 1997:70

Broadly, water price is divided in the full supply costs which are a reflection of infrastructural service cost and the full economic costs which include externality and opportunity cost. The full supply costs include costs of supplying water to users only and are divided into *operation and maintenance (O&M) costs* of concurrent management components such as electricity for pumping, labour and repair costs for the supply infrastructure such as irrigation canal and dam and *capital costs* of renewal and new investment of the infrastructure[7]. The full economic costs however cover *the opportunity (resource) costs* and *the economic cost of externalities* in addition to the full supply costs and would entail efficiency and internalization of ecosystem values and hence more accountable for wider social welfare whereas it is the full supply cost for which financial recovery of infrastructure investment is usually concerned. The opportunity cost pricing implies resource will be allocated to the use which produces a higher value[8]. For instance water market is a mechanism in which opportunity cost may determine allocation efficiency among competing demands in a society between different sectoral uses between industries, hydroelectric generation and potentially recreation and environmental needs. In reality the financial implications for realizing full economic cost pricing may be so enormous that implementation costs associated with data collection, weather forecasting, afforestation, land use regulation, ecosystem

[7] Ibid. OECD, 2010:36

[8] Ibid. OECD, 2010:36

management and pollution control in addition to physical infrastructure is suggested to cripple budgetary capacity of local governments in arranging the market mechanism[9]. Nevertheless, the underlying logic is optimal pricing may serve to demand side management policy goal of ensuring viable and sustainable irrigation water governance. Optimal pricing delivers a signal to users informing of scarcity value of water and supply cost and incentivise conservation of water and ecosystems in addition to cost recovery of infrastructure investment for efficient and long term operation[10].

Water for irrigated farming consists of the largest consumptive use and a shift to optimal pricing linking to volume used rather than non-volumetric methods, notably area water is applied, has been advocated as the most crucial but difficult option in the demand management strategy. This volumetric pricing which is equal to the marginal cost of supplying water (i.e. the cost of supplying one more unit of water) is said to be the most efficient as it reflects scarcity value in a source (e.g. river), infrastructural (capital and running) and administrative costs and in theory generates the highest return for the amount of water used[11] because this incentivise water users to make efficient decisions whether to increase their water use through cost benefit analysis[12]. In contrast, area based charging is the most common method for irrigation in which users are

[9] Winpenny, J and Camdessus, M, 2003:5

[10] EUWI-FWG, 2011:14

[11] Webber, M et al., 2008: 619

[12] PRI Synthesis Report, 2005 :16

charged per irrigated area and easy in implementation and administration[13]but it is regarded as “fixed” cost and efficiency is low because of its weaker influence on the cost benefit analysis of balancing input and output[14] and is hence less effective to water conservation. There are number of ways to analyse efficiency and usefulness of volumetric pricing methods. The first best efficiency is attainable only with a condition of no “distortionary” constraints notably information asymmetry, institutional arrangement or political intervention[15]. As mentioned, implementation costs tend to be larger in economic cost pricing, and volumetric method requires sophisticated institution i.e. installation of water meters to monitor use and administration to read and conduct maintenance of the meter, and collect fees[16], and consequently there may be a situation where difference in implementation cost between volumetric and non volumetric methods outweigh difference in efficiency, non volumetric methods could make more economic sense to use[17]. Yacov Tsur (2000) found out implementation costs as a percentage of water proceeds is in inverse proportion to water price, and he identified when implementation cost is zero water price is US$ 11.5 and both water proceeds and social benefit (per acre) are among the highest US$355.10 and US$409.03

[13] Johansson, R.C., 2000: 5

[14] Tsur, Y, 2000: 106

[15] Ibid. Johansson, R.C.,2000: 7

[16] Ibid. Johansson, R.C., 2000:4

[17] Ibid. Tsur, Y, 2000: 106

respectively and farmer's profit per acre is the lowest at US$408.71[18] (see Table 1). However as implementation cost increases, the price decreases and at 10 percent threshold, water price is reduced to zero as the cost of conducting pricing scheme is so high that render water pricing unreasonable and result in lowest social benefit and highest farmer's profit and the effect produced is still the same as adopting per acre

Effects of Transaction Costs

Example	Pricing method	Water price	Water proceeds (US$/acre)	Farmer's profit (US$/acre)	Cost of water (US$/acre-inch)	Social benefit (US$/acre)	Implementation costs as a percentage of water proceeds
1	Volumetric	11.521[a]	355.102	408.710	354.780	409.030	0.000
2	Volumetric	5.569[a]	180.271	596.750	372.590	395.410	0.050
3	Volumetric	2.069[a]	68.837	711.650	383.070	392.260	0.075
4	Volumetric	0.000[a]	0.000	781.050	389.260	391.790	0.100
5	Volumetric with balanced budget	11.510[a]	354.815	409.030	354.810	391.290	0.050
6	Per acre	0.000[b]	0.000	781.050	389.260	391.790	0.000
7	Per acre with balanced budget	389.261[b]	389.261	391.790	389.260	391.790	0.000

a. US$ per acre-inch.
b. US$ per acre.
Source: Tsur and Dinar (1997).

Table 1. Effects of Transaction Costs, Source: Tsur, Y (2000) pp 111

(area) pricing method (implying at higher than 10 percent threshold, volumetric effects would become more skewed than fixed per area pricing)[19]. The condition strengthens a type of economic rent which makes private investment in wells for irrigation economically rational and efficient option for farmers. Operating and maintaining

[18] Ibid. Tsur, Y, 2000:110-112

[19] Ibid. Tsur, Y, 2000:111-112

irrigation wells and pumps are often the only direct consumption costs[20], and high cost of implementation associated with fast and widespread development in private wells makes volumetric pricing unreasonable.

A Canadian study based on Hanneman' s (1998) work further argues that there is theoretically no necessity in linking economic efficiency and cost recovery with volumetric pricing to cover the fixed cost component (construction of infrastructure and pipes). According to Hanneman, the average cost (capital and unit operating costs divided by quantity sold) and the marginal cost in water supply service are in equal relationship if costs of all units of water are the same[21]. Difference between the two costs, however, occurs in practice as the first instalment or a single water supply project will see the marginal cost fall faster than the average cost. The short term decline over the average cost occurs because while the average cost can be spread, the marginal cost corresponds with rising economies of scale with incremental production of unit of water[22]. Over the longer term, when deterioration necessitates an addition of newer and costlier capacity or additional projects, the marginal cost increase is much more rapid than the average cost[23] and will then become lower again as scale economies gain become sufficiently large. Hence pricing based on marginal cost alone "*can*

[20] Wichelns, D, 2010:8

[21] Hanneman, 1998: 144

[22] Ibid. Hanemman, 1998:145-146

[23] Ibid. Hanemman, 1998:146-147

unintentionally lead to excessive profits or to deficits"[24] and not suitable as stable measure for efficiency and cost recovery as revenue fluctuation can be large. On the other hand, if dividing the tariff into two components; volumetric portion to cover operating cost and fixed part to pay the fixed cost, or using changes in block rates (increasing or decreasing of price rate by blocks of quantity of water used)[25], stability in cost recovery can be achieved while allocation efficiency is accounted for with volumetric price rates.

There are also opinions that marginal cost pricing does not provide a useful concept. Molle and Berkoff (2007) argues that irrigation water is not designed to expand in the same manner as municipal water so as to allow economic pricing to be charged for an incremental capacity because irrigation water is treated as an intermediate good[26]. They say most surface canal water supply system is built to meet peak water requirements for a designated cropping arrangement because of stochastic nature of water availability and expanding the capacity simply because they had some good years cannot be justified as it would result in unit costs increase and permanent excessive capacity[27].

Pricing reflecting opportunity cost has its own limitations too, such that metrics to correctly evaluate values do not appear to exist. It is because opportunity value is

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[24] bid. PRI Synthesis Report, 2005: 17

[25] Ibid. PRI Synthesis Report, 2005: 17

[26] Ibid. Molle and Berkoff, 2007:31

[27] Ibid. Molle and Berkoff, 2007:28-29

variable by place, season, time and reliability of water supply and such information is difficult to collect[28]. Frederiksen (1997) in a World Bank report, while accepting this as potentially feasible concept in allocation mechanism at least in developed countries, notes the variation is so much that affects investment plans, strategy to nullify political influence, and application to other usage aforementioned[29]. Morell and Berkoff (2007) question the expected effectiveness of the opportunity cost pricing when applied for irrigation water. They argue demands between municipal and irrigation sector the competitive allocation is limited by period and locations and as a resultant opportunity cost declines significantly once the urban demand is saturated[30].

The opportunity cost in such a case would diminish to the level of a residual value of irrigation which accounts for a very little part of full domestic demand[31].

To summarize, the value of water is characterized with complexities. The value may be contextual and is subject to a great variation given a type of use, time of use, and physical and policy environment (i.e. physical water flow and level of subsidy) a use is made. A lack of clarity and accuracy in information and knowledge may prohibit

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[28] Ibid. FAO 2004:6

[29] Ibid. Frederiksen, H.D, 1997:572

[30] Ibid. Molle, F and Berkoff, J, 2007:32

[31] Ibid. FAO 2004:6

objective judgement and a proper and viable framework for optimal water pricing[32]. That complexity is greater in groundwater since monitoring is more difficult and particularly in an absence of systems of efficient allocation in India's groundwater resource rights regime which will later be discussed more in detail. Water therefore may have certain innate susceptibility to be driven and influenced by particular "interests" as FAO water report (2004) agrees that the issue is a political rather than economic and that "discretion" involved in the decision on what exact values to incorporate in a cost evaluation seems to be pointed out fundamental as a conceptual platform[33] for value, cost and pricing discussions.

3. Policy and Legal Setting for Water Efficiency

Having discussed water pricing as an economically difficult concept to apply practically, a water policy and legal setting now enters into a focus for the two main themes of pricing: allocation efficiency and cost recovery.

To answer the question, it helps to take a focus on institutions in particular as to whether there is an institutional framework in India where policy makers have a mindset for and are equipped to deal with complicated issues associated with water resource use. The conceptual groundwork for such holistic view and coordinated approach is already

[32] Dinar, A, 2000:6

[33] Ibid. FAO, 2004:6

laid in public policy forum notably with IWRM in which the notion calls for a process for coordinated management and development of water, land and associated resources for maximized economic and social benefit in sustainable manner[34]. Cullet (2009) argues although the ideals in its principles are agreeable to many actors involved in the water management, it falls short of presenting specific and practical measures[35]. IWRM instead tells a conceptual guideline for actors to align with what some sections of international community identify as vital for reforming the existing management framework of water sector plagued with inefficiency and narrow and short-sighted sectorial approaches. Among the most essential elements include coordination of (policies surrounding) the competing factors such as water, land and other resources. As Cullet (2009) observes examples include linkage with the reforms in power sector since dominant role groundwater plays make electricity "*a prime determinant of access to water*"[36]. Focus on water as economic good and eventual creation of water rights trading is implicitly reflected in an IWRM objective and as a reason for reforming water policy, legal framework and realignment of physical unit of management into river basins[37]. It is not, hence, surprising that the ideas such as water pricing and property rights are given greater emphasis to achieve and ensure efficiency of water resource

[34] Cullet, P, 2009:64

[35] Ibid. Cullet, P, 2009:64

[36] Ibid, P, 2009:65

[37] Ibid, P, 2009:67

allocation within the reformed water management framework[38]. This thesis aims to deal with background issues i.e. those theoretical claims currently advocated in the debate of water sector reform with a focus on economic dimensions in particular, water pricing and regrettably excludes analysis on specific operational aspects of IWRM such as ways to achieve effective coordination or participation to strengthen the effectiveness for "integrated" management.

In India, there is no legal framework which enables water management to be delivered in coherent and comprehensive manner. It is multilayered and fragmented by sector, by the states, by the balance of power and by the historical developmental needs. Except judicial and constitutional recognition of human rights to water[39], a guideline to balance supply side and demand side management towards sustainable use and to govern pricing and water entitlements does not exist as a single legal document. Instead, diversity is allowed as the state government's right of drafting water regulation is statutory protected by the Government of India Act, 1935 and the exclusive right is given to each state over regulation of water supplies, irrigation and canals, drainage and embankments, water storage, hydropower and fisheries with some restrictions on the use of trans-boundary rivers between the states[40]. On the other hand, the constitutional

[38] Ibid. P, 2009:66

[39] Cullet, P, 2007:3

[40] Ibid. Cullet, P 2007: 4

role of the union (national) government over water management is mainly as a mediator and facilitator of trans-boundary water disputes or developments concerning the rivers shared between the states. But consideration for social equity in water policy has been the traditional stance of the Indian government and when the British introduced commercial irrigation, works for social needs were carefully separated[41]. In 1972 the Irrigation Commission of the Indian government had put forward tariff rate review for irrigation water but priority consideration is given for user (farmer) welfare and food security[42]. The policy for public water service reform thus inevitably faces this dilemma between the competing needs of opposite purposes. There exists an interface between economic infrastructure such as electricity and transport and social infrastructure such as health and education and as a consequence, water falls in a policy "limbo" in which decision makers find themselves dichotomised to choose either to charge appropriately higher as economic infrastructure (and justify its claims for larger budget allocation as in road service and potential private investment) or to charge low as social infrastructure which draws money entirely from public finance[43]. With ambiguity of the value of water, political inclination bound to be for a safer option. Consideration is given for lower value agriculture produces relative to other sectors and implementation of optimal

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[41] Mohile, A.D.,2007:10

[42] Cullet, P, 2009:71

[43] Ibid. EUWI-FWG, 2011:2

(economically justifying higher) pricing may be circumvented. Irrigation infrastructure is the epitome of such dichotomy. In the latest National Water Policy 2002 Document (NWP 2002), the urgent need for achieving efficiency in water utilization in light of rising water stress due to population and economic growth is highlighted and the national requirement for enhancing utilization of existing water potential is also stated[44]. Relevance for optimal pricing is in section 4 where it is articulated necessity with improved institutional arrangement for (managing) O&M and financial sustainability in section 11 where "water charges for various uses should be fixed in such a way that they cover at least the O&M and a part of the capital costs"[45]. Mohile (2007) points out water pricing as having given administration cost function and efficiency function through market mechanism is not given a place in the NWP 2002[46]. Failure to specifically stating (introduction of) market mechanism for promoting water efficiency may be explained by several reasons pertaining to India. Accurate and timely information on certainty of resource availability, exclusion or internalization of externalities or no harm to utilization by third parties, and possibility of reallocation over time in response to changing conditions all requires arrangement by well designed institutions[47]. But India

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[44] Ibid. Mohile, A.D., 2007: 13

[45] Ibid. Mohile, A.D., 2007: 13

[46] Ibid, Mohile, A.D., 2007: 13

[47] Livingston, M.L., 1998: 19-20

lacks the institutions, legislation and regulatory framework for formal market transactions to work[48].

The existing institutional arrangement for allocation by surface irrigation in Punjab is Warabandi which is basically a 'queuing system" and not conductive to efficient allocation through formal market mechanism. The water rights are by historical doctrine on water access by the prior appropriation (first come first serve) and riparian (land) rights and because the legitimacy of these rights are grounded by virtue of discovery or possession and the most senior rights are vested in the owner of land who can put to beneficial use (e.g. by virtue of closeness to canal head)[49] which is determined by the design of unlined canal systems. Certainty of water availability is also hampered by a lack of supply reliability because of neglect on maintenance of these canal systems and loss of water (detail of Punjab canal water system and Warabandi will be discussed in later section). The most significant institutional constraint in Punjab or India for implementing policies on efficient water allocation is relationship between land and (ground) water. The appurtenance of water to land effectively put a prohibition on

[48] Mohanty, N and Gupta, S: 9

[49] Zilberman, D et al., 1997: 223

permanent water transfer unless land is accompanied in the sale[50] which limits ability of timely reallocation in response to changing needs.

Groundwater has been a realm of common law rights in India which are associated strongly with a land ownership of individual owners. This secures a certainty of private investment in groundwater well for extraction by existing land owing farmers. Even though there is a “principle of equitable allocation and no harm” to other riparian owners who share the same river stream[51], the said does not apply to groundwater. The common law rules are based on customs and precedence, and the question is how much integration of such prerequisite principles into current laws for surface and ground water use is possible and in what way and how much it is enforceable to change the practices.

One clue is the national groundwater law, the 2005 Model Bill on groundwater management and development. But the Model Bill does not seem to fulfil the role of helping implementation for optimal groundwater pricing policies. Firstly it is a newest update but based on previous suggestions made in 1970s and economic good aspects, demand management and cost recovery which have evolved since are not reflected[52]. Secondly only a registration to a groundwater authority is suffice for existing use which

[50] Ibid. Livingston, M.L., 1998: 21

[51] Ibid. Cullet, P 2007:4

[52] Ibid. Cullet, P 2009: 102

means the authority has no means of exercising its control on current over-exploitative use[53]. In spite of such drawbacks on effectiveness, Punjab state is inclined to manage the groundwater not with the Model Bill but with incentives for crop diversification, investment in artificial recharge, micro irrigation and metering electricity use on well motor in critically withdrawn areas. The assumed reason is political consideration and sensitivity to implicit and explicit impacts on farmers[54].

Even in the developed countries, the EU Common Agricultural Policy has only recently started in calling for the shift of priority from issues of rural poverty alleviation, food self sufficiency to pollution, sustainable development, and budgetary and economic efficiency issues with accompanying calls for a shift from lower to higher irrigation price[55].

There is also a sense that international principles concerning water as an economic good may still fall short of gaining national consensus. As discussed, human rights and historical social rights maintain visible presence in Indian statutory and customary laws and institution, but pricing for economic efficiency and infrastructural cost recovery is a prescription based on neo-liberal policies with wider agenda of reducing a state role in

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[53] Cullet, P, 2010: 3-4

[54] Ibid. Cullet, P, 2010: 4

[55] Ibid. Molle and Berkoff, 2007:23

management of irrigation at farm level and which aims at ultimate transfer of control to individual Water User Associations and traditional community groups such as Panchayat[56]. In India such self governance structure is increasing in the form of Participatory Irrigation Management (PIM) with a goal of improving efficiency and cost recovery driven by a sense of ownership[57]. Although achieving certain improvements in revenue recovery and availability of irrigation water to farmers, there seems to be a large variation between states in the degree of autonomy granted by irrigation or water department and capacities built and effectiveness which is often diminished by a lack of canal system rehabilitation and maintenance[58]. Madhav (2007) argues the reform may be driven more by the need of multilateral financial institutions to justify continued loans to irrigation projects and less concerned with ground realities and the assessed needs[59].

The prevailing picture today still seems to be continuing plurality of official and local and traditional rules in terms of water access and use for domestic and irrigation purposes throughout India and this makes centralised implementation difficult. Local

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[56] Madhav, R, 2007: 5-6

[57] Bassi, N: 2

[58] Ibid. Bassi, N: 19-20

[59] Ibid. Madhav, R, 2007: 7-8

rules are often institutionalised based on specific local historical use: i.e. governed by caste, unwritten and informal and displaced by new law formally enacted[60].

4. Water resource use and state of agriculture in Punjab:

The thesis now turns attention to water management conditions and systems in Punjab state which is located in the northwestern edge of India. Punjab may best illustrate the experience of agrarian led growth achieving a certain level of success and offer important lessons of the development dilemma between securing irrigation water and food and rural economic welfare that other water stressed emerging countries can face and of the need for appropriate water management for reliable irrigation supply. Also it shows the kind of economic development which may not be designed to accommodate a neo liberal economic prescription for an economy which is inflated by substantial financial support in inputs.

The Indus plains that provide the flat and fertile soil is a creation over the years of erosion of the Himalayas and siltation carried by the Indus River flooding which has a thick alluvium layer over the depth of 1,300 feet (396 metres) down to the rock bottom[61]. According to the information based on Central Ground Water Board in 2006, this thick alluvial floodplain deposits cover 97 percent of the state's whole area

[60] Ibid. Cullet, P 2007:pp5

[61] Gosal. G.S, 2004: 21

characterized with a considerable aquifer storage capacity and saline part which is only present at greater depth[62]. Having a better storage capacity means its resources may be better prepared for scarcity if managed properly. Given regional variation in rainfall and growing industrial capacity, it is in fact suggested the returns from supporting (growing) population centre and food needs of other neighbouring basin is inherently large, but intense, variable and concentrated nature of monsoonal rainfall which lasts only three or so months requires efficient use for such incremental future needs of water resources[63].

Punjab is characterized by substantial utilization of groundwater resources for agriculture. According to the Ministry of Water Resources data in 2003, Punjab state has 18.66 BCM/yr (billion cubic metres per year) as total replenishable groundwater resource and 16.79 BCM/yr as available groundwater resources for irrigation with a net draft of 16.40 BCM/yr which lead to 97.66% as a percentage of groundwater development[64]. During 2001-2002 groundwater accounted for 48.9 percent as a share of total ultimate potential for irrigation in the state[65]. It is estimated in India as a whole groundwater contributes to over 60% of irrigated agriculture and 85% of drinking water needs[66] which denotes that the resource dependency is of an extraordinary scale.

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[62] The World Bank, 2010:15

[63] Morris, S, 2007:262-263

[64] Ghandi, VP and Namboodiri, NV, 2009:7

[65] Ibid. Ghandi, VP and Namboodiri, NV, 2009:6

[66] Ibid. The World Bank, 2010:1

Groundwater development is associated with Punjab's large agricultural economy in which farmers make livelihood of growing rice and wheat, the two nationally important crops.

The Green Revolution since 1960s provided farmers with input subsidies on electricity and water as well as new seeds and fertilizers[67]and had propelled significant agrarian economic development in the state. Credit support was provided to help farmers

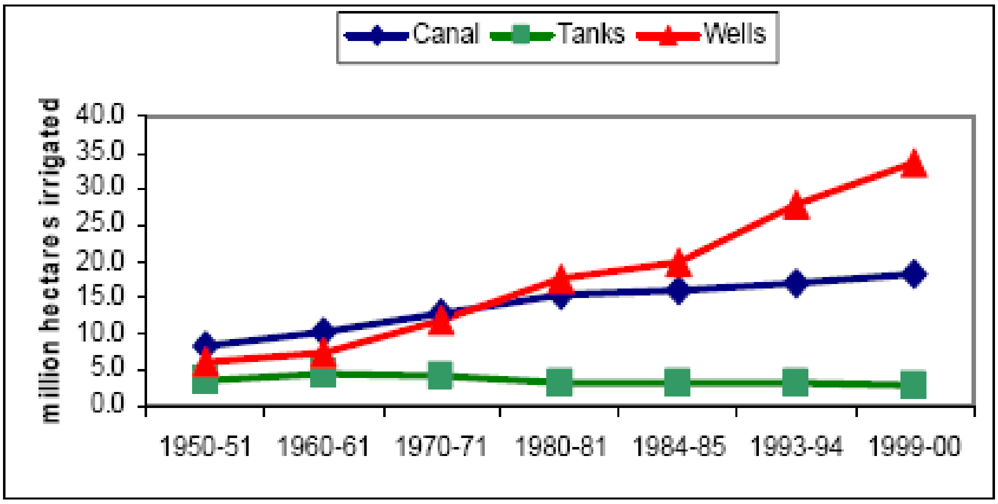

Figure 1. Evolution of canal, tank, and well irrigation in India 1950-2000

Source: Bhatia 2005, cited in Asia Development Bank 2009

purchase pump technologies and subsidized rural electricity prices to operate the well[68]. Easy availability of bank loans have assisted farmers construction of deeper wells with

[67] Ibid. the World Bank, 2010 :1-2

[68] Ibid. the World Bank, 2010 :2

sophisticated pumps first with dug-cum-bore wells that reached 50 to 100 feet deep with centrifugal pumps and later in mid 80s the investments were made in submersible pumps with the well depth increased to 400 feet in large areas[69]. Figure 1 shows timescale of development of agricultural water source which explains rapid expansion of tube well overtaking surface canal as a main contributor to irrigated areas in India, which grew by 84% since 1960s[70]. Until around 1981, the agrarian boom contributed to a significant decline in the number of small and marginal farmers who had responded to the economic opportunities for which rising yield, employment, lease or sale of land, and diversifying into non-farming jobs provided[71]. Currently, 20 percent of wheat and 9 percent of rice is produced in the state for the nation's food stock and the agriculture supports rural livelihood for 66 percent of the total 27.5 million people with per capita income of Rs35, 700[72]. Punjab's switch of production to rice and wheat from traditional rain-water crop (maize) is also induced by a food grain procurement programme in which the national government promises to guarantee a minimum support price (MSP) for rice and wheat above world and local prices[73]. The policy is designed to satisfy food

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[69] Ibid. Ghandi, VP and Namboodiri, NV, 2009:11

[70] Ibid. the World Bank, 2010:2

[71] Sidhu, H.S, 2005:199

[72] Sidhu, R.S. and Vatta, K, 2009 PPT

[73] Narula and Lall, 2010:88

stock requirement for public distribution[74]. In 1970 and 71 the MSP for rice and wheat per 100 kilogram was at Rs 51 and Rs 76 respectively and increased in 2008 and 2009 to the level of Rs 1,050 and 1,000[75].

As a result of guaranteed purchase scheme and the input subsidies, cropped area under irrigation in Punjab today is 97 percent and 74 percent of which is from groundwater source and 80 percent of which grows rice and wheat[76]. Cropping intensity and productivity of rice and wheat are very high, between 2003 and 2004 it had 188.2 percent, 3,694kg/ha, and 4,207 kg/ha respectively[77]. Paddy rice however is the principal source of water consumption whose typical irrigation water requirement is 180cm and between 1998 and 2005 in central Punjab district, groundwater table had fallen by 76cm with corresponding increase in area under rice paddy from 1,733,000 to 2,000,000 hectare[78]. According to State Department of Soil and Water Conservation, 14.5 lakh hectare meters (one lakh =100,000) of water come from surface canal and 16.6 lakh hectare meters come from ground recharge for 43.7 lakh hectare meters of the state's agricultural water requirement and the remaining 12.4 lakh hectare meters has to be

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[74] Ibid. Sidhu, R.S. and Vatta, K, 2009, PPT

[75] Ibid. Sidhu, R.S. and Vatta, K, 2009, PPT

[76] Ibid. Sidhu, R.S. and Vatta, K 2009 Ppt

[77] Sidhu, R.S, 2006 PPT

[78] Ibid Sidhu, R.S and Vatta, K 2009 PPT

sourced through (overexploitation of) groundwater[79]. This is largely related to flood irrigation of paddy field which has been a main irrigation technique but also widespread use of high yielding varieties (HYVs) of rice crops.

According to national assessment in 2004 by the Central Ground Water Board, 75 percent of groundwater blocks in Punjab state are already overdrawn[80] (see Figure 2). The depth of water tables: 6.79metre in Ludhiana, 5.86m in central belt area, and 6.85m in all Punjab average had dropped in 2001 to currently 10.01m, 11.44m, and 9.93m respectively[81]. Of particular importance is the fact that the majority of tube well is shallow and owned and operated by private farmers. Apart from some use for drinking and industrial purpose, there are around a million shallow tube wells as compared to 3,162 deep tube wells and primarily having been served irrigation for area by 2.8m ha and 1.6m ha respectively[82]. Groundwater contributes to better yields and purchases are made by non-well owners because of the merit. For instance the data shows rice's average yield by canal only is 522kg per acre, but 709kg/acre by public tube well, 784kg/acre by purchased water from tube well and 859kg/acre by own tube well[83]

[79] Sharma, D, 2011

[80] Ibid. the World Bank, 2010:3

[81] Ibid. Sidhu, R.S, 2006 PPT

[82] Punjab Dept of Soil & Water Conservation, website

[83] Ibid. Ghandi, VP and Namboodiri, NV, 2009:13

In South Asia (India, Pakistan, Bangladesh and Nepal) as a whole, some estimate puts the electricity consumed for agricultural pumping is around 69.6billion kWh per year with implying total cost Rs 174 billion ($3.8 billion)[84]. It further estimates irrigation water generated has a market value around Rs 450-550 billion ($9.8 to $12 billion) and contribution to agricultural output at roughly Rs 1,350 to 1,650 billion ($29.3 to $35.9 billion)[85].

In India alone, it is estimated that 70 to 80% of the value of output from irrigation is derived from pump source[86]. Shah et al argue that this economic structure and scale of farmer income and livelihood dependence makes unfit to take any hard-line policy intervention in immediacy[87]. But subsidy to rural electricity for the tube wells constitutes a significant portion of financial loss to State Electricity Board (SEB). The 2002 Planning Commission figure suggests national gross subsidy made to agricultural consumers was Rs 281 billion in 2001-2 which is estimated to have risen almost 80 percent from Rs 156 billion in 1996-7 and during 1999-2000 SEBs have realized a mere 3.2 percent in the total revenue of the sales made to agriculture sector which consists of one third of SEBs overall customers[88]. The agricultural subsidy was responsible to the

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[84] Shah, T, et al. 2007:211

[85] Ibid. Shah, T, et al. 2007:211

[86] Ibid. Shah, T, et al. 2007:211

[87] Ibid. Shah, T, et al. 2007:211

[88] Ibid. Bhatia, R, 2007: 222-223

state revenue deficit of Punjab by two- thirds in 2000-1[89]. As a consequence currently in Punjab electricity for farmers is provided free of charge[90] and itself provides no incentive for users to conserve water and a large number of scattered private wells

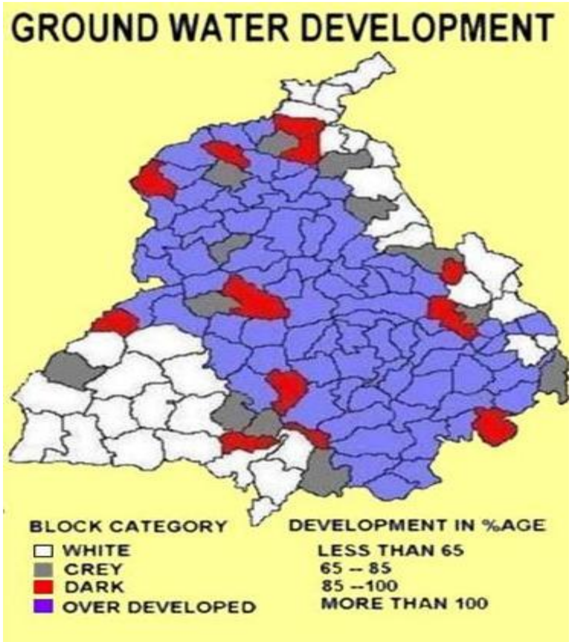

Figure 2. Area and intensity of groundwater development and use in Punjab

Source: Department of Soil & Water Conservation, Punjab State Government, as of 1998

makes it undesirable to meter the power use and volumetric pricing a difficult policy option[91]. There are also socio-economic constraints for implementing optimal pricing.

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[89] Ibid. Bhatia, R, 2007: 225-226

[90] Ibid. Bhatia, R, 2007: 222

[91] Shiferaw, B et al., 2008: 329

According to Sidhu (2005) productivity of shallow tube well yield has become lower and average cost of deepening of a well for marginal productivity has almost doubled from Rs.4,219 per deepened tube well in 1990 to Rs. 8,184 in 1999 which cumulatively have been costing Punjabi well users Rs. 200 crore (one crore = ten million) every year[92]. Singh further notes economic difficulty of small and marginal farmers which consist of 62 per cent of the total farm households (1,143,500 households) in the state and 56.25 per cent of which are indebted[93]with average amount of Rs.47,516[94]. Bhatia (2007) points out devastating impacts if electricity subsidies were slashed completely on marginal farmer income in neighbouring Haryana state in which tariff is "charged at flat rate" and can illustrate the similar impact on Punjabi farmers. He estimates that an average tariff increase would be 213 per cent as a result of rationalization which would push the electricity cost alone to Rs 12,365/ha as compared to total irrigation cost Rs 11,230/ha with subsidized electricity and would result in negative net farm income at Rs 2,935/ha which is a decrease by around 153 per cent from net farm income at Rs 5,480[95]. This would make a policy intervention which involves removal of electricity subsidies difficult politically and in practical sense.

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[92] Ibid. Sidhu, RS, 2005:206-7

[93] Singh, L, 2008:11

[94] Singh, L, 2008:12

[95] Ibid. Bhatia, R, 2007:235

There is also a limited prospect for increase in farmer's income through national food distribution system which has guaranteed purchase at MSP. The 1955 Essential Commodity Act (ECA) authorizes a compulsory levy on rice millers by the Food Corporation of India (FCI) in which 75 percent of Punjab's milled rice is commanded to be sold to the state agency at a predetermined price that is often lower than the market price[96]. The ability of farmers for marketing freely of their rice produce is further restricted by the ECA provision to limit farmer sales to wholesale market yards and until the levy commitments are fulfilled[97]. This is played out in a general trend in which crop productivity has been stagnant and climatic change factor which projects impacts on reduced average annual rainfall and noticeable variation in both maximum and minimum temperature and humidity levels during the crucial term of growth of the crops[98]. The deterioration of farmer economic welfare may have an important implication that further exacerbation of groundwater mining would spontaneously come to a certain degree of stabilization and economic optimization through electricity subsidy rationalization may render harder socio-economic damage to individual farmers and possibly beyond. There is also a prospect that Punjab may have reached a saturation point in cultivated area and net irrigated area which limits prospect of significant

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[96] Gulati, A and Dutta, M, 2010: 281-282

[97] Ibid. Gulati, A and Dutta, M, 2010: 281-282

[98] Ibid. Sidhu, R.S. and Vatta, K, 2009, PPT

irrigation expansion[99]. These specific factors may stop the new developments of groundwater but still fall short of ensuring conservation and long term sustainability of existing use and especially to adapt to predicted negative impacts of climate variability on water resources in Punjab. So what other options are effective for achieving such objectives?

5. Restoring Reliability of Water Supply and Water Use

Punjab's gravity canal supply systems were investments by the then British East India Company in 19th century which completely transformed the region's pattern of agriculture from pastoral to intensively cultivated irrigation[100]. Official government schemes and projects have been directed at supply augmentation rather than demand management and have resulted in the systems failure due to poor operation and maintenance[101]. Yet the state assumes a role as a protector of rural interest and a provider of large public irrigation. The Northern India Canal and Drainage Act 1873 transferred planning, implementation and management responsibility of the irrigation water systems to the state bureaucracies from local communities and landlords who had exercised traditional control[102].

[99] Ibid. the World Bank, 2010: 37

[100] Ibid. Shah, T, 2009:3

[101] Ministry of Rural Development, GOI, Swajaldhara Guidlines 2003: 2

[102] Ibid. Shah, T, 2009:3

Contrary to the promise, a lack of reliability of public irrigation services in Punjab may have persisted since and argued as a root cause of extensive groundwater development. Restoration of the reliability constitutes a logical answer to more sustainable conjunctive use and management of surface and subsurface water. However India as a whole has achieved only half the target of surface irrigation development projects as specified in the Ninth Five Year Plan (1997-2002) and still around 30 percent of an estimated national irrigation potential total (140 million hectares) is said to be under-exploited[103]. In the latest Tenth Plan (2002-2007), the outlay had jumped to Rs71,213 crore (one crore equals ten-million) from the previous Rs 42,968 crore[104]. This is not easy given India has an overall fiscal stress of central and state budget with a deficit and rising public debt[105]. Though public investment for irrigation infrastructure (new construction and rehabilitation of the existing) had risen by US$ 20billion from 1990 to 2007, the data available suggests a fall by more than 3 million hectare of the net area supplied by all sizes of irrigation infrastructure[106]. This raises a question of efficiency in public irrigation water supply investments. To understand the reason and explain why farmers turn their back to public scheme may need to look at the institutional problems of state irrigation department.

[103] von Braun et al., 2005:4

[104] Government of India, 15th May, 2010

[105] Herd, R and Leibfritz, W, 2008: 5

[106] Ibid. Shah, T, 2009:5

Neglecting the need and a lack of capacity for proper infrastructure management relates to low value attached to irrigation water. Jairath J (1985) points out this link as the conditions of Punjabi farmers' access to water and operational efficiency in terms of quantity, certainty and control of water supply ruled by a certain allotted time, which is hindered by underinvestment and exacerbated by the mode of utilization[107]. The surface water supply from multipurpose storage dams constructed on major Indus river tributaries such as Bhakhra on Sutlej and Pong on Beas was often fluctuated due to canal closure for maintenance of breaches and cuts and shortage resulting from drought and diversion to other sectoral needs notably hydroelectricity and flood control[108]. In addition to supply unreliability closer at the river source, distribution mode based on time allotment, called 'warabandi', rather than volumetric allocation, and unlined channels (named as 'kutcha') all subjects to lower allocation efficiency particularly for the tail land holders. Warabandi, the system prevalent in Punjab in India and Pakistan, of an irrigation schedule allotted to equal groups of members for every 8 days does not necessarily guarantee certainty and control as the rotation gets passed around each group and the time for the second round of irrigation water allotment is after 8 multiplied by number of groups[109]. The time given for each turn is further influenced by

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[107] Jairath, J, 1985:A-2

[108] Ibid. Jairath, J, 1985:A-3

[109] Ibid. Jaraith, J, 1985:A-5

the size of land and the distance from the head. The time calculated by the available water time per week per acre multiplied by land size is granted with an allowance for extra time needed for water reaching to each plot (known as 'bharai') and the tail water flow is granted to the last beneficiary (known as 'nikal')[110]. The discharge (flow per unit of time) and capacity potential is undermined by fluctuation at the source, and then farther down the watercourse, with evaporation, leakage, seepage and even breaches[111]. Punjab's unlined-gravity canal structure degrades water efficiency more quickly as it is prone to weeds and silt and reduces velocity and discharge crucial for time based allocation[112]. The losses in water efficiency and capacity potential could be mitigated if proper maintenance was provided by the Irrigation Department. However, often the justification to provide adequate expenditure in maintenance of the conveyance system has not been strong due to the low economic value of water in agriculture[113]. It disregards the importance of prioritizing irrigation service and consequently, expenditure is made only at no-plan and ad-hoc basis which results in persistent shortage of capacity for proper construction and maintenance of the system[114]. Consumed by departmental costs, budgetary dispensation for the maintenance fund

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[110] Ibid. Jaraith, J, 1985:A-5

[111] Ibid. Jairath, J, 1985:A-5

[112] Ibid. Jairath, J, 1985:A-6

[113] Zilberman, D et al., 1997:231

[114] Ibid. Jairath, 1985:A-6

could only cover Rs5.00 per hectare out of Rs 50.00 per hectare as per recommended[115]. This is a serious problem because economic incentive of individual farmers to invest in maintenance and betterment of irrigation systems tends to be low due to the system's public good nature which necessitates collective management[116]. Distribution beyond the government mandated control point is however, delegated to individual plot holders who are left to self-manage arrangements such as the turn of their water allotment time sequence, field channel layout and maintenance[117].

Unreliability in irrigation system has secondary negative economic impacts because this forces farmers, as in Maharashtra, to choose low value and drought tolerant crops such as coarse grains and millet[118]. The prospect of individual allocation efficiency is further reduced by the location of 'nakkas', the fixed water feeding points for individual plot, at which allocated time for users is reduced proportionately to the number of nakkas needing to be fed ahead of his[119].

The necessary coordination between the Punjab State Irrigation Department and individual irrigators to deliver irrigation water efficiently and equitably did not seem to

[115] Ibid. Jairath, 1985:A-6

[116] Ibid. Zilberman, D. et al., 1997:231

[117] Ibid. Jairath, 1985:A-6

[118] Ray, I, 2007:118-119

[119] Ibid. Jairath, 1985:A-7

have existed. The mistrust to the State Irrigation Department seemed to exist as long as its management problem derived from neglect and of corruption [120]. A collective management framework with laissez-faire approach is weak without any incentives. Irrigators simply leave from a collective responsibility of canal management as soon as one of member farmers possessed an alternative access to his tube well source[121]. In such an environment, pursuing policy for a recovery to financial health by optimal volumetric pricing on canal supply would put collective management system at more risk when better alternatives (incentives) exist. Reforming canal water pricing to economically optimal level seems unrealistic in Punjab's context. But there is evidence to suggest that farmers might have a certain willingness to pay for a better service. Peter Rogers et al (1997) argue potentially very high willingness to pay for timely and reliable irrigation water supplies citing Haryana farmers, who are charged below US$ 10/ha/yr for canal water supplies, spend nearly US$90/ha/yr in irrigation costs which accounts for roughly 20 percent of the net value of additional output capacity per hectare (twice as much from canal irrigation) from groundwater[122]. Similarly Upmanu Lall (2009) finds in his study in Punjab villages that wasteful water extraction is primarily due to "not-on-demand" unreliable electricity supply which forces farmers

[120] Ibid. Jairath, 1985:A-7

[121] Ibid. Jairath, 1985:A-6

[122] Rogers, P, 1997

with no choice but to operate constantly by leaving the pumps on and over irrigate[123]. Many Punjabi farmers explicitly state their willingness to pay for metered use if the electricity supply is dependable[124]. From the argument, what may be clear is that farmers are as rational actors once risks and uncertainty are addressed. The inefficiency may not necessarily entirely be attributable to many Punjabi or Indian farmers neglect or idleness.

Implementing fully an optimal volumetric pricing for efficient use seems questionable in other countries. A study in one French regional agricultural sector has shown irrigation pricing based purely on marginal cost first best efficiency principle had to be dented in favour of less painful "conjunctive method of pricing and quota. In Charente river basin, water price is structured for farmers to choose either a fixed rate based on irrigated acreage (€81) or the subscribed flow (€38) with a variable rate proportional to the water volume (either rate at €0.06/m^3), and maintains homogeneous average price which is determined with consideration for cropping patterns, market conditions, and willingness to pay which is compared to infrastructure's financial costs (total and average per hectare) and the rate for subsidy for the investment[125]. The study findings

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[123] Lall, U, 2009

[124] Ibid. Lall, U, 2009

[125] Rieu, T, 2005: 6-7

invoke a careful consideration when designing a water pricing structure. There is a general tendency of low price elasticity for water to farmers when the price is a small portion in their total production costs or incomes and is different at elasticity at each level which is influenced by different constraints[126]. Although the increase did lower the water use, the blanket application of volumetric-based-only price increase would simply damage farmers and invited their strong opposition[127]. Berbel et al (2007) points in south Italy where water price increase would come to a point of demand inelasticity as only the high value vegetables and fruits are left to pay the higher water price and if other water saving techniques has already been available, water demand come down to zero above the threshold of water demand inelasticity because farmers are better off not using the water[128]. It is in agreement with findings by Jalota et al (2007) whose biophysical-economic model simulation demonstrated a pattern of price elasticity to water demand up to a certain threshold and change in behavior of Punjabi farmers in favour of choosing crops more economically lucrative at the expense of growing traditional water intensive crops such as rice in certain conditions. But above the threshold, water demand becomes inelastic due to more important considerations. Data used for simulation were based on extension services practiced in the Punjab

[126] Ibid. Rieu, T, 2005: 8

[127] Ibid. Rieu, T, 2005: 8

[128] Barbel, J et al., 2007 : 308

Agricultural University, and incorporate inputs such as rainfall patterns and the area's soil type to allow for optimal timing for irrigation application and thereby enable to calculate efficient frontier for irrigation water [129]. Without irrigation pricing considerations, the simulation results suggested rice, the main summer season (kharif) crop had the lowest yield response to irrigated water which only increased at a rate of 8kg per hectare while other summer crop maize expanded yield per mm of irrigated water by 32kg per hectare and winter (rabi) crop wheat by 34 kg per hectare[130]. This supports stagnant crop productivity Punjab is experiencing. Jalota et al (2007) found response to irrigation water pricing increases could lead to diversification into soybean in summer (kharif) and wheat in winter (rabi) seasons as the most economically efficient choice giving higher returns to the irrigation cost (see Table 2). Beyond \$10 mL^{-1} both risk neutral and risk-averse farmers stop growing rice and shift to cotton and/or soybeans with significant decrease in the quantity of irrigation water applied on the paddy (Q_{IW}). Risk of income variation is the biggest factor of influencing cropping pattern choice. Inclusion of cotton for risk averse farmers at higher water price signifies that while a shift to soybean monoculture has higher income variance than cotton, they prefer lower income variance (i.e. prefer income stability) to higher income[131]. The

[129] Jalota, S.K et al., 2007:1075-77

[130] Ibid. Jalota, S.K et al., 2007:1077

[131] Ibid. Jalota, S.K et al, 2007:1082

problem with this simulation is that they are not based on empirical data and for risk-averse farmers above a threshold price at US$15 to $20 mL^{-1}, water demand stays Strong in summer and more importantly, a high value alternative crop lacks guaranteed income stability unlike rice and wheat which has a support through government procurement policy[132]. Crop diversification away from rice and wheat is in fact contemplated as Punjab's state policy. According to Shergill (2005), Punjab's sense of "agrarian crisis" and the policy with which the state tries to address is not driven primarily by groundwater and related environmental problem, but rather by stagnation in farm income and farmers' fear "psychosis" of possible deterioration in the staple crop price for which implementation of the World Trade Organization free trade agenda in complete and inadvertent manner can cause[133].

Having discussed water from angles of economic demand management based on pricing and potential relevance to Punjab's particular situation, one would begin to see appropriate approach to (ground) water management in the state and it would involve two tracks – one with alternatives, using cost effective water saving techniques to volumetric pricing in arresting decline of water table for immediate effect and being able to avoid causing negative repercussions on farmers' economic welfare.

[132] Ibid. Jalota et al., 2007: 1082-1083

[133] Shergill, H.S., 2005: 240

Table 6. Economic model results for the response of a risk neutral producer to alternative irrigation water prices during the summer growing season (kharif).

Item	Irrigation water price, \$ ML^{-1}						
	$P_W = 0$	$P_W = 5$	$P_W = 10$	$P_W = 15$	$P_W = 20$	$P_W = 40$	$P_W = 60$
			Summer growing season				
Planted area†, ha				risk neutral			
Rice	3.0	3.0	3.0	0.0	0.0	0.0	0.0
Cotton	0.0	0.0	0.0	3.0	3.0	0.0	0.0
Maize	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Soybean	0.0	0.0	0.0	0.0	0.0	3.0	3.0
Profit§, \$	1046	884	654	554	516	432	410
Variance, \$ 10^3	376	406	576	1056	1338	1612	2460
Q_{IW}, mm	4170	3975	3682	990	923	134	93
Returns to irrig., \$ mm^{-1}	0.25	0.22	0.18	0.56	0.56	3.22	4.40
Planted area, ha				risk averse‡			
Rice	3.0	3.0	1.63	0.0	0.0	0.0	0.0
Cotton	0.0	0.0	1.17	1.41	1.42	1.02	0.68
Maize	0.0	0.0	0.0	0.36	0.0	0.0	0.0
Soybean	0.0	0.0	0.0	1.23	1.58	1.75	1.47
Profit, \$	1008	838	630	508	492	362	264
Variance, \$ 10^3	145	149	276	350	502	792	862
Q_{IW}, mm	4579	4427	2465	779	613	335	113
Returns to irrig., \$ mm^{-1}	0.22	0.19	0.26	0.65	0.80	1.08	2.34
			Winter growing season				
Planted area, ha				risk neutral			
Wheat	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Mustard	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chickpea	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Profit, \$	1332	1270	1212	1152	1092	866	652
Variance, \$ 10^3	2820	3040	3260	3480	3700	4620	5520
Q_{IW}, mm	1229	1213	1197	1181	1165	1101	1037
Returns to irrig., \$ mm^{-1}	1.08	1.05	1.01	0.98	0.94	0.79	0.63
Planted area, ha				risk averse			
Wheat	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Mustard	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chickpea	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Profit, \$	1132	1060	988	918	850	584	338
Variance, \$ 10^3	146	146	146	146	147	148	150
Q_{IW}, mm	1192	957	934	911	889	802	721
Returns to irrig., \$ mm^{-1}	0.95	1.11	1.06	1.01	0.96	0.73	0.47

† Authors' economic model (Eq. [2] through Eq. [7]).
‡ The risk aversion coefficient used in the E-V model was 0.000003, a modest degree of risk aversion.
§ Profit was calculated using returns above variable costs. No fixed costs were included in the calculations.

Table 2. Simulation of farmer response of alternative crops to water price increase

Source: Jalota SK et al (2007) pp 1081

The other would be a long term strategy to progressively reform public water supply system for improved reliability in canal irrigation and electricity for groundwater as a buffer resource and gradual introduction of two-tier pricing structure similar to the French example primarily to restore financial health of the public water sector.

6. Reform at Dual Track - Cost Effective Technology and Electricity Subsidy

Punjab's fortune as well as misfortune is that the region has one of the most fertile soils in the world[134] and the central government and rice farmers do not want to lose the advantage they have to deal with impending food demand increase. The promise of potential better income with implementation of economic pricing policy to induce production of higher value vegetables and fruits sound unconvincing due to various uncertainties. It is thus likely that the state retains rice and wheat as main crops for foreseeable future. Theoretically, the state of Punjab can reduce water use without recourse to volumetric pricing and has already elaborated measures using agricultural techniques which are potentially able to save water at least individual (not cumulative) scale which can come close to level rice's water consumption. For instance, the state government order in 2008 to prohibit early transplanting of paddy which has been the practice and necessitated flood irrigation is estimated to have water saving effect by 210 mm because by delaying the transplant from mid-May to mid-June, the peak water need for paddy can be arranged with the arrival of monsoon rains[135]. In addition to water saved the new practice also has two beneficial factors. It does not raise qualms among farmers about the shift since yields have not been negatively affected and it results in saving electricity as data reports the savings of 1,950 million kWh of energy which

[134] Columbia Water Centre

[135] Ibid. the World Bank, 2010: 37

could otherwise cost Rs 585 crore[136]. It is also cost effective. Against the net saving the method can generate, infrastructure rehabilitation could cost roughly US$0.02 per cubic metres and on farm canal lining at the cost of US$0.06 per cubic metres with smaller effect on water availability increase[137]. The system of rice intensification (SRI) is estimated to reduce the water need by 370 mm[138] and still conductive to higher productive tillers and more leaves[139]. The World Bank report suggests implementing all major water saving methods with laser leveling (410 mm), timed irrigation with tensiometer (370mm) and short duration rice varieties (300mm), plus delayed transplanting and SRI can save 1,660 mm which makes up almost 90 percent of baseline water requirement for growing rice (1,840mm)[140].

As discussed earlier groundwater development is a consequence of both unreliable canal supplies as well as subsidized agricultural input policies. Current electricity subsidy scale is likely to pass down costs with consequences of persistent deficit at SEBs balance sheet. This would undermine seriously energy utility's capacity to deal with a rising future demand not just from farmers but from other sectors. Singh and

[136] Kumar, B, 2007

[137] The 2030 Water Resource Group, 2009: 12

[138] Ibid. the World Bank, 2010: 37

[139] Singh, A, 2008: 7

[140] Ibid. the World Bank, 2010: 37

Kumar (2010) argue between 1995 and 2100, India, with current growth scenarios, would need to increase total electricity generation capacity from 96 GW to 912 GW[141].

The objectives of tariff reform at electricity must be to disconnect the vicious circle of inefficient water and electricity use and poor level of electricity supply management. Sebastian Morris (2007) argues that subsidies reform would have to entail change to direct and incentive compatible that generates multiple benefits in order to garner necessary political support[142]. The political support is essential because the realignment has objectives to address ineffectiveness of current subsidy allocation which creates waste and possible corruption. Morris points out almost two-thirds of total fiscal cost spent for subsidization may be in excess of the value of transfer actually delivered to intended groups and about the third of the cost may be paid for illegitimate transfers (leakages etc) and the rest for avoidable losses and the various social costs may reduce the actual value of subsidy transfers to the intended beneficiary to a small part of the total social cost[143]. Reform design to improve efficiency of subsidies rather than removal or reduction eventually serves for two goals of saving of costs and of strengthening the SEBs finance to improve the supply reliability. For instance direct subsidies can be in a form of issuing stamps which do not distort the market price (in

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[141] Singh, R.D and Kumar, C.P 2010: 5

[142] Ibid. Morris, S, 2007: 247

[143] Ibid. Morris, S 2007: 247-248

the event of eventual introduction of two part pricing structure, quota and volumetric, for electricity or water which allows transaction in the market) and prevent parallel distribution system from developing [144]. Subsidies which are direct and incentive compatible can be provided for seeds which consumes less water and high value crops and also for technologies such as aforementioned and drip irrigation. The cumulative cost saving effect on farm level of electricity upon full implementation of such measures could be enormous as some individual cases aforementioned have exemplified. This would in a long run relaxes budgetary stress through savings and incentive gains and by retaining transfer benefit to honest and hard-working farmers and marginalizes those group who has illegitimately benefited from leakages and diversion of electricity and may lower political hurdle for continuing a deeper structural reform including progressive shift to a French style two tier pricing[145].

7. Conclusion: What scenario for stronger Punjab water resource management?

Decisions on water management are made within specific socio-political and technical context and constrained by the factors such as capacity of infrastructure, physical availability of surface water and resource impacts of supply system development and limited further by different administrative regulations and court decreed rights and these

[144] Ibid. Morris, S 2007: 248

[145] Ibid. Morris, S 2007: 247-248

are not always amenable to economically optimal outcomes[146]. Financial restrictions can exacerbate the political setting[147].

Technically economic efficiency in water use and effectiveness in water conservation may be counteracted by necessary institutional i.e. legal and administrative arrangements to implement mechanisms such as trading via market and for monitoring volumetric usage. Findings and discussions on the issue appear to imply volumetric marginal cost based pricing for irrigation work effectively only in a condition – on individual farm level – that when price elasticity for water demand is high. For many Punjabi farmers it may turn out to be too high to bear for their economic survival. It also appears that for India the cost of price rationalization may be unacceptable for the reason of food and social security. Therefore the system of larger scale, equitable and economically optimal pricing and market for irrigation water requires long term approach for Punjab or India.

A more likely scenario for possibly short or medium term is to aim for "soft landing" of current practice causing excessive stress of groundwater in the state. The thesis attempted to show the potential effectiveness of realistic approaches using cost efficient and water saving techniques or technology with which author believes of having a good

[146] Ibid. National Research Council, US, 1997: 26

[147] Ibid. National Research Council, US, 1997: 26

prospect given positive results in pilot cases. The author also believes viability of the discussion for attempting the institutional reform first on restoring an efficiency of current electricity subsidy to recover reliability of supply while securing political support from farmers for eventual recovery to sustainable and profitable basis of the operation of the utility. Direct subsidy makes conditions where it may encourage farmers to invest for at least diversification into less water consuming crops and irrigation technology. Given strategic importance of rice and wheat and prospect of agricultural trade liberalization, the government should at least prepare for developing an enabling environment and a safety net to absorb the shock over which farmers have no control. Saving of water and the cost of supporting this input provision should also be encouraged to help finance this objective.

This would further lead to eventual water management framework in the scale of river basin for the region. This is because the cost-benefit analysis would increasingly demand considerations for service of upstream ecosystems and externalities involving diverse sectorial needs. The sheer scale benefit this entails could also open economic possibilities for formal basin water trading and public (or potentially private) investments in water infrastructure for new capacity or maintenance purposes. However to justify the administrative costs e.g. formal registration of water rights, surface and groundwater physical monitoring to supervision and mediation of ensuring equitable allocation[148], proper economic valuation for benefits and costs of basin water systems has to be made, and a revision of existing irrigation water pricing would in this end remain relevant. A major problem in pushing this agenda is how to mobilize political will to work on internalization of such neglected values and costs for designing practically and politically implementable water (electricity) pricing at individual farm level to pay as "sustainability cost".

Analysis on Punjab's water management is thus essential due to an unusually important role groundwater plays. How to treat groundwater's benefits and costs has several important implications. Groundwater's main value lies as a supplementary source for diminished availability in times of droughts as natural storage[149]. According to Tsur and Graham-Tomasi (1991), total value of groundwater is derived from its contribution as an increased overall water supply and on-demand usage which can reduce fluctuation in surface water source and hence has a positive buffer value in irrigation system[150]. As discussed with supply constraints of unlined canal irrigation, Punjab's groundwater buffer value would remain high for tail-end land holders who

[148] Thobani, M, 1998: 43

[149] Luis Santos Pereira et al., 2009 :133

[150] Tsur and Graham-Tomasi, 1991:201

lose out at the end of supply queue and would remain important if the system aims to follow conjunctive water supply.

Groundwater also represents greater resource value - its reliability contributes to higher yield and income and stabilizes demand for more associated inputs and labour[151]. Many in groundwater economics discussions seem to suggest that best efficiency is attained when the rate of extraction maximizes net benefits (total benefits net of total costs) over time and the costs included are of extraction and delivery which increases with depth of water table and of opportunity (or user) cost of future users[152]. The current extraction is only efficient if higher costs of future are properly estimated[153]. But the thesis's analysis showed this is not the case in Punjab's current context and even cost benefit analysis for efficient use is hampered due to difficulties in monitoring. Institutional arrangements foreseeing the user cost increases uncertainties surrounding transaction costs.

This thesis has discussed opportunity and marginal costs are variable components subject to changes in usage and availability. If conserving groundwater is increasingly attainable goal in Punjab using several low cost water saving techniques, the implied assumption is a growth in marginal benefit derived from savings in (ground) water and

[151] Ibid. Ghandi, VP and Namboodiri, NV, 2009: 25

[152] Ibid. National Research Council, US, 1997: 37

[153] Ibid. National Research Council, US, 1997: 37

electricity. One Columbia University study indicated prospective result from a pilot case in Punjab paddy fields in which conservation by up to 35 percent of water was attained using originally devised tensiometer costing just $6 to monitor precise timing for paddy water application and a number of test application is increased to 5,000 farmers[154]. One would have to include specific costs of these measures, empirical data on marginal benefit on such pilot farm plots and rule of balanced financial account of the electricity provider (affecting the rate of electricity price change considerations) to estimate whether this could lead to an overall efficiency gain. A marginal value of water determines farmer willingness to pay for water[155], but this is still too simplistic assumption in that other variables such as farm inputs uses (e.g. fertilizer), hours of irrigation, soil characteristics and other exogenous factors need to be considered. One integrated estimation model in a semi-arid Indian community suggests marginal value of rice Rs 4.5/ hour of irrigation and as compared to other crop types such as pulses (Rs 114/h) and flowers (Rs 98/h), rice still reflects significantly low water scarcity value[156].

The assumption that volumetric charge may prove more implementable once such balance offsetting effects are attained also calls for a challenge. Two-tier pricing method with block rates structure as briefly discussed may allow flexibility and equity because

[154] Polycarpou, L, 2010

[155] Ibid. Shiferaw, B et al.,2008: 333

[156] Ibid. Shiferaw, B et al.,2008: 334

farmers with greater agricultural output either try to avoid a use in excess of a certain block of volume otherwise they are penalized with increased price and are rewarded for a reduction if crop pattern change drops water use. Brill et al (1997) found out in empirical studies of Israeli farmers that block pricing did not necessarily prompt behaviour leading to water efficiency in at least one of three groups in which the assigned quota is based on historical rights and alternative option would simply diminish efficiency due to information cost associated with access to the details of each crop functions for production[157]. Though groundwater in Punjab is historical rights attached to land, decisions to diversify crop patterns could be related more with income security as discussed i.e. lower profit variance as a consequence of lower productivity and exogenous factor such as lack of assured markets[158]. Nevertheless, water user association could save transaction costs in districts of Punjab where homogeneity is strong which allow comprehensive metering. Alternatively the indigenous warabandi system has accessibility to information on the duration of irrigation and could allow possibility of charges based on hours as a proxy for volumes[159]. A profitability threshold in a semi-arid Indian community is estimated at Rs 0.5/h of charge based on irrigation hours for rice and indicates higher price can only be absorbable by promoting

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[157] Brill E, et al, 1997: 958-959

[158] Ibid. Jalota et al., 2007: 1073

[159] Ibid. Shiferaw, B et al., 2008 337

crop diversification[160] in this method. The brief analysis suggests price optimality is dependent on crop patterns and constraints may be greater in rice and measures such as market price support are necessary for diversifying into less water intensive crops in a place such as Punjab.

Then the role of quota and/or taxation may be to charge for the sustainability cost of groundwater ensures equitable collection also from non well owners. Potential economic damage especially for the poor could be mitigated with issuance of purpose direct subsidy such as a stamp (for pump electricity) as discussed. In the same reason, a possibility may exist on provision of "green payments" as an incentive to those farmers to lower the irrigation water and grow high value crops which help recover "social and environmental" costs[161]. A taxation to halt groundwater mining is an official policy contemplated for the Twelfth Five Year Plan of India's Planning Commission[162] and it could pay for the environmental purpose such as enhancing natural recharge zones and remedying aquifer contamination so it effectively works as a cross subsidization. A delayed realization in the benefit with possibilities of time span difference may coerce a

[160] Ibid. Shiferaw, B et al., 2008 337

[161] Ibid. Jalota et al., 2007: 1074

[162] OOSKA News, Apr. 20, 2011:11

contriving. However to verify, a separate analysis would be necessary for the level and design of appropriate groundwater tax.

Water price optimization is a right path in principle, with basin scale water trading market as ultimate goal and gradual and targeted volumetric pricing in which effectiveness may be sub-optimal, can be made possible with (water and) cost savings and targeted electricity subsidy reform.

What can be argued for Punjab is that the change is just a part of broader and long term adjustments for sustainability path and be influenced by government response to food demand growth and to demand for farmers' welfare. The pricing would therefore denote an inducement to engaging in a wider reform agenda of governance and never as a stand-alone panacea.

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