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"Water Policies are never implemented, but negotiated": Analyzing Integration of Policies using a Bayesian Network[1]

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Abstract

The paper contributes by analyzing non-linear and complex integration of policies in framing a water management problem in a case study hamlet in the Indian Himalayas. It reveals that water policies are never implemented, but integrated through the negotiation with other policies and socio-cultural settings in (re)shaping water resources management. It demonstrates the incremental and cumulative integration of multifaceted governance arrangements in (mis)managing water. In such a regime, the paper calls for statutory public actors to lay-out broad principles in their policy statements that allow multiple actors to debate and negotiate diverse alternatives in order to make policy-making process integrative, adaptive and dynamic.

Keywords: Policy processes, Policy network, Bayesian network, institutional analysis, India

Introduction

The formulation and implementation of policy packages (consisting of an enabling environment, coordinated institutional roles, a participatory watershed approach, and treating water as an economic good) with linear implementation strategies are the hallmark of 'good policies' in integrated water resources management (IWRM). There is growing realization that the implementation of such policy packages complex and non-linear, which offers opportunities for actors to exploit for claiming competency and legitimacy (e.g., Allan, 2003; Cardwell et al., 2006; Mollinga et al., 2007; Mostert, 2006; see Water Alternatives, Volume 1, Number 1). The paper contributes by analyzing the integration of policies in framing a water management problem in a case study hamlet in the Indian Himalayas. Examining this from an institutional perspective helps to identify the actors and the rules to strengthen the developmental role of the state (Fritz and Menocal, 2007). For the purpose, the water management problem perceived by the households in the case study is analyzed to understand the integration of policies. In particular, the role of diverse actors, contextual factors, and the rules are identified that integrated to frame the water management problem.

Policies provide strategic directions for actors to adopt a particular course of action. These policies range from paradigms, public sentiments, programmes and frames (Campbell, 1998). This may be in the form of written policy statements of public and private organizations, national and international organizations, water users groups, religious groups, and other groups of individuals. Similarly, they may be unwritten from community groups, caste, religion, values and sentiments of individuals. These policies are supported with legislation, guidelines, programmes, strategies, incentives and other instruments that come as a policy package. These packages from a diverse set of actors represent a complex process of policy integration in shaping and reshaping water resources management. There is a growing body of literature highlighting the importance of policy integration[3] for sustainable development (e.g., Lafferty and Hovden, 2003; Lenschow, 2002; Janicke and Jacob, 2005). While most studies focus on integration of strategies, structures and processes within governmental institutions, the attempt to examine the integration of policies across statutory and socially-embedded actors and ecological context in influencing a water resource

[3] A similar emphasis is placed among literatures on policy processes (e.g., Sabatier, 1999; Keeley and Scoones, 1999; Sutton, 1999; IDS, 2006).

management is less common. The paper applies a Bayesian network approach to analyze the integration of policies. The following section highlights the significance of applying a Bayesian network approach as an analytical tool. The third section outlines a systems approach for analyzing the integration of policy as a process. The fourth section describes the empirical application of this framework using a combination of research methods and usefulness of the Bayesian network as an analytical tool. The fifth section reveals the incremental and cumulative interplay of multiple actors with diverse governance arrangements in framing water management problems in a case study. The sixth section draws implications of integrated water management research and policy. The final section highlights the importance of integrative, adaptive and dynamic policy-making in a multifaceted governance arrangements and the strength Bayesian network as an analytical tool.

Bayesian Network as an Analytical Tool

Bayesian network is a modeling tool that quantifies the relationship among variables, even if the relationships involve uncertainty, unpredictability or imprecision. It is based on probability calculus following Bayes'[4] rules. A Bayesian network comprises three elements: firstly, a set of variables that represent the factors relevant to a particular environmental system or problem; secondly, the links between these variables, and finally, the conditional probability values that are used to calculate the state of the variables (Bromley, 2005). Application of Bayesian networks (BN) has gained prominence as a Decision Support System (DSS) for integrated water resources management (Batchelor and Cain, 1999; Cain, 2001; Bromley, 2005). Studies[5] that apply BN for IWRM highlight the importance of the model as a decision-support system. Varis and Kuikka (1999) illustrate the application of BN in a number of water and fisheries management cases. They note the empirical application of the model is too long, and it requires acceptance from established scientific communities. Robertson and Wang (2004) demonstrate the potential impacts on farmers of water allocation

[4] Thomas Bayes was an 18th Century English clergyman, who is known for Bayesian Probability theory.

[5] Also refer to the Special Issue on Bayesian belief network in the *Canadian Journal of Forest Research* Vol.36, Issue 12, 2006.

decisions using BN. Batchelor and Cain (1999) highlight the benefits of the BN in using a simple, integrated methodology for modeling complex systems. Molina et al. (2005) apply BN to predict and manage floods through spatio-temporal hydrological modeling. Borsuk et al. (2001) used BN to integrate a combination of process-based models, such as multivariate regression and expert opinion of river eutrophication, to predict probability distributions of policy-relevant ecosystem attributes. Varis and Lahtela (2002) analyze basin-wide policy impacts on different user groups in the Senegal River. Ames et al. (2005) use Bayesian network to model watershed management decisions on phosphorus management in a small catchment in Utah. These studies have demonstrated that the BN is a powerful tool for understanding the inter-linkages among variables that connect physical, economic and social variables (Batchelor and Cain, 1999) in managing water resources.

In brief, the significance of BN includes (Batchelor and Cain, 1999; Uusitalo, 2007; Barton et al., 2008): (i) the graphical nature of its presentation that demonstrates the interaction between social, cultural, institutional and ecological factors, thereby encouraging interdisciplinary discussions; (ii) suitability for small and incomplete data sets when sampling size varies; (ii) ability to specify the relationships among variables; (iii) flexibility to incorporate and combine quantitative and qualitative information; and (iv) explicit treatment of uncertainty in environmental systems. However, its limitations include (Barton et al., 2008:93): (i) inability to capture the cyclic feed-back effects in process dynamics, (ii) tendency to make the network too complex given the scale of the management problem, (iii) sensitive to discretization of probability distributions, as there is loss in each node due to discretization assumptions, (iv) diverse techniques to validate the model, and (v) implicit assumptions of geographical and temporal scale of variables, as the consistency across the variables with different sampling regime is difficult to meet.

The past studies apply BN as a decision support tool to inform *how to integrate* water resources management. The problem with this approach is the existence of a perceived logic (among research communities) on what (variables) to integrate, which is driven by a theoretical argument in data collection. In the process the researchers attempt to marshal[6] those theoretically-relevant variables (and its potential linkages) for understanding the

[6] Though participatory approaches are applied, they provide broad and consensual information and are therefore rarely able to capture the less explicit information.

management problem. Second, these studies exclusively rely on the BN as the only tool for taking policy and management decisions, placing definite boundaries for spatial and temporal variables (Barton et al., 2008). Also they believe that once the model is built it can remain stable, (possibly updated) and can be useful for future decision-making. Many studies have excluded the dynamic and complex nature of social-political and ecological process involved in water management. This requires reading the network to describe an event or a situation suitable for analyzes, rather than as a stable entity. Third, the Bayesian network is often considered as an all encompassing model to illustrate the interaction process for management decisions, ignoring the conventional quantitative and qualitative approaches to interpret information. This paper attempts to overcome some of these challenges by applying BN as an analytical tool to understand the socio-political process of framing water management problems in the watershed.

Understanding Policy Processes – A Conceptual Approach

This paper applies the institutional integration framework (Saravanan, 2008) to understand the policy processes. The framework builds on the institutional analysis development framework (IAD) (Ostrom et al., 1994) but makes amendments by drawing on Dorcey (1986) and Holling and Gunderson (2002). The process involves multiple actors to negotiate diverse policies to frame water management problems, distribute water resources, and build capacity of strategic actors (Fig. 1). These actors collectively structure a water management problem in a region. Given a problem agents are active in evolving adaptive strategies through agents of institutional change (or agency) to overcome inadequacies in the existing institutional arrangements and ecological system. The framework is shaped and reshaped by three situational variables: the prevailing rules, characteristics of stakeholders, and existing bio-physical resources.

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Fig. 1 Framework for Analyzing Policy Processes

Rules are patterned behaviors of a social group, evolved over a period (Mitchell, 1975; Ostrom, 1998), which interact along with contextual factors (such as climate, demography, historic evolutions and so on) to govern human activity. They are structures of

power relations that actors/agents draw in the socio-political process of water management. They are classified as statutory and socially-embedded rules. While there are many rules, Ostrom et al. (1994) broadly classify them as boundary rules (specifying who the actors are), position rules (setting the position for actors to take), scope rules (setting the outcomes from their decisions), aggregation rules (specifying the outcome), information rules (providing channels for communication), authority rules (setting the actions assigned for actors), and pay-off rules (prescribing the benefits and costs). Rules (along with resources) are drawn by actors and/or agents to interact in diverse arenas through networks. Actors are defined as stakeholders, having legitimate interest in managing water resources. They are organizations and/or groups having an incumbent role and possess a unique social identity. Agents are human individuals possessing a transformative capacity and are members among the actors. These agents draw on the activities of the actors and their rules, along with the bio-physical resources to bring about changes in the existing institutional arrangements and bio-physical resources in a number of decision-making arenas.

Arenas are social settings accessed, activated and created in a strategic context, for agents to contest, negotiate, dominate, exchange goods and services, and solve problems (Dorcey, 1986), similar to Ostrom's (1998:68-69) and Long's (2001) arenas. There are no single arenas, but multiple, existing at various levels in the social sphere (Dorcey, 1986), representing 'panarchy' (Holling and Gunderson, 2002); this 'panarchy' interacts (following as in Ostrom et al., 1994) with situational variables (bio-physical resources, characteristics of human entities and prevailing rules) in linear, cyclic and nonlinear forms of networks. Such a network highlights the power relations and its ability to emphasize the contribution of micro-scale actions to large-scale outcomes (Klijn and Koppenjan, 2000). The decision-making process is punctuated by contextual variables, such as geological factors, climate, physiography, demography, and other forces punctuating the framework at various periods of a decision-making process. These characteristics make the policy process adaptive and dynamic. For analytical purposes, the framework represents a cyclical process. However, in real life, interaction among variables is a complex messy process of shaping and reshaping policies.

The current paper examines how diverse policies integrate in the form of a network influence to frame water management problems in the larger part of policy processes. The application of a network approach to policy analysis, in the past has failed to fully explain the

driving forces or functions behind the network (Dowding, 1995; Klijn, 1996; Medizable, 2006). The paper helps to overcome this by analyzing the integration of policies from an institutional perspective to identify the activities of the actors and their rules that facilitate the perception of the households to frame the problem.

Methodology

A water management problem exists when there is a discrepancy between (1) technically achievable and desired social goals, and (2) actual outcomes (circumstances) that arise from current institutional arrangements (Livingston, 1987:287). The problem is dialectic, meaning, it is framed differently by different actors depending on how they make sense of their world. For the purpose of this paper, the framing of water management problem by the households is examined to understand the integration of policies. In such a problem-context there is 'a definite ordering and models of complexities' (Crothers, 1999: 221) that can be established for the analysis. Herein, ethnomethodology is applied in a pragmatic and contextual nature. This approach enables one to capture the assumptions and practices through which the most commonplace activities and experiences are framed by local communities (Pollner, 1987:ix). Furthermore, of concern in this paper is "how society puts together; how it is getting done; how to do it; the social structures of everyday activities," (Garfinkel, 1974) in managing water. An ethnomethodology combines diverse research methods of semi-structured interviews, structured interviews, focus group discussions, participatory resource mapping, participant observation, maintaining field notes and information derived from secondary documents (archives and published government records) from a year-long field research programme in 2004. Structured interviews were conducted with 43 households (40% of the total households), semi-structured interviews with 25 officials (with government, non-government, politicians and experts), focus group discussions, participatory mapping exercises (resource mapping, transects, and wealth ranking), and participant observation. The combination of methods helped to contextualize information, and also to obtain both quantitative and qualitative information for comprehensive understanding of the water management problem.

Data collected were analyzed statistically, through qualitative interviews and from the researcher's one year experience in the region to draw on selected variables that influence the

framing of the water management problem. These selected variables were then applied in a Bayesian network. In combination with narratives, it helped to understand the integration of policies in a socio-ecological context that facilitate frame the problem. This approach allows one to gain a better understanding of the interaction between each part of the larger policy making process. The Bayesian network approach helps to integrate both qualitative and quantitative information, and to quantify the probability of relationships amongst variables. In this network, the variable indicates the actors or the contextual factors. The linkages between these variables indicate the rule (or contextual causal linkages) that governs their relationship, which is derived either through chi-square (significance *p* value), or through qualitative statements obtained from field research or through the logical reasoning of the researcher, or a combination of all of these. Based on a rule in the network, these variables are classified as 'boundary', 'position', 'aggregation', 'information', 'authority', 'scope' and 'outcome' variables. The variables and their linkages are applied into a probability model of a BN using NETICA software (Norsys Software Corporation Canada). A panel of advisors for the research (households, village leaders, bureaucrats, intellectual experts, non-government officials and politicians) validated the findings in the Bayesian network to ensure the model accurately reflects the reality of the situation it is used to understand. In case of conflicting views from the panelist, the author's critical judgment based on their experience in this and other regions, the trust with the panel and the type of information obtained takes precedence.

Rajana Watershed –Competing Terrain for Resource Management

The Rajana watershed falls under the jurisdiction of the Rajana revenue village (lowest revenue division in the Indian administrative divisions) in the district Sirmaur in Himachal Pradesh, India. The watershed and the village boundary do not coincide, but a large part of the village falls within the hydrological boundary; the watershed is officially named after the revenue village Rajana for carrying out a community-based watershed development programme. The watershed represents a diverse, fragile, ecological region, which is rapidly being transformed (due to market forces and externally-aided projects). These contemporary initiatives are embedded with socio-cultural and historical institutional settings to create a water management problem in the watershed.

The Rajana watershed is located in the mid-hill sub-humid zone of the Indian Himalayas. It is limited by available arable land, is characterized by steep sloping terrain with salty-loamy to clayey soil that is prone to landslide. The watershed has a population of about 1,070 (from 2002 data, compared to 1068 in 2001) spread over six hamlets; the area is politically and economically dominated by the Rajputs community (constituting 36% of the population), though numerically the Kohli community (the Scheduled Castes[7]) dominate (with 60% of the total population), with just a few families from other communities. Of the six hamlets in the watershed, more than 95 percent are concentrated in two hamlets, the Uppala (meaning, up in the mountain) Rajana and Nichala (meaning, down the mountain) Rajana. The Uppala Rajana was selected as a case study, as the hamlet had survived without irrigation system for several centuries, but in recent years is demanding for one.

One of the problems facing the hamlet Uppala Rajana is lack of irrigation system, which seems to have deprived the livelihood of the households in the hamlet. Households believe implementing irrigation system in the hamlet will give assured returns from cash crops during the dry months that will increase their income, where other livelihood opportunities are limited. Literacy is quite high (about 52 percent of the sampled household), but equally is so unemployment rate, with 60 percent of the literate adult households unemployed. As one of the household remarked, "it takes about two to three hours to reach Dadahu, the nearest urban centre for any employment. Government jobs (like Water Operators for pumps to supply drinking water to the villages) within or near to the hamlet is limited. The only option is to depend on our agriculture". For an average household in the hamlet, agriculture contributes 60 percent of the annual household income (the average household income of the sampled households in 2004 was 68,737 Indian Rupees). It is supplemented from income from other sources, such as labor employment, employment in government organizations, and marketing of milk products. Rainfed agriculture is practiced higher up the mountain in Uppala Rajana, where staple food crops are grown for subsistence from October to March, and vegetables (tomato, okra, chilly, turmeric, and ginger) from March to July. At Uppala Rajana the crops are organically grown in rainfed conditions, in addition to the staple food grains (maize, ragi and wheat). It has loamy soil, enabling good

[7] The caste system is a hereditary-based, social stratification of communities. Scheduled Castes and Scheduled Tribes are groupings of the Indian population explicitly recognized by the Constitution of India as deprived.

production. One of the village leader claimed, "Our village is a remote, poverty stricken (percentage of Scheduled Caste community - based on one of the criteria set by government as poverty stricken region), but has fertile soil with assured water supply for agriculture crops the households can get good returns from cash crops and generate employment for the poor". Given this the village leaders are actively pursuing to get an additional water sources for their hamlet.

The history of Uppala Rajana dates back to the 14th Century, when the Rajput community (hereafter, Rajputs) migrated from the Delhi province due to the invasion of the Moghuls from Turkmenistan into India. The invading forces (in Uppala Rajana) occupied and owned (as landlords) most of the resources, such as land, water and forest. To meet the labor requirements (for agricultural activity, maintenance of the irrigation system, distribution of the irrigation water, and to carry out menial jobs for the Rajput families), they brought-in the Kohli community (hereafter Kohli's), as tenant cultivators. After India's Independence in 1947, the Land Reforms Act[8] in the 1960s, attempted to obscure the distinction between landlord and tenants through land redistribution in order to increase agricultural production and alleviate poverty. The Act redistributed excess lands from the Rajputs to the tenant Kohli's. In the process, the Rajputs gave away less fertile, rocky lands and lands far away from the main settlements (often near forest) to the Kohli's. Though this gave the Kohli's ownership of land and subsequently met the purpose of the Land Reforms Act, most of it was less productive compared to that of the Rajputs. The conferment of Statehood in 1971 led to planned development in the state. One of the early initiatives of the Five Year Plan[9] in the state gave priority to agriculture and infrastructure development. The hamlet witnessed electricity connection in 1967-68, road access to nearby townships in the 1970s, the introduction of bus services, the establishment of educational institutes, health services, and

[8] The Land Reforms Act (1958) of the government of India was implemented in the state of Himachal, as The Himachal Pradesh Transfer of Land (Regulation) Act, 1968, and Himachal Pradesh Tenancy and Land Reforms Act, 1972, by the department of Land Revenue in the state.

[9] India carries out planned development through Five-Year Plans; these plans began in India in 1950 upon becoming a sovereign nation of Social Democratic Republic; India gained independence in 1947.

access to telephones during the 1990s[10]. Centralized neo-liberal programmes have been implemented since 2000, including the integrated wasteland development programme under the Ministry of Rural Development, which implements Community-Based Watershed Management (CBWM) through the respective District Rural Development Agency (DRDA) within the state (GoHP, 2004). The other programme is the 'Technology mission for integrated development of Horticulture' (hereafter, referred to as the Horticulture Mission) for making the state the 'Fruit Bowl of India' (Tribune, 2000). This initiative aimed to commercialize agriculture in the state by exploiting the wide-ranging agro-climatic conditions for cultivation of fruits and vegetables. The programme offered incentives to expand cultivable areas under horticulture, the creation of water sources for private or collective needs, on-farm water management, and other technical inputs. In addition, the watershed also witnessed externally-aided projects promoting community-based resource management programmes. These projects included one funded by the World Bank (WB) under a Mid-Himalayan watershed development programme[11], and another, the Department for International Development[12] (D*f*ID) assisted Himachal Pradesh Forest Sector Reform project, which carries out an integrated area development programme (IADP) in the watershed (GoHP, 2004). What is interesting is each of them (national and international) has their own jurisdiction or sector (such as water, education, forest, and infrastructure) for management. Over the decades, these agencies compete[13] among each other claiming superiority over the physical and social implementation programmes and also claiming superiority in their interventions and impacts. Though these have opened-up the subsistence economy to a market-oriented economy, these developments have significantly influenced

[10] These developments would not have been feasible without the action of the current Member of Legislative Assembly (MLA) of Sangrah, who is originally from this Rajana village.

[11] This project began after the completion of the study in 2004.

[12] The D*f*ID programme is targeted towards forest management through an integrated development programme, while the government of Japan aims to manage floods.

[13] The District Project Officer, DRDA Nahan, claimed that they were the first to enter the watershed and create a good data base, adopt a community-based approach, and link the project implementation with the Panchayat institutions. In contrast, the Divisional Forest Officer, Renuka, claims their D*f*ID programmes allocate more money per hectare and consider an integrated approach within the watershed by linking with livelihood activities.

the households to frame the problem as "lack of irrigation as depriving their livelihoods from agriculture". The other problems that the households framed were 'inadequate employment opportunities within and outside the region', and 'need for better access to market and urban centers'. For the paper, the problem 'lack of irrigation depriving the (households) livelihood' was examined to understand how diverse policies integrate to influence the perception of the households to frame the water management problem.

Agriculture Prosperity Leading to Demand for Water in Uppala Rajana

In Uppala Rajana small-scale subsistence cultivation of vegetables that often depended on virtual water resources (available in the form of moisture on land and in the atmosphere) is being transformed into a large-scale cultivation. This has placed enormous pressure on the existing virtual water resources, and as a consequence, causing households to manually irrigate their crops[14], which makes them to perceive existence of water scarcity in the village. This has led community leaders to demand lift irrigation scheme (through letters to the District Collector and the Member of the Legislative Assembly-MLA of this constituency) from the government to overcome water scarcity in the hamlet. Though there is a large number of variables (such as education, social network, knowledge, demographic and other factors), not all had significant influence in framing the problem. Only a handful of factors were found to be statistically significant (Chi-square testing), or were highlighted through interviews with households and local officials, or logically reasoned by the researcher. In the process, the network combines both qualitative and quantitative information to understand the linkages and probability of their relationship.

Of a handful of variables, the boundary variables set the context and policies on how the households should frame the problem (Fig. 2, Table.1). These variables were related to contextual factors (the climatic conditions for vegetables, nature of product, and size of landholdings), socially-embedded actors (caste of the household), statutory public actors (Government of Himachal Pradesh), and statutory private actors (competition from markets,

[14] Often farmers carry water from the springs or from government-supplied sources in order to irrigate vegetable crops during April/May. Being a very steep sloping terrain, they carry water on their back climbing as high as 500 metres.

national and international organizations campaigning for CBWM). These boundary variables offer various positions to households. The socially-embedded actors influence the choice over the 'caste of the middleman' and 'location of landholdings'; the statutory public actors take 'opportunities for the 'fruit-bowl'' economy, while statutory private actors take positions by defining the 'nature of market', and the 'perception on CBWM'. The decision of the household to cultivate the 'area under cash crops' depends on their ability to aggregate the position variable (location of land, and benefits from the incentives), and boundary variable (size of landholdings). The scope variable, the 'access to market' for marketing the cash crops, is determined by socially-embedded actors (the caste of the households). In the market, the 'income from cash crops' depends on the market forces (position variable -nature of market, and boundary variable –competition from Mumbai), which authorises on the particular outcome. Similarly, the lower the income, the higher the demand for irrigation; furthermore, this demand is therefore not based on the informed assessment of the household, but is based on the 'perception of CBWM' that is influenced by the boundary variable – 'campaign for CBWM'.

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Fig. 2 Variables Influencing the Framing of the Problem in Uppala Rajana

Table 1. Summary of Variables Influencing the Framing of the Problem in Uppala Rajana

The boundary variables 'caste of the household' and 'source of landownership' offer positions for the households through 'location of land'. In this hamlet, there is a 55 percent probability that a household will be from the Kohlis, rather than the Rajputs community. The BN shows that if all households were Rajputs, there would be a 61 percent probability of land being near the residence (Fig. 3a). Thanks to the Land Reform Act implemented in the state, which allowed the Rajputs to retain their near-residence land, land was of better quality, and easy to protect from wild animals. In contrast, the probability of Kohli owning land near their place of residence was just 3 percent, with more than an 82 percent probability of them owning land near the forest (often rocky, steep slopes and crops prone to attacks from wild animals) (Fig. 3b). Caste also influences households' choice on the 'caste of the middleman' to gain access to the market; the choice matters for getting adequate returns from the sale of cash crops in the market.

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Fig. 3 Scenarios for Illustration

A household's decision to cultivate cash crops depends on the 'location of land', 'size of landholding', and 'benefits from the incentives'. These variables help households to aggregate the 'area under cash crops'. In Uppala Rajana, there is a 47 percent probability of a household having 'high' (meaning, cultivating cash crops in more than 0.6 acre of land in the year 2004) area under cash crops. The probability of Rajputs cultivating high 'area under cash crops' is about 78 percent (See Fig. 3a). 'Location of land' significantly (*p* value = 0.02) influences the households in cultivating cash crops. Land near residence has a higher probability for cultivating cash crops, compared to land near the forest. Cash crops require more man-months especially for weeding, and watering during the dry months. In addition, these crops require protection from wild animals (namely monkeys and wild boars). The near-residence land offers incentives for meeting labor requirements and is easier to protect from wild animals. The importance played by 'location of land' makes the 'size of landholding' insignificant (*p* value = 0.049) in influencing the 'area under cash crops'.

The third variable influencing the 'area under cash crops' is the 'benefits offered through incentives' under the Horticulture Mission. The Horticulture Mission by the state of Himachal Pradesh attempts to exploit the climatic condition and the existing infrastructure facilities in the state for being a 'Fruit Bowl' of India; the Mission offers assistance in the cultivation of cash crops[15]. An official in charge of horticulture promotion (the Junior Agriculture Officer, Sangrah) in the region claims that such an initiative will increase the production of cash crops in the region and so alleviate poverty (personal communication to the authors). This programme has led government and market players offering various incentives for the cultivation of cash crops in the region. Interviews with officials (government and non-government), key villagers and experts reveal that there is only a 43 percent probability for favoring to this programme. Though these have offered opportunities

[15] The government offers incentives for expanding the area under cash crops, construction of water resources structures, on-farm management, technology, bio-fertilizers and other technical incentives

for opening-up the village economy, as Mr. Subhash Mendhapurkar, Director of a non-government organization Social Upliftment for Rural Action (SUTRA) claimed, these have been "formulated keeping in mind the exploitation of precious land and water resources, and not taking poor people's interest into consideration or the landholding characteristics in the mountainous region[16]". This opinion was reinforced by a household in the watershed, "the government incentives are only for cultivating the crops, but the market is left to the middleman and the brokers in the market centers who exploit us". The probability a household perceives less 'benefit from these incentives' is higher (59 percent), than those who perceive medium benefits (receiving assistance for area expansion, on-farm water management, and through seedlings). The fewer the incentives received, the less area there is under cash crops in the hamlet. The decision of the households to cultivate the required 'area under cash crops' depends on their ability to aggregate the 'location of land', size of landholding' and the 'benefits from the incentives' offered under the Horticulture Mission.

Just cultivating cash crops (area under cash crops) do not enable the household to 'access the market', as the access is socially determined by the position variable (the 'caste of the middleman'). The probability of any household getting good 'access to the market' is about 64 percent. As is a common practice in many Indian villages, the middleman buys the agriculture produce from the households and sells at higher price in the *mandis*[17] (whole sale market centers in urban centers). Of the seven middlemen buying the produce in 2004 from this watershed, four were from the Rajputs, one from Kohli and two from other communities, aligned with Kohlis. The Rajput middlemen offered a better price for the cash crops than others. The price offered was 5 to 8 Indian Rupees (INR) per kilogram of tomatoes in 2004, and 12 to 14 INR per kilo for ginger, were categorized as good, while the middlemen from other castes offered less and were categorized as medium. As Rajput middlemen had kinship

[16] The distribution of unirrigated landholding in the hamlet revealed 43 percent of the households owned marginal landholdings (less than 1 acre), 37 percent small landholdings (between 1 and 2 acres), only 18 percent were large landowners and 2 percent landless. On an average, a household had the average of 0.85 acres distributed in at least 8 pieces, given the steep sloping terrain and rugged terrain.

[17] At these *mandis*, the products are auctioned to retailers at the market price. The market price depends on the competition for the same product from other *mandis*, quality, and timing of the arrival of the produce.

ties with Rajput households (who were also large landowners, had their land located near residence, and were growing more areas under cash crops) in the hamlet, many of them sold cash crops to Rajput middlemen. Often Kohlis had no other option than selling to the Rajput middlemen because they produce less quantity and prefer to gain from the higher price, though some were socially pressured by Rajputs. A few Kohli households did engage with two middlemen who were not Rajputs, but they offered a lower price, which were not as competitive as that of their counterparts. Most of the Rajput middlemen offered good 'access to market', as they were involved in marketing business at all times (even during off-season for marketing other forest produce), while the Kohli's and other middlemen operated only during the peak production season. In order for a household in Uppala Rajana to get good 'access to market', they have to be Rajputs, choose to sell to Rajputs middlemen, and should be cultivating more than 0.6 acres of land under cash crops. Unfortunately, for the Kohlis there is limited scope (with 37 percent probability of them having good 'access to market' – Fig. 3b) for cultivating required 'area under cash crops' in less than 0.6 acres and have only medium 'access to market'.

The scope variable 'access to market', along with market forces, influences the authority variable for the households– 'income from cash crops'. Apart from ginger, all other vegetables are perishable (93 percent probability) and therefore have a seasonal market (93 percent probability). Gaining adequate returns from crops is complicated by competition from produce that comes from Indian plains, known locally as the Mumbai market (as they mainly come for Maharashtra). The market in India depends on the climate of the producing region. The Himalayan region has a comparative advantage over the rest of the country in the cultivation of cash crops. When many parts of the country are dry (March-August), the Himalayan region is cool, with showers that are suitable for cultivating vegetables. This means that households in the Himalayan region are able to exploit the advantage by selling and producing their cash crops before August every year, after which the prices fall as produce from the Indian plains arrives. But the late onset of the monsoon season, late rainfall, and other conditions in the year 2004 led to a delay in the marketing of vegetables.

This subsequently affected the price of the produce with a 59 percent probability of low income[18] from cash crops.

The authority variable, 'income from cash crops' is the deciding factor for households to perceive the need for an irrigation system. While diverse set of policies, along with contextual factors influence the income from cash crops, households attribute the reason as "lack of irrigation". This perception was legitimized by media, government, NGOs and international agencies portraying a gloomy world where will be scare and 'catching water where it falls' as a potential solution. The boundary variables 'campaign for CBWM' by national and international agencies through exposure field visits (organized by project implementing agencies), promotional materials (posters and documents), and sharing success stories from experiments elsewhere in the world played an influential role in framing the problem. About 68 percent of the households give 'high' interest to the demand for irrigation. However, 32 percent of the households report 'medium' interest to the demand for irrigation, as they claim improving infrastructure to access market could significantly increase their income from cash crops.

The President of the Rajana Watershed Committee, a leader among the Rajputs and also a lead farmer in the hamlet, has made various pleas to the government for lift irrigation in the watershed. The interaction with officials is in addition to his social networking with middlemen outside the watershed to try to obtain adequate returns from cash crops for his villagers. His choice is strategic and spontaneous, as he capitalizes on market, national and international agencies to establish his social and economic status in the village. Though the network reveals the influential role of caste in the demand for irrigation, a scenario analysis reveals a regulated market could play a prominent role in overcoming the water problem in the hamlet and reduce the influential role of socially-embedded actors. If the 'nature of market' is controlled to be in the perennial state, there is a significant reduction in the high demand for irrigation (Fig. 3c). A farmer, who had served in the Indian Army rightly pointed out "if we have any technologies to store these produce for a long time, then we could sell it at the time of good price". This view was also supported by the district planning officer,

[18] Income was considered to be low if the annual earnings from cash crops were less than 20,000 Indian Rupees. Income is considered to be at a medium level when earnings are between 20,000 to 60,000 Rupees and 'high' when greater than 60,000 Rupees.

Nahan (personal communication), who emphasized the need to have cool storage facilities to promote agri-based industries in the region for vegetables and fruits to ensure good returns from cash crops.

Implication for Integrated Water Resources Management

Multiple actors exploit the contextual factors to influence the perception of the households to frame the water management problem in the hamlet. The boundary rules are set by contextual factors (climate, landholding size etc.), socially-embedded actors (e.g., caste) and by the policies of the national and international agencies promoting Community Based Water Management (CBWM). Statutory public actors (Government of Himachal Pradesh), socially-embedded actors (Caste of the household) and the statutory private actors (market forces) use these to take positions. Interestingly, households exploit these rules along with socially-embedded rules to aggregate their decision to cultivate the required 'area under cash crops' and access the market. However, the authority to frame the problem is influenced by the statutory private actor (market brokers and middlemen), which determines the income from the cash crops. This authority along with the position rules taken by the national and international agencies in portraying the finite nature of water availability and the emphasis on 'catching water where it falls', enables households to frame their problem as 'lack of irrigation depriving their livelihood'. What is important in this integration of policies is the absence of information rules that has constrained actors to adopt 'fire-fighting approach' to manage resources in this hamlet.

The 'fire-fighting' approach is adopted depending on the actors' own assessment of the situation and by exploiting the contextual characteristics of the region. In the process, they facilitate the perception of the households to frame the water management problem. Land Reform Acts in the 1960s and 70s attempted to redistribute land, but they inherently sanctioned the traditional hierarchy of land ownership in terms of quality. Subsequent policies of agricultural development like the Horticultural Mission, and other agriculture and irrigation development programmes, exploit the climatic conditions and focus mainly on expansion of the cultivable area under horticulture crops. In the process, they facilitate the existing inequality promoted by the caste system and ignore other options, such as regulating the market. Similar is the case of community-based management promoted by World Bank

and D*f*ID in the hamlet. Often these packages are programmed as 'blue prints' for implementation of integrated water resources management. In a recent update of policy packages to promote watershed developments in India, the Honorary adviser for the Technical Committee on Watershed Programmes (widely known as the Parthasarathy Committee) (GoI, 2006) claimed their report as "a detailed blueprint of a new course of watershed implementation in rainfed India" (Shah, 2006:2982). The report claims that such government reforms hold "the key to banishing poverty" (Shah, 2006:2984). This report was followed by a Common Guidelines for Watershed Development projects (GoI, 2008). Often these statements are based on disaggregated success of non-governmental organizations, which are deceptive in their presentation and remain a 'black-box'[19] in the Indian democracy.

This is further constrained by inadequate scope rules that do not enough incentives for households to cultivate cash crops, and the caste-driven access to market. Incentives for households to cultivate cash crops are constrained due to steep and rugged terrain in this region. This influences the landholding pattern that is marginal in nature and disaggregated in number of pieces. The access to market is caste-driven, with the middlemen and brokers who have kinship relations with better-off Rajputs in the hamlet. This is further complicated with poor infrastructure for storage and unregulated market conditions. Offering information and strengthening the scope rules is an important component for comprehensive policy making.

Chaotic negotiation of different actors and their policies has in part resulted in the current framing of the problem; also contributing to the problem is poor infrastructure development, (roads, education and health), rural unemployment and inadequate poverty alleviation programmes. These factors significantly widened the differences between Rajput and Kohlis in the hamlet, especially in the remotely located and culturally secluded watersheds in the Indian Himalayas, like Rajana. As one Kohli household women claimed, "It will take one more generation for us to buy a good piece of land in this region". The

[19] The black box contains information how NGOs negotiated watershed and administrative boundaries? How they ensured participation? How they integrated diverse interest groups to promote environmental management and alleviate poverty? What happened after they withdrew formally? And more important how much money do they actually spend compared to funding received, for meeting the needs of the poor? Unfortunately, this 'black box' is unlikely to be opened up as these agencies seek the immunity from the Indian democracy.

market is open and driven by price; rarely does the government interfere in regulating the functioning of markets. The national and international agencies implementing community-based programmes (such as D*f*ID's and ministry of rural developments through IWDP) unfortunately promote an inaccurate image of the water availability and romanticize the resource management practices.

Conclusion

The paper reveals that the water management problem in the hamlet is the result of diverse policies, including water policies that interact over period of time. It reveals policies are never implemented, but integrated through the negotiation with other diverse policies and socio-cultural settings in (re)shaping water resources management. The analysis reveals that water is managed by different forms of governance arrangements (state-centric, market or community-based). In this multifaceted governance arrangement state-centric or market-oriented or community-centered institutional arrangements are not superior to each other, rather they incrementally and cumulatively superimpose to (re)shape water resources management. In this decision-making process, integration represents a complex blend of statutory and socially-embedded actors bringing with them diverse rules to negotiate, along with contextual factors. Analyzing the integration from an institutional perspective reveals absence of information rules and inadequate scope rules which has resulted in 'fire-fighting' approach by various actors, without adequate assessment of the context. The statutory public actors can facilitate comprehensive understanding of the context by laying out broad principles in the policy statements. This will allow multiple actors to integrate, adapt and remain dynamic in the policy making processes by debating and sharing available information for comprehensive assessment. To facilitate this comprehensive assessment for an informed water management decisions that are sustainable the statutory public actors will need to build the capacity of actors, regulate water distribution, and offer diverse forums for actors to debate and share available information.

The paper highlights the usefulness of Bayesian networks to describe policy integration across space and time in framing the water management problem. The BN as an analytical tool helps to overcome some of the challenges raised in the existing Bayesian literature. For example, by focusing on the problem-context, one can examine only those

variables that actually influence the framing of the water management problem, thereby reducing complexity into a manageable form. Similarly, BNs applied with an institutional logic helps in identifying diverse actors (and contextual factors), different rules, and their interactions involved in framing water management problems. Such an institutional logic also helps to identify the different roles of actors and rules in framing the problem for institutional intervention. Furthermore, by applying BNs from an analytical perspective one can incorporate diverse socio-political processes in interpreting the network. This helps to overcome the slicing of the dynamic policy processes into different sequence for analysis and interpretation. Finally, BNs provide a cross-sectional view of a complex and dynamic resource management process. They do not attempt to include the implicit assumptions of geographical and temporal scale of variables in contemporary studies. The aforementioned advantages, in addition to others recognized by Bayesian literature (such as graphical presentation, integration of qualitative and quantitative information, suitability for small and incomplete data sets and explicit treatment of uncertainty) can further its application for understanding integration of water resources management.

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The authors would like to acknowledge Prof. Maria, R Saleth, Dr. John Bromley, Dr. David Barton, two anonymous reviewers from the journal and ZEF research group on Governance and institutions, for their comments on a previous draft of this paper. The support from UQIPRS and IWMI Doctoral Fellowship is gratefully acknowledged. The usual disclaimers apply.

Appendix 1 Details of Variables Influencing the Framing of the Problem in Uppala Rajana

VARIABLES	CONTEXTUAL FACTORS	ACTORS	RULES or CAUSAL LINKAGE
Boundary			
Climate for Vegetables[1]	**Climate**	**-**	**Conducive climate more suitable is opportunity for 'Fruit-bowl' economy.**
Infrastructure Facilities[1]	**-**	**GoHP**	**Good facilities are favourable opportunity for 'Fruit-bowl' economy.**
Size of Landholding	**History**	**-**	**Higher the landholding, the more is the area under cash crops (X^2=8.95; df=4, p=0.04)**
Source of Land ownership	**History**	**GoI/ GoHP**	**Land obtained through land reforms were located near forest (X^2=9.61; df=4, p=0.04)**
Caste of the Household	**History**	**Caste**	**Rajput the caste higher is the probability of land located near-residence (X^2=12.95; df=2, p=0.001) and higher is the probability of choosing Rajputs as the middleman (X^2=11.99; df=4, p=0.01)**
Awareness on CBWM	**-**	**GoI/ GoHP/ D*f*ID**	**Increased visit to CBWM field experiments, the more is water available for development (X^2=.5.85; df=2, p=0.04).**
Nature of product[1]	**Natural characteristics**	**-**	**The perishable the produce, seasonal is the market.**
Competition from Mumbai[1]	**-**	**Market**	**Higher the competition from produces from Mumbai, the lower is the price.**
Position			
Opportunity for 'Fruit-Bowl'[1].	**-**	**GoI/ GoHP**	**Favourable is the climate and infrastructure, offer incentives to increase area under cash crops.**
Location of Land	**-**	**Caste**	**Land near-residence, has higher probability under cash crops (X^2=10.79; df=4, p=0.02).**
Caste of Middleman	**-**	**Caste**	**Rajputs as middleman, the higher probability of getting good access to market (X^2=15.16; df=6, p=0.02)**
Nature of Market[1].	**-**	**Market**	**Seasonal the market, the lower the returns for cash crops.**
Perception of CBWM	**-**	**Households**	**The perception that more water can be harvested, the higher the demand for irrigation (X^2=13.07; df=2, p=0.00)**
Scope			
Benefit from incentives	**-**	**Households**	**The lower the benefit from incentives, the lower the area under cash crops (X^2=11.21; df=33; p=0.01)**

Access to market	**-**	**Caste/ Market**	**Good access to market, higher is the income from cash crops (X^2=13.85; df=3, p=0.00).**
Aggregation			
Area under Cash crops	**-**	**Households**	**Higher the area under cash crops, good is the access to market (X^2=7.79 df=3, p=0.04).**
Authority			
Income from cash crops	**-**	**Caste/ Market**	**Lower the return, higher is the demand for irrigation (X^2=12.89; df=3, p=0.01)**
Outcome			
Demand for Irrigation	**-**	**Households**	**Higher the demand for irrigation, increasing pressure on agents to seek government.**

Note: [1]These variables are nominal and ordinal quantified from the responses received through qualitative interviews. The rest of the variables are derived from household interviews.

GoI – Government of India; GoHP- Government of Himachal Pradesh; D*f*ID- Department for International Development.

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Table. 1 Summary of Variables Influencing the Framing of the Problem in Uppala Rajana

VARIABLES	CONTEXTUAL FACTORS	STATUTORY ACTORS	SOCIALLY-EMBEDDED ACTORS
Boundary			
Climate for Vegetables[1]	**Climate**	**-**	
Infrastructure Facilities[1]	**-**	**GoHP**	
Size of Landholding	**History**	**-**	
Source of Land ownership	**History**	**GoI/ GoHP**	
Caste of the Household	**History**	**-**	**Caste**
Awareness on CBWM	**-**	**GoI/ GoHP/ D*f*ID/ WB**	
Nature of product[1]	**Natural factor**	**-**	
Competition from Mumbai[1]	**-**	**Market**	
Position			
Opportunity for 'Fruit-Bowl'[1].	**-**	**GoI/ GoHP**	
Location of Land	**-**	**-**	**Caste**
Caste of Middleman	**-**	**-**	**Caste**
Nature of Market[1].	**-**	**Market**	
Perception of CBWM	**-**	**-**	**Households**
Scope			
Benefit from incentives	**-**	**-**	**Households**
Access to market	**-**	**Market**	**Caste**
Aggregation			
Area under Cash crops	**-**	**-**	**Caste/Households**
Authority			
Income from cash crops	**-**	**Market**	**Caste**
Outcome			
Demand for Irrigation	**-**	**-**	**Households**

Note: [1]These variables are nominal and ordinal quantified from the responses received through qualitative interviews. The rest of the variables are derived from household interviews. For details on the rules and linkages, please refer to Annexure 1.

GoI – Government of India; GoHP- Government of Himachal Pradesh; D*f*ID- Department for International Development; WB – World Bank.

Fig. 1 Framework for Analyzing Policy Processes

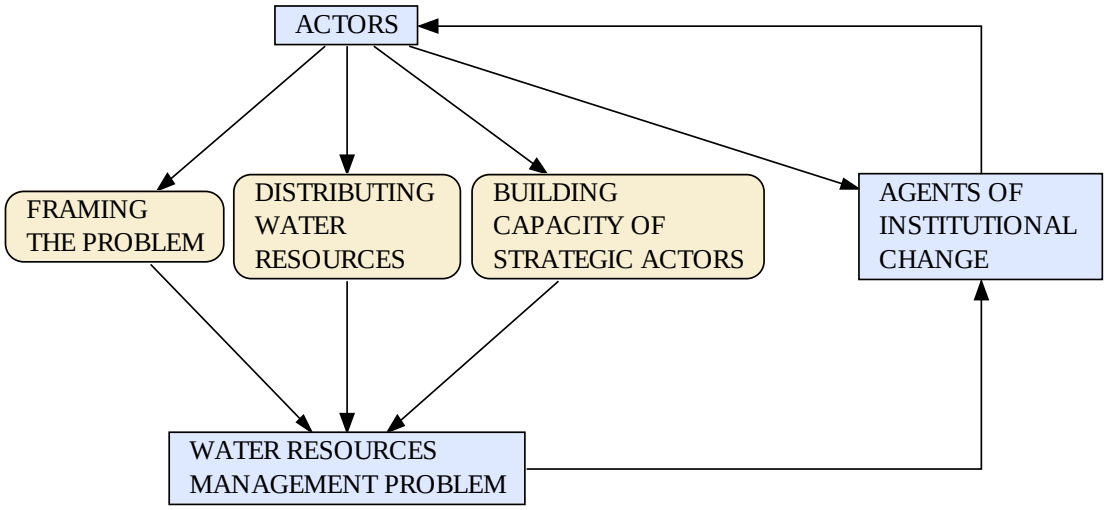


Fig.2 Variables Influencing the Framing of the Problem in Uppala Rajana (Probability values in %)

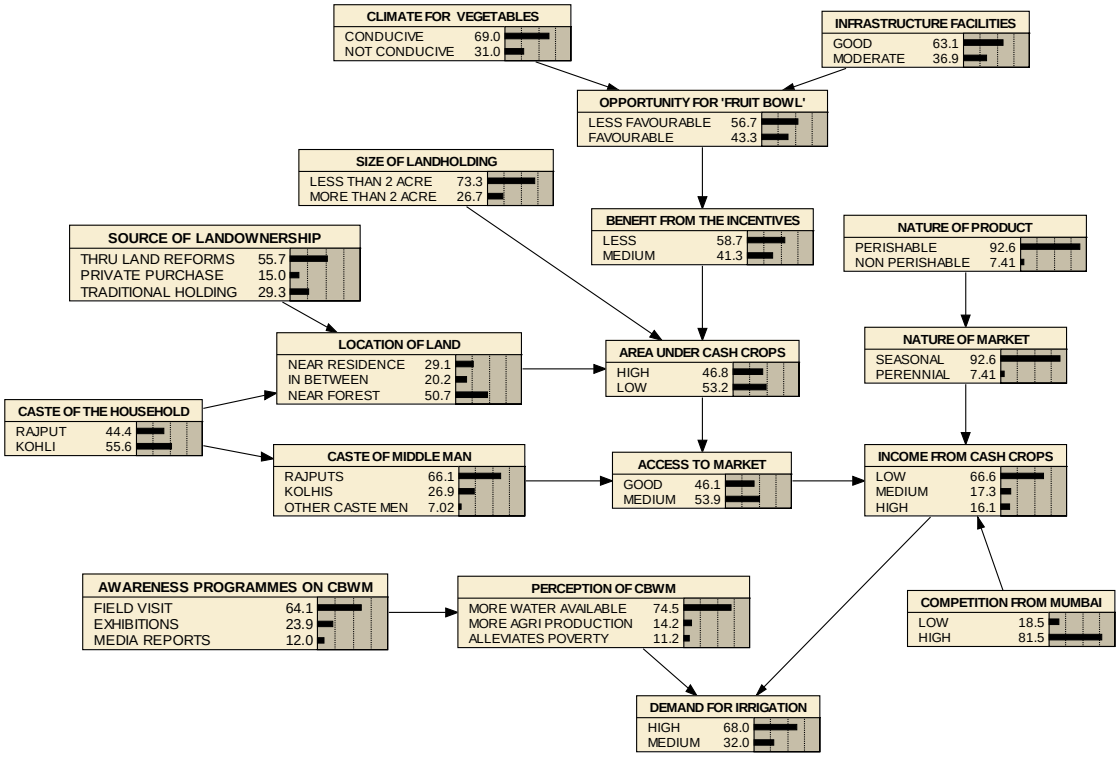
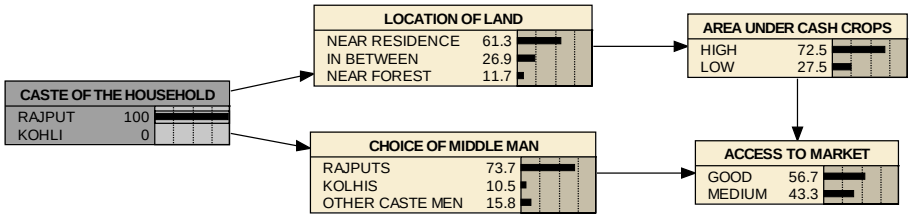
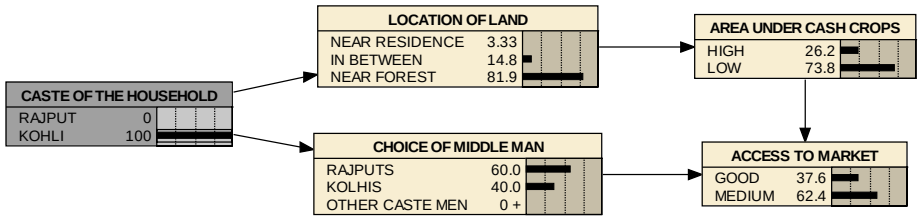


Fig. 3 Scenarios for Illustration (Probability values in %)

a. Domination of Rajputs



b. Suppression of Kohlis



c. Role of Market in Influencing the Demand for irrigation