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Integration of Policies in Framing Water Management Problem

Analysing Policy Processes using a Bayesian Network[1]

Saravanan V. Subramanian

[1] The paper is dedicated to Prof. Geoff T McDonald and Dr. Basil von Horen.

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Abstract

While there is growing realization that IWRM policy packages are exploited by various actors, there is inadequate understanding of the integration of these in shaping and reshaping water management. This paper contributes to this understanding by analyzing this policy process using Bayesian network tool from a case study in the Indian Himalayas. The analysis reveals that multifaceted governance arrangement influencing water management. The paper reveals that in such regime, policies are never implemented, but integrated through the negotiation of diverse other policies and socio-cultural settings in shaping water resource management. In such an regime, the paper calls for policies to lay-out broad principles for multiple actors to debate and negotiate diverse other policy packages for an informed decision.

Keywords:
Policy processes; policy modeling; integrated management; Bayesian network; South Asia.

Introduction

The formulation and implementation of policy packages (consisting of 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 resource management. While, there is growing realisation that such policy packages are exploited by various actors claiming competencies and legitimacy (eg, Allan, 2006; Cardwell et al, 2006; Mollinga, 2007; Mostert, 2006; see Water Alternatives, Volume 1, Number 1), there is an inadequate understanding of the integration of these packages across levels in shaping and reshaping water management in a given socio-political and ecological context. This paper makes a contribution by examining the integration of policies in framing the water management problem with the aim to strengthen the developmental role of the state (Fritz and Menocal, 2007). We assume the best way to understand policy integration in practice is to examine various actors (government and others) who draw on diverse rules (and exploiting contextual factors) to integrate their diverse policies in shaping and reshaping water management. This proposition is examined in a case study hamlet in a watershed in the Indian Himalayas. In particular, the role of diverse actors is identified (along with contextual factors), as well as the functioning of rules, in framing water management problems.

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 organisations, national and international organisations, 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 diverse actors represent a complex process of policy integration in shaping and reshaping water resource management. There is a growing body of literature highlighting the importance of policy integration[2] for sustainable development (eg., Lafferty and Hovden, 2003; Lenschow, 2004; Janicke and Jacob, 2005). While most studies focus on integration of strategies, structures and processes within governmental institutions, the attempt to examine the integration across socio-ecological systems in influencing policy processes is much less common. The paper applies a Bayesian network approach to unravel the complex integration of policies supported by qualitative analysis of the decision rules and context for analysing policy integration as a process. The following section highlights the significance of applying a Bayesian network approach as an analytical tool to overcome some of its limitations facing researchers. The third section outlines a systems approach for analysing 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 final section draws implications of integrated water management research and policy.

[2] A similar emphasis is placed among literatures on policy processes (eg. Sabatier, 1999; Keeley and Scoones, 1999; Sutton, 1999; IDS, 2006). These literatures highlight three themes - policy discourse, politics and actor-network, without offering insights on the inter-relation between them and ignore the developmental role of the state.

Bayesian Network as an Analytical Tool

Bayesian network is a modelling tool that quantifies the relationship among variables, even if the relationships involve uncertainty, unpredictability or imprecision. It is based on probability calculus following Bayes'[3] 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 network (BN) has gained prominence as a Decision Support System (DSS) for integrated water resource management (Batchelor and Cain, 1999; Cain, 2001; Bromley, 2005). Studies[4] that apply BN for Integrated Water Resource Management (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 impacts of water allocation decisions that might have on farmers using BN. Batchelor and Cain (1999) highlight the benefits of the BN in allowing simple, integrated methodology for modelling complex systems. Molina et. al. (2005) apply BN to predict and manage floods through spatio-temporal hydrological modelling. Borsuk et al (2001) used BN to integrate combination of process-based models, 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 to phosphorus management in a small catchment in Utah. These studies have demonstrated the BN is a powerful tool for understanding the inter-linkages among variables that connect physical, economic and social variables (Batchelor & 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, encouraging interdisciplinary discussions; (ii) suitability for small and incomplete data sets; (ii) ability to specify the relationships among variables; (iii) flexibility to incorporate expert knowledge on the same basis as including objectively derived data; and (iv) explicit treatment of uncertainty in environmental systems. Barton et al., (2008) highlight the following aspects of the BN: (i) limitations in capturing feed-back effects in process dynamics, (ii) a tendency of over-complexity of network structure relative to the scale of the management problem, (iii) sensitivity to discretisation of probability distributions, (iv) cumulative uncertainty and resulting insensitivity of environmental objective variables to measures, (v) selecting validation techniques, (vi) implicit assumptions of geographical and temporal scale of variables, and (vii) correct specifications of correlation between probability distributions.

The past studies apply BN as a decision support tool to inform *how to integrate* water resource management. The problem with this approach is the existence of a perceived logic (among research communities) on what (variables) to integrate is driven by a theoretical argument in data collection. In the process the researchers attempt to marshal[5] those theoretically-relevant variables (and its potential linkages) for understanding the 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 seeing the network to describe an event or a situation rather as a stable entity. Third, the Bayesian network is often considered as an all encompassing model to illustrate the interaction process

[3] Thomas Bayes was an 18th Century English clergyman, who is known for Bayesian Probability theory.
[4] Also refer to the Special Issue on Bayesian belief network in the Canadian Journal of Forest Research Vol.36, Issue 12, 2006.
[5] Though participatory approaches are applied, they provide broad and consensual information and are therefore rarely able to capture the less explicit information.

for management decision, ignoring the conventional qualitative 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 Systems Approach

This paper applies the institutional integration framework developed by Saravanan (2008) to understand the framing of water management problems. 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), to analyse the integration of policies. The framework represents a processes, where multiple actors apply their rules to negotiate policies to frame water management problems, distribute water resources, and in capacity building of strategic actors (Fig. 1). These collectively structure a water management problem in a region. Given a problem, strategic actors are active in evolving adaptive strategies through agents of institutional change (or agency). These agents, draw on existing rules to build their transformative capacity or power, which they actively negotiated with other agents in bringing out necessary changes to overcome inadequacies in the existing policy packages. The framework is influenced by three situational variables, the prevailing rules, characteristics of stakeholders, and existing bio-physical resources.

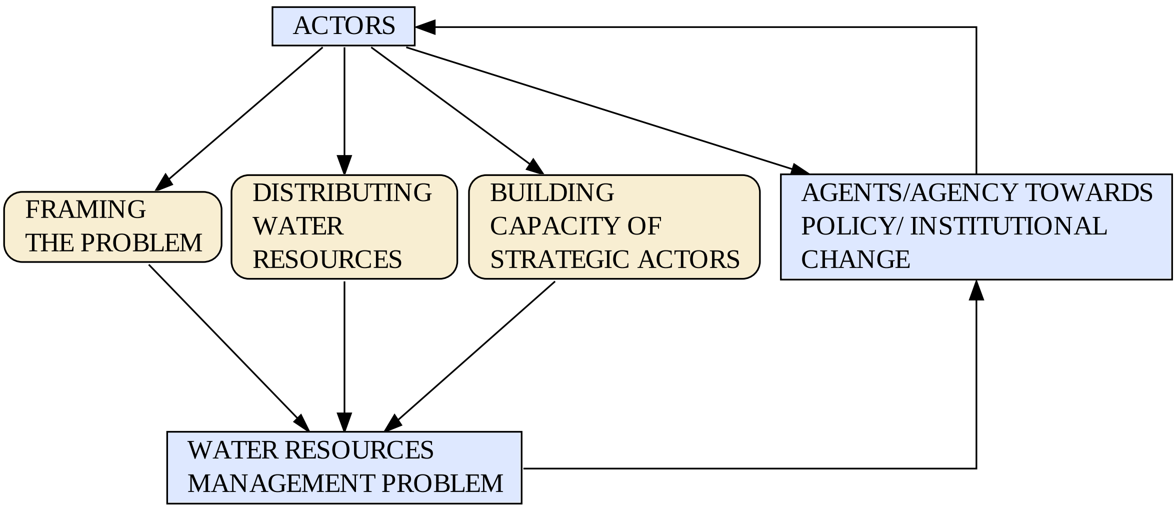

Fig. 1 Framework for Analysing Integration of Policy Processes

Rules are patterned behaviours of a social group, evolved over a period (Mitchell, 1975; Burns and Flam, 1987; 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 in arenas, 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 for 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 organisations having an incumbent role and possess a unique social identity. Agents are human individuals possessing a transformative capacity and are members among the actors. The bio-physical resources are drawn along with rules by actors and agents.

Actors and/or agents and rules (along with bio-physical resources) interact in the policy arena. Arenas are social settings accessed, activated and created in a strategic context, for agents to contest, negotiate, dominate and exchange goods and services, 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 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. These networks describe a coordinated set of heterogeneous human entities interacting more or less successfully to develop, produce, distribute and diffuse methods for generating goods and services (Callon, 1991). Such a network highlights the power relations and its ability to emphasise the contribution of micro-scale actions to large-scale outcomes (Klijn and Koppenjan, 2000). 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 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 decision-making process. These characteristics make the policy process adaptive and dynamic. For analytical purposes, the framework represents a cyclical process, though in real life, interaction among variables is a complex messy process of shaping and reshaping policies. Such a framework embraces the themes – policy narratives, actor-network and politics, but goes beyond in placing them in an institutional context that takes the developmental role of the state.

Methodology

A 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 perceived or framed differently by different actors depending on the strategic context. For the purpose of this paper, water management problem are perceived by the communities in the watershed to understand the integration of policies that shapes their perception. It is only during this problem-context that human entities having a shared vision are triggered to make a well-informed strategic choice (in contrast to their static roles and responsibilities) in the socio-political process of water management. Furthermore, in such a problem-context there is 'a definite ordering and models of complexities' (Crothers, 1999, p. 221) that can be established for the analysis.

Herein, ethnomethodology is applied in a pragmatic and contextual nature to describe the ways in which local communities make sense of their world to frame the water management problem. This approach enables one to capture the assumptions and practices through which the most commonplace activities and experiences are framed by local communities (Pollener, 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 yearlong 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 discussion (12), participatory mapping exercises (resource mapping, transects and wealth ranking), and participant observation. The combination of information gathering helped to contextualise information, and also to obtain both quantitative and qualitative input to more comprehensively understand the water management problem.

Data collected were analysed statistically, through qualitative interviews and logical reasoning to draw on selected variables that influence the framing of the water management problem. These selected variables were then applied in a Bayesian network to describe the integration of actors and rules (along with contextual factors) in framing of the water management 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 information obtained from field research or through the logical reasoning of the researcher, or a combination of all 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.

Rampur Watershed – Competing Terrain for Resource Management

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

The Rampur 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 (as on 2002) spread over 6 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[6]) 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) Rampur and Nichala (meaning down the mountain) Rampur. The Uppala Rampur was chosen to understand the integration of policies that facilitate the households in framing the water management problems in the area.

Agriculture contributes 60 percent of the average household income (the average household income of the sampled households in 2004 were Indian Rupees 68,737) in Uppala Rampur. It supplements 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 Rampur, where staple food crops are grown for subsistence between October to March, and vegetables (tomato, okra, chilly, turmeric, and ginger) from March to July. At Uppala Rampur, the vegetables are organically grown in rainfed conditions, in addition to the staple food grains (maize, ragi and wheat). It has loamy soil, enabling good production.

The history of Uppala Rampur dates back to 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 Rampur) occupied and owned (as landlords) most of the resources, such as land, water and forest. To meet the labour 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[7] in 1960's, attempted to obscure the distinction between

[6] 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.

[7] 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.

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 Rajputs. The conferment of Statehood in 1971 led to planned development in the state. One of the early initiatives of the Five Year Plan[8] in the state gave priority to agriculture and infrastructure development. The watershed region witnessed electricity connection in 1967-68, road access to nearby townships in the 1970s, introduction of bus services, the establishment of educational institutes, health services, and access to telephones during the 1990s[9]. 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 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 Mid-Himalayan watershed development programme[10], and the Department for International Development[11] (DfID) 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 these agencies (national and international) has their own jurisdiction or sector (such as water, forest, floods) for management. In the process, they compete[12] among each other claiming superiority over the physical and social implementation programmes and also claiming superiority in their impacts. Though these policies and programmes have opened-up the subsistence economy to a market-oriented economy, these developments have significantly constrained the available water resources in the watershed.

Results - Agriculture Prosperity Leading to Demand for Water in Uppala Rampur

In Uppala Rampur, 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[13]. This has led community leaders to demand lift irrigation (through letters to the District Collector or Member of the Legislative Assembly-MLA in the region) from the government to overcome water scarcity in the hamlet. Though

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[8] 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.

[9] 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 Rampur village.

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

[11] The DfID programme is targeted towards forest management through integrated an development programme, while the government of Japan aims to manage floods.

[12] The District Project Officer, DRDA Sohan, 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 DfID programmes allocates more money per hectare and considers an integrated approach within the watershed by linking with livelihood activities.

[13] 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 above sea level.

there is a large number of variables (such as education, social network, knowledge, gender and others), 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 control who the actors are and how they should take decisions (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 (infrastructure facilities), and statutory private actors (completion from markets and campaign on CBWM). These boundary variables offer various positions to actors. 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 'perception of CBWM' influenced by the boundary variable – 'campaign for CBWM'.

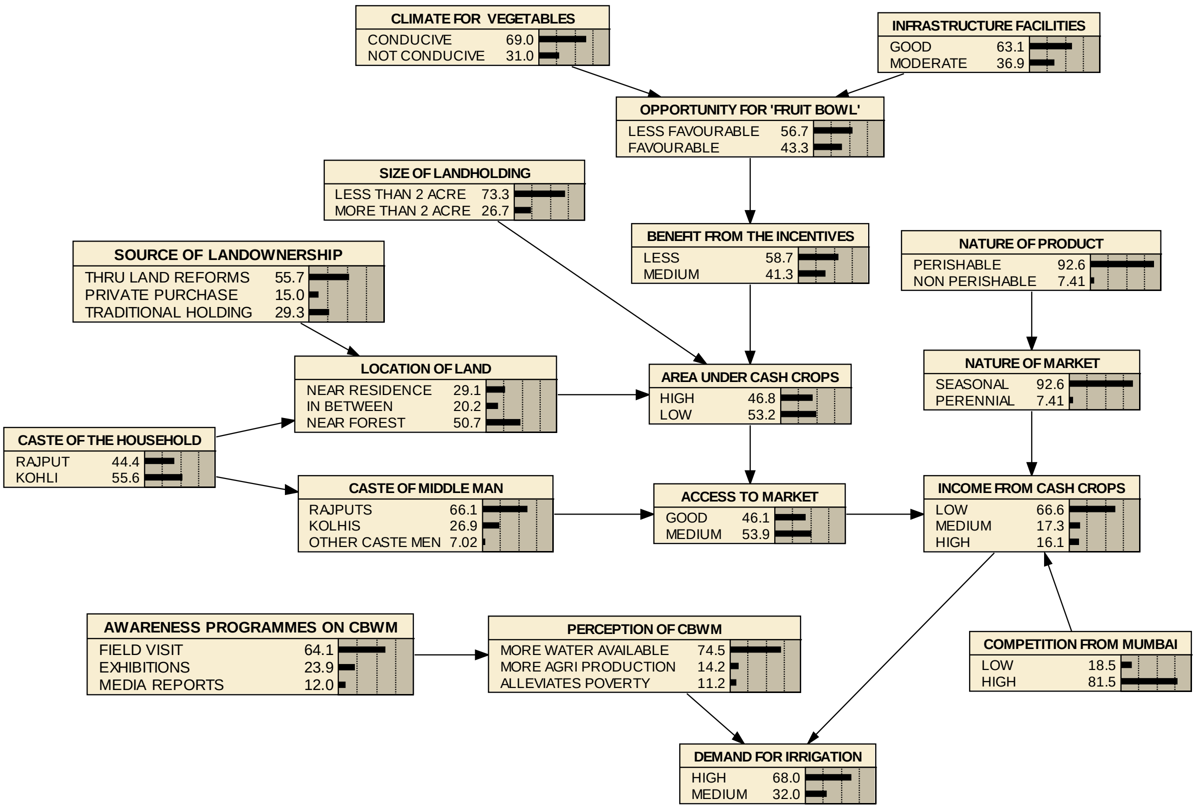


Fig.2 Variables Influencing the Demand for Irrigation in Uppala Rampur

Table 1. A Summary of Variables Framing the Demand for Irrigation

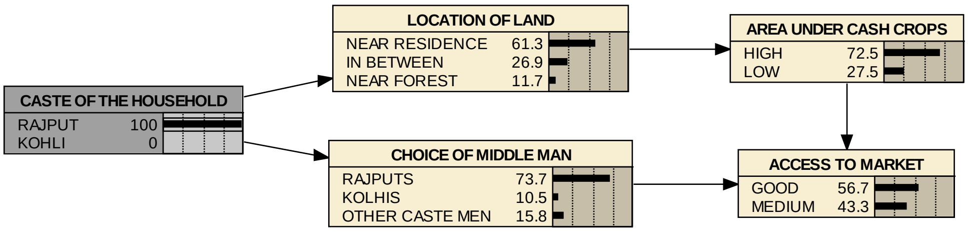
VARIABLES	CONTEXTUAL FACTORS	STATUTORY ACTORS	SOCIALLY-EMBEDDED ACTORS
Boundary			
Climate for Vegetables[1]	Climate	-	
Infrastructure Facilities[1]	-	GoHP	
Size of Landholding	History	-	
Source of Land ownership	History	GoI/ GoHP	
Caste of the Household	History	-	Caste
Awareness on CBWM	-	GoI/ GoHP/ DfID/ 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: 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; DfID- Department for International Development; WB – World Bank.

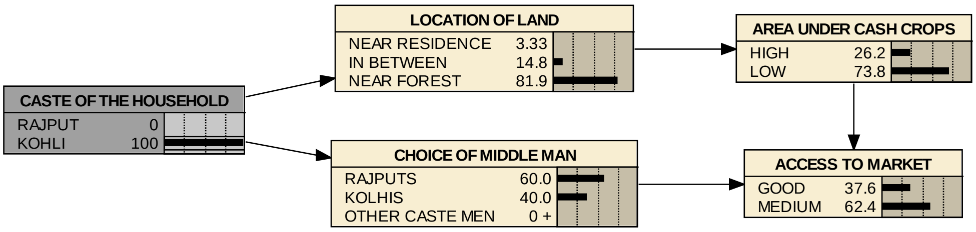
The boundary variables 'caste of the household' and 'source of landownership' offer positions to actors through 'location of land'. In this hamlet, there is a 55 percent probability that a household will be from the Kolhis, rather than the Rajputs community. The BN shows that if all households were Rajputs, there would be a 61 percent probability of land being near to the residence (Fig. 3.a). 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 to 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. 3 b). 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.

Fig. 3 Scenarios for Illustration

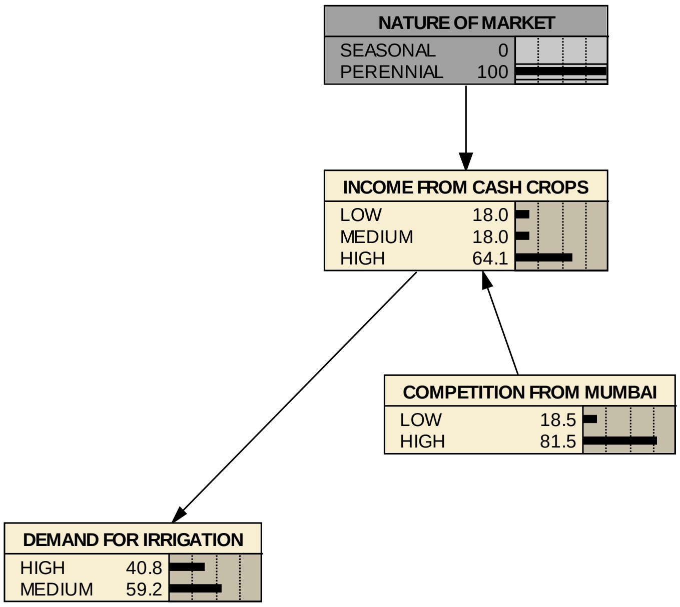
a. Domination of Rajputs



b. Suppression of Kohlis



c. Role of Market in Influencing the Demand for irrigation



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 Rampur, 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 labour requirements and is easier to protect from wild animals. In contrast, land near the forest is not suitable for growing cash crops or food grains; due to the distance of these holdings more labour is required for activities such as weeding and watering, and also because the crops are prone to attacks from wild animals. The importance played by 'location of land' makes the, 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. An official in charge of horticulture promotion in the region claims that such an initiative will increase the production of cash crops in the region and so alleviate poverty. This program has led government and market players offering various incentives for 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 of this programme offering the opportunity for the state to become a 'fruit-bowl' of India, with the rest claiming that the programme is less favourable. 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, while market players (unregulated by the state) have more middlemen willing to buy cash crops from villages than before and have informal social networks for marketing produce. Though these have offered opportunities for opening-up the village economy, as Mr. Subhash Mendhapurkar, Director of a non-government organisation Social Upliftment for Rural Action (SUTRA) claimed during interviews, 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". 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 centres who exploit us". The probability a household perceives less 'benefit from these incentives' (59 percent probability) is higher, than those who perceive a 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) does not make the household eligible 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*[14] (whole sale market centres in urban centres). 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 offer of 5-8 Indian Rupees (INR) per kilo of tomato in 2004, and 12-14 INR per kilo for ginger, was categorised as good, while the middlemen from other castes offered less and were categorised as medium. As Rajput middlemen had kinship with Rajput households (who were also large landowners, had their 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 options than selling to the Rajput middlemen because they produce less quantity and prefer to gain from the price though some were socially pressurised by Rajputs. A few Kohli households did engage with two middlemen who were not Rajputs, but these offered a lower price and could not compete with 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 Rampur to get good 'access to market', they have to be Rajputs, Rajputs were chosen as

[14] 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.

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% 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% probability) and therefore have a seasonal market (93 % 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 from cash crops; income was considered to be low if the annual earnings from cash crops was less than Indian rupees 20,000. 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. These low returns from cash crops have led to a demand from farmers for irrigation or water harvesting structures that can supplement water during dry months and utilise the comparative advantage over the Indian vegetable market.

The authority variable, 'income from cash crops', is the deciding factor for households in the demand for an irrigation system. Households surveyed through structured interviews claimed "water supply through irrigation schemes can enhance income from cash crops". This is often legitimised by media, government, NGOs and international agencies portraying 'catching water where it falls' as a solution to overcome water scarcity. The boundary variables 'campaign for CBWM' by national and international agencies play an influential role through exposure field visits (organised by project implementing agencies), promotional materials (posters and documents), and sharing success stories from experiments elsewhere in the world. This helps households to frame the water related problem in the hamlet, with a 67 percent probability of a household demanding 'high' priority for an irrigation scheme in their hamlet.

The President of the Rampur Watershed Committee, a leader among the Rajputs and also a lead farmer in the hamlet, has made various pleas to the government and politician 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; it is strategic, since he blames the educational status of the Kohli community for the situation. 'It is difficult to educate the poor households (generally he refers to Kohli community) to cultivate cash crops'… 'I am planting new horticulture crops, in discussion with experts, to show these people that the benefits that they could gain are enormous'. The social and historical problems, such as land being located near the forest and limited landholdings among the poor households, are considered to be 'fate endowed upon them'. The choice is also spontaneous as he capitalizes on market, national and international agencies to establish his social and economic status in the village. It is this ability to capitalize that makes him an agent for institutional change.

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 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, 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 IWRM

Different variables are influenced by multiple actors exploiting contextual factors, and drawing on diverse rules in framing the households demand for irrigation in the hamlet. The boundary rules are set by contextual factors (climate, landholding size etc.), socially-embedded actors (e.g caste) and by 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 rules 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 where it falls', enables households to frame their demand for irrigation facilities in their hamlet.

Multiple actors exploit the contextual factors to adopt a 'fire-fighting' approach depending on their own assessments of the situation. In the process, they cumulatively and incrementally integrate in framing the water 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 DfID in the hamlet. Often these packages are programmed by defining the 'nuts and bolts' and '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 organisations, which are deceptive in their presentation and remain a 'black-box' in the Indian democracy.

The inadequate understanding of the contextual factors by government agencies, along with international agencies, is exploited by other actors. The market is uncontrolled and functions through middlemen and brokers who interact with watershed communities through social networks. 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 employment and targeted poverty alleviation programmes. Both factors play a significant role in improving improvished areas, especially in the remotely located and culturally secluded watersheds in the Indian Himalayas, like Rampur[15]. 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 market is open and driven by price; rarely does the government interfere in regulating the functioning of markets. Interestingly, international agencies community-based programmes (such as DfID's and ministry of rural developments through IWDP) fail to convince households to work towards solution in water scarcity, in fact, these organizations promote an inaccurate image of the infinite nature of water.

What is important in all these government (or through international agencies) initiated policy packages is the absence of information rules that can enable all actors to make informed decisions in the sustainable management of water. The focus is more in a comprehensive assessment of various options prior to making policies, and to facilitate other actors to debate and share the available information for making informed, water related decisions. It is not necessary for governmental agencies to get policies

[15] A study in the plains of Himachal Pradesh revealed infrastructure facilities (roads, education and health) had significantly blurred the relationship among various castes (see Saravanan, 2008).

right, rather they need to lay-out broad principles that can be shared and debated by multiple actors to negotiate and renegotiate water management; all the while taking into consideration the diverse needs of stakeholders in the many different contexts. To enable these multiple actors to take informed decisions, governments therefore need to strengthen the existing infrastructure facilities, such as roads, telecommunications, mass media, and set-up help-line centres in government institutions that allow actors to interact and seek various options for desired outcomes. Such an approach would require government agencies to be forthcoming in sharing information for awareness creation and willingness to adapt the existing policies and programmes depending on context (through helpline services in government departments). Equally important for the government agencies is to regulate the distribution of water resources, build capacity of strategic actors and facilitate agents of institutional change for a comprehensive facilitation for the integration of policy process.

Conclusion

The paper highlights the usefulness of Bayesian networks to describe policy integration across space and time in framing the water management problem. While the sensitivity to discretisation of probability distribution remains, 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 taking complexity in 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 recognised 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.

The analysis reveals that water is managed incrementally and cumulatively by different forms of governance arrangements (state-centric, market or community-based). In this multifaceted governance arrangement policies are never implemented, but integrated through the negotiation of diverse policies and socio-cultural settings in shaping water resource 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. This paper calls for de-emphasising the precondition of policy packages for resource management. Instead, emphasis should be placed on laying out broad principles as policies that can be debated and shared among diverse actors to negotiate diverse policy packages, along with conventional governance instruments to regulate the distribution of water resources, build capacity of strategic actors, and facilitate agents of institutional change towards a comprehensive approach for the sustainable management of water resources. This will require harnessing the strengths of diverse instruments of governance, (such as legislations, programmes, incentives and disincentives), that enable the government to design rules, and at the same time, facilitate other actors to design rules.

Annexure

Annexure 1. Details of Variables Framing Water Demand – Uppala Rampur

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/ DfID	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; DfID- Department for International Development.

References

Allan, T., 2003. “IWRM/IWRAM: A new sanctioned discourse”, *SOAS Water Issues Study Group Occasional Paper. 50,* School of Oriental and African Studies/ King's College London, University of London, London.

Ames, D. P., Nielson, B. T., Stevens, D. K. and Lall, U., 2005. “Using Bayesian networks to model watershed management decisions: An east canyon creek case study”, *Journal of Hydroinformatics,* 7(4), 267-282.

Barton, D., Saloranta, T., Moe, S. J., Eggestad, H. O. and Kuikka, S., 2008. “Bayesian belief networks as a meta-modelling tool in integrated river basin management — pros and cons in evaluating nutrient abatement decisions under uncertainty in a Norwegian river basin,” *Ecological Economics,* 66, 91-104.

Batchelor, C. and Cain, D. J., 1999. “Application of belief networks to water management studies,” *Agricultural Water Management,* 40 (1), 51-57.

Borsuk, M., Clemen, R., Magure, L. and Reckhow, K., 2001. “Stakeholder values and scientific modelling in the Neuse river watershed,” *Group Decision and Negotiation,* 10, 355-373.

Bromley, J., 2005. *Guidelines for the use of Bayesian networks as a participatory tool for water resource management,* Centre for Ecology and Hydrology, Wallingford, Oxford.

Cain, D. J., 2001. *Planning improvements in natural resources management : Guidelines for using Bayesian networks to support the planning and management of development programmes in the water sector and beyond,* Centre for Ecology and Hydrology, Wallingford, Oxford.

Callon, M., 1991. “Techno-economic networks and irreversibility,” in: J. Law (Ed.) *A sociology of monsters: Essays on power, technology and domination.* London and New York, Routledge).

Campbell, L. J., 1998. “Institutional analysis and the role of ideas in political economy,” *Theory and Society,* 27, 377-409.

Cardwell, E. H., Cole, A. R., Cartwright, A. L. and Martin, A. L., 2006. “Integrated water resources management: Definitions and conceptual musings,” *Journal of Contemporary Water Research and Education,* 135, 8-18.

Crothers, C., 1999. “Let's get real: Developing realist approaches within the philosophy of social science,” *South African Journal of Philosophy,* 18(2).

Dorcey, A. H. J., 1986. *Bargaining in the governance of pacific coastal resources: Research and reform,* Northburn Printers and Stationers Ltd. University of British Columbia Press, British Columbia.

Dowding, K., 1995. “Model or metaphor? A critical review of the policy network approach,” *Political Studies.,* XLIII, 136-158.

Fritz, V. and Menocal, R. A., 2007.”Developmental states in the new millennium: Concepts and challenges for a new aid agenda,” *Development Policy Review,* 25(5), 531-552.

Garfinkel, H., 1974. *Studies in ethnomethodology,* Polity Press, Cambridge.

GoHP, 2004. *Draft annual plan (2003-2004).* Report for Planning Department, Government of Himachal Pradesh, Shimla.

GoI, 2006. *From hariyali to neeranchal: Report of the technical committee on watershed programmes in India,* Department of Land Resources, Ministry of Rural Development, Government of India, New Delhi.

GoI, 2008. *Common guidelines for watershed development projects,* Report for Government of India New Delhi.

Gunderson, L. H. and Holling, C. S. (Eds.), 2002. *Panarchy: Understanding transformations in human and natural systems,* Island Press, Washington D C.

IDS (2006) *Understanding policy processes: A review of IDS research on the environment.* Report for Knowledge, Technology and Society Team, Institute of Development Studies, University of Sussex, Sussex.

Janicke, M. and Jacob, A. (Eds.), 2005. *Environmental governance in a global perspective: New approaches to ecological and political modernisation,* Free University of Berlin, Berlin.

Keeley, J. and Scoones, I., 1999. Understanding environmental policy processes: A review. *IDS Working Paper. 89,* Institute of Development Studies, Sussex.

Klijn, E.-H., 1996."Analyzing and managing policy processes in complex networks: A theoretical examining of the concept policy network and its problems," *Administration and Society,* 28(1), 90-119.

Klijn, E.-H. and Koppenjan, J. F. M., 2000. "Public management and policy networks: Foundations of a network approach to governance," *Public Management,* 2(2), 135-158.

Lafferty, W. and Hovden, E., 2003. "Environmental policy integration: Towards an analytical framework," *Environmental Politics,* 12(3), 1-22.

Lenschow, A. (Ed.), 2002. *Environmental policy integration: Greening sectoral policies in Europe,* Earthscan, London.

Livingston, M. L., 1987. "Evaluating the performance of environmental policy: Contributions of neoclassical, public choice, and institutional models," *Journal of Economic Issues,* 21(1), 281-294.

Long, N., 2001. *Development sociology: Actor perspectives,* Routledge, London and New York.

Mitchell, B. (Ed.), 1975. *Institutional arrangements for water management: Canadian experiences.* Department of Geography, Faculty of Environmental Studies, University of Waterloo,Ontario.

Molina, M., Fuentetaja, R. and Garrote, L., 2005. "Hydrologic models for emergency decision support using Bayesian networks," *ECSQARU*.

Mollinga, P., Meinzen-Dick, R. S. and Merrey, J. D., 2007. "Politics, plurality and problemsheds: A strategic approach for reform of agricultural water resources management," *Development Policy Review,* 25(6), 699-719.

Mostert, E., 2006. "Integrated water resources management in the Netherlands: How concepts function?," *Journal of Contemporary Water Research and Education,* 135, 19-27.

Ostrom, E., 1998. "The institutional analysis and development approach," in: E. T. Loehman and D. M. Kilgour (Eds) *Designing institutions for environmental and resource management.* Massachusetts, Edward Edgar Publishing Limited), 68-90.

Ostrom, E., Gardner, R. and Walker, J., 1994. *Institutional analysis and common-pool resources,* The University of Michigan Press, Ann Arbor.

Pollner, M., 1987. *Mundane reason: Reality in everyday and sociological discourse,* Cambridge University Press, Cambridge.

Robertson, D. and Wang, Q. J., 2004. "Bayesian networks for decision analysis - an application to irrigation system selection," *Australian Journal of Experimental Agriculture,* 44, 145-150.

Sabatier, P. A., 1999. "Fostering the development of policy theory," in: P. A. Sabatier (Ed.) *Theories of policy process.* Westview Press, Colorado, United States and Oxford, United Kingdom, 261-275.

Saravanan, V. S., 2008. "A systems approach to unravel complex water management institutions," *Ecological Complexity,* 5(3), 202-215.

Shah, M., 2006. "Towards reforms," *Economic and Political Weekly,* 41(26-27), 2981-2984, July 8.

Sutton, R., 1999. The policy process: An overview. *Overseas Development Institute Working Paper. 118,* Overseas Development Institute, London.

Tribune, The., 2000. HP to be made fruit bowl of India: CM, *The Tribune*. January 20.

Uusitalo, L., 2007. "Advantages and challenges of Bayesian networks in environmental modelling," *Ecological Modelling,* 203(3-4), 312-318.

Varis, O. and Kuikka, S., 1999. "Learning Bayesian decision analysis by doing: Lessons from environmental and natural resource management," *Ecological Modelling,* 119.(177-195).

Varis, O. and Lahtela, V., 2002. "Integrated water resources management along the Senegal river: Introducing an analytical framework," *Water Resources Development,* 18(4), 501-521.

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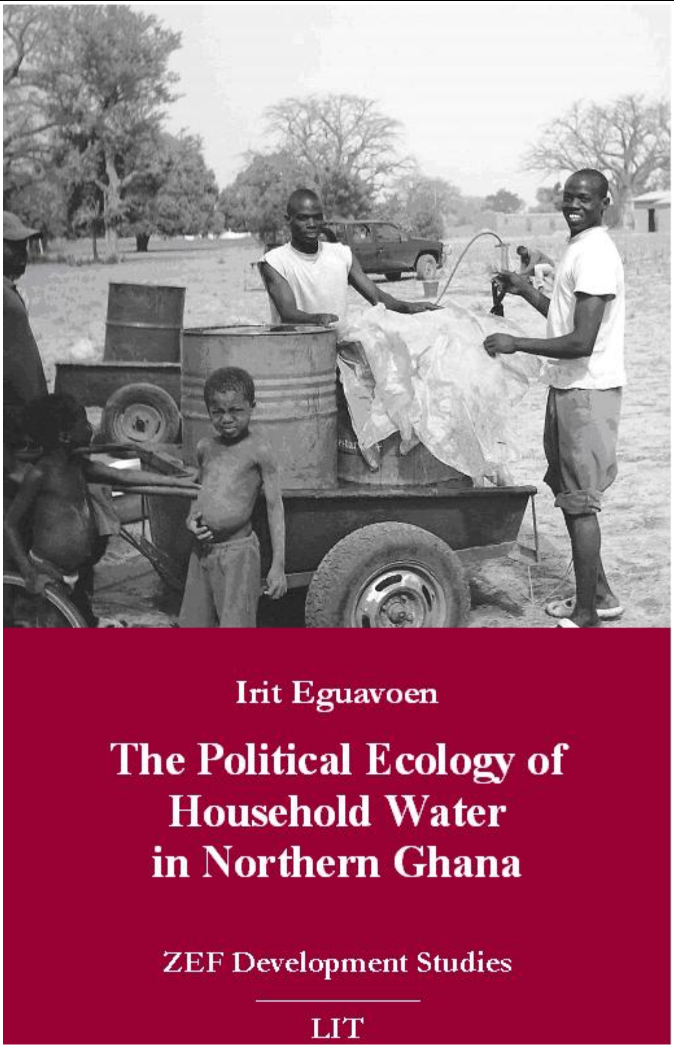

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