A Bayesian belief network synthesises complex interactions between irrigation-driven land development, diffuse pollution, and land and water values in a New Zealand watershed.

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There is considerable interest in expansion of irrigated agriculture on plains and inland alluvial basins of the east coast of the South Island of New Zealand, where low rainfall constrains agricultural intensification. This raises complex questions about: (i) How much irrigation-driven intensification can occur without diffuse pollution and effects of irrigation-infrastructure (e.g., dams, river flow regimes) degrading aquatic values? (2) Can application of diffuse pollution mitigation tools control aquatic impacts within acceptable limits? and (3) How does agricultural intensification and mitigation effect on-farm and regional economic indicators?

This paper describes a Bayesian Belief Network (BBN) that links a wide variety of economic, water quality and aquatic ecological values to guide management of irrigation-driven land use intensification in the Culverden Basin of the 2500 km^2 Hurunui River catchment (Fig. 1). The Basin's irrigated agricultural area has potential to increase from the current 16,800 ha (irrigated since 1980s) to 42,000 ha. Monitoring of the Hurunui River upstream and downstream of the basin since 1989 has shown increasing nitrate at the downstream site, where dissolved reactive phosphorus increased until 2000 then declined 35% to 2010 as irrigation methods were improved to reduce "irrigation wipe-off" and associated periphyton blooms in the river (exceeding the Environment Canterbury's Plan standard of 20% filamentous algal cover). The basin-average groundwater nitrate concentration is 35% of the drinking water standard, and average nitrate-N concentrations of 3 of 4 basin tributaries exceed a toxicity protection guideline (1.7 mg/l).

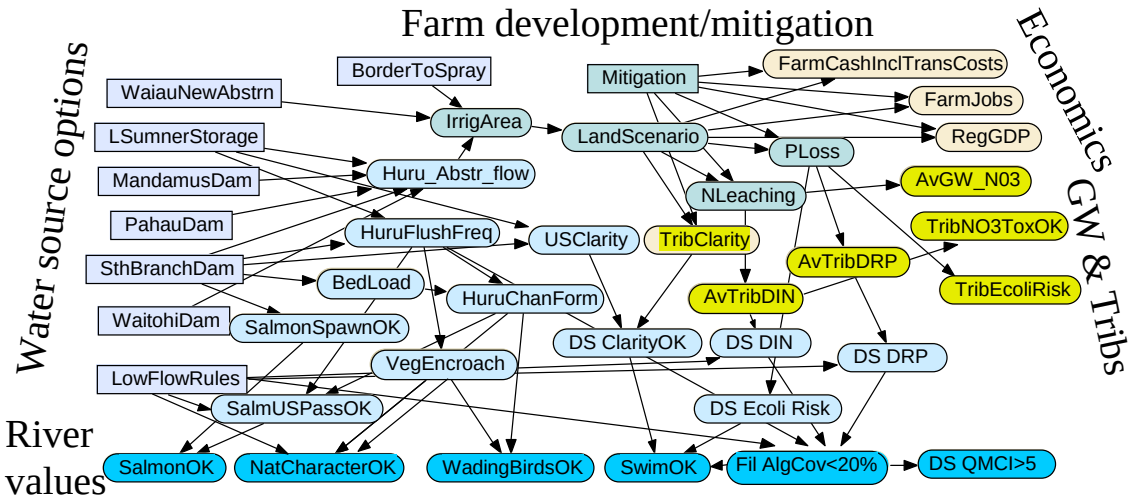

Figure 1.1 Linkage model showing the relationships between catchment drivers associated with irrigation-driven land use intensification and key economic and aquatic values included in the BBN. US, DS = Hurunui River upstream and downstream of the Culverden basin. GW =groundwater. GDP = Gross Domestic Product. QMCI = Quantitative Macroinvertebrate Community Index.

The BBN development drew on a range of information sources, including stakeholder workshops to identify key values, linked land management/nutrient loss and groundwater models, published information, expert knowledge and 20 years of monitoring river water quality, periphyton and invertebrates. It was used to examine the effects on a range of aquatic and economic values of four scenarios for land development with and without a suite of mitigations (i.e., conversion from flood (border-dyke) to spray irrigation, nitrification inhibitors, riparian buffers, nutrient management, dairy herd wintering shelters and wetlands), and use of different irrigation water sources. These scenarios were: (i) Current state; (ii) Business and Usual (BAU), involving increased intensity of stocking rate in line with historic trends, and increased irrigated area from efficiency gains; (iii) 1990-95 Hurunui Water Quality Target, requiring 10% reduction in P in the mainstem and 20% reduction in N in the tributaries but allowing some increased irrigation due to mitigation use, and (iv) New Water, increasing irrigated area to 42,000 ha. Six options for irrigation water supply were considered.

The BBN predictions for various combinations of land development scenario, water source and mitigation (defined above) are summarised in Figure 1.2. The BBN predicts full irrigation development, with a suite of mitigation measures applied and water sourced from elsewhere than a dam on the South Branch (that dominates flow variability and bedload in the lower river), will result in strong increases in farm jobs and regional GDP, modest increases in Farm Cash Surplus (after allowing for development costs), and minor improvements in aquatic values. In contrast, full irrigation development with water sourced from a South Branch dam is predicted to degrade the river for salmon and wading birds, because this branch provides much of the flow-variability and bed-load in the lower river and is a key salmon spawning area.

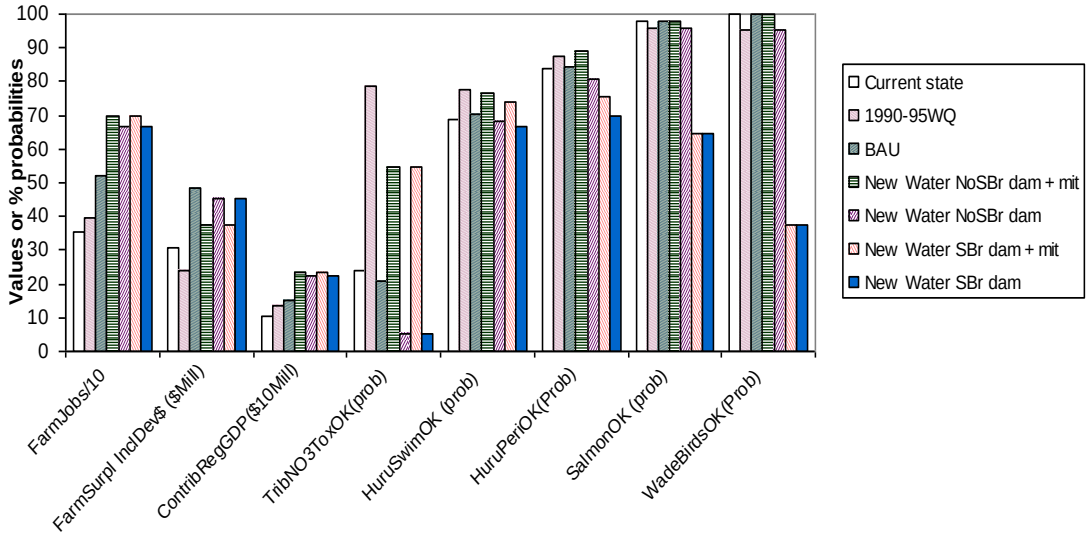

Figure 1.2 Summary of BBN predictions for key economic and aquatic values under the current state and 3 land development scenarios, including water source and with/without a full suite of land management mitigations (see text). S Br = South Branch of the Hurunui that provides much of downstream flow variability and bedload.

This synthesis of a complex system enhances the ability to include aquatic values alongside economic and social values in land use and water resource planning and decision-making.