DATA MINING MULTIPLE STAKEHOLDERS' RESPONSES TO DECLINING *SCHIZOTHORAX* FISHERY IN THE LAKES OF KASHMIR, INDIA

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ABSTRACT

This study documented the historical perspective of lake fisheries in Kashmir, India, estimated the trends in fish production using the Kane's cross impact analysis and the stakeholders' willingness to pay (WTP) for the restoration of *Schizothorax* fishery in the lakes of Kashmir. The cross impacts of introduction of carps in the lakes of Kashmir on *Schizothorax* fishery and total fish production are evaluated by Kane's cross impact analysis. Considering the obvious shortcomings of logistic regression, Classification and Regression Trees (CART) has been used for data mining multiple stakeholders' responses to make a case for sustainable development of the *Schizothorax* fishery in the lakes of Kashmir. On the whole, time spent on the lakes to earn their livelihoods emerged as the root node, as the single most important variable that determined WTP of stakeholders followed by income, type of stakeholder and age in the tree model. The CART analysis not only yielded the variables that determined the WTP but the pruned tree gave the hierarchy of the variables that determined WTP. The results of the study strongly made a case for a concerted multi-institutional action plan for the restoration of *Schizothorax* fishery in the lakes of Kashmir.

Key words: Willingness to Pay, Kane's cross impact analysis (CIA), Classification and Regression Trees (CART, multiple stakeholders, lake fisheries, Kashmir, India

INTRODUCTION

Fisheries in lakes of Kashmir, India are facing multi-dimensional problems. On the one hand, we have an ever-growing demand for fish which is being fed by increasing carp production while on the other, the local choice fish of Kashmir, the *Schizothorax* is registering steadily declining landings (Qureshi 2013)[1]. The declining *Schizothorax* fishery has been caused by not only an inadvertent introduction of carps in the lakes of Kashmir but also by other issues like pollution caused by tourism, vegetable gardens, civic discharges and poor maintenance and up keep of the lake (J&K Tourism 2012[2] and Lakes and Waterways Development Authority(LAWDA))[a]

The two lakes Dal and Wular produce 70 per cent of the total fish production in the state of Jammu & Kashmir. The Dal and Wular lakes also have had a flourishing fishery but an examination of data on fish production shows a decline in fish catches in both these lakes. Though one of the objectives of the Department of Fisheries (DoF)[3] is to promote endemic fisheries, the accidental introduction of carps in Dal lake and heavy siltation in Wular lake compounded by other externalities have led to a consistent decline in the production of *Schizothorax*, the local fish species (Qureshi *et al*., 2013)[b][4]. In addition to introduction of carps, negative externalities of tourism, excessive fertilization of vegetable crops on floating gardens leading to algal blooms have all led to a consistent decline and destruction of the breeding grounds of the local fish species *Schizothorax*. The problem of fisheries in

Kashmir lakes is a double edged weapon. While on the one hand the primary stakeholders, the fishers and those who derive the primary income from lake fishery are in favor of *Schizothorax* fishery, on the other hand there is an urgent need to increase total fish production from the lakes to meet the ever increasing demand of the local consumers irrespective of the species (Qureshi *et al.*, 2013)[4]. The priorities get further complicated when we weigh the objectives of DoF vis-a-vis the department of tourism (DoT). The whole questions boils down to whether the lakes need to serve the interest of the primary stakeholders of the lake ie. the fishers or serve the larger interest of the state economy by generating increased revenue from tourism.

Trends in Fish Production.

Table 1 gives the data on total fish, carps and *Schizothorax* production in Dal (1981-2011) and Wular (1991-2012) lakes. The total fish production in the Dal lake has remained almost constant in absolute terms during 1980-2012. The maximum recorded catch was 4750 tonnes in 2003-04 and the minimum 2620 tonnes in 2007-08 in the Dal lake. In the Wular lake whose water spread area was once 252 square kilometers which has now shrunk to 24 square kilometers, produced, and all time high of 5820 tonnes in 2006-07 and a minimum of 1800 tonnesin 2007-08. It can be seen from the data that severity of fluctuations in catch is more pronounced in the recent years than in the earlier years. *Schizothorax*production in Dal (1980-2011) and Wular lakes (1990-2012) are also available in the same table. The maximum *Schizothorax* production was registered during the year with 6810 tonnes in the Dal in 2009-10 and 1560 tonnes in the Wular in 1995-96 and the lowest with 1630 tonnes in the Dal in 2000-01 and 500 tonnes in the Wular**.**

The trends in carp fish production are also not glowing. Carp production was maximum during the year 2009-10 with landings of 4000 tonnes in the Dal and 4100 tonnes in the Wular during the year 2005-06. It was the lowest in the Dal during 1983-84 with a catch of 1100 tonnes and in the Wular during 2008-09 with 1250 tonnes. In absolute numbers, the quantity of landings in the Dal appears to be evenly increasing during the entire period considered, the performance of carps in the Wular has been quite erratic especially in the end years.

Table I: Fish Production in Dal (1981-2011) and Wularlakes(1991-2012), Kashmir, India

('000 Tonnes)

S.no	Year	Carps		*Schizothorax*		Total catch	
		Dal lake	Wular lake	Dal lake	Wular lake	Dal lake	Wular lake
1	1980-81	1.13	-	2.535	-	4.66	-
2	1981-82	1.12	-	2.522	-	3.64	-
3	1982-83	1.10	-	2.485	-	3.58	-
4	1983-84	1.05	-	2.463	-	3.51	-
5	1984-85	1.24	-	2.425	-	3.66	-
6	1985-86	1.20	-	2.403	-	3.60	-
7	1986-87	1.32	-	2.142	-	3.46	-
8	1987-88	1.55	-	2.122	-	3.67	-

9	1988-89	1.60	-	2.203	-	3.80	-
10	1989-90	1.87	-	2.332	-	4.20	-
11	1990-91	1.82	2.70	2.352	1.11	4.17	3.81
12	1991-92	1.92	2.90	2.325	1.13	4.24	4.03
13	1992-93	2.01	3.10	2.256	1.15	4.26	4.49
14	1993-94	2.05	3.30	2.167	1.17	4.21	4.57
15	1994-95	2.10	3.50	2.148	1.19	4.25	4.67
16	1995-96	2.29	3.22	2.126	1.56	4.42	4.78
17	1996-97	2.43	2.58	2.252	0.76	4.68	3.34
18	1997-98	2.42	3.53	2.193	1.47	4.61	5.00
19	1998-99	2.40	3.31	2.21	1.42	4.61	4.73
20	1999-2000	2.45	3.78	2.1.2	1.00	4.64	4.78
21	2000-01	2.53	3.65	1.63	1.20	4.22	4.85
22	2001-02	2.62	3.91	1.74	1.02	4.37	4.36
23	2002-03	2.72	3.51	1.81	1.17	4.53	4.68
24	2003-04	2.82	3.39	1.92	1.31	4.75	4.70
25	2004-05	2.16	3.51	1.90	1.41	4.06	4.92
26	2005-06	2.22	4.10	2.06	1.05	4.26	5.15
27	2006-07	2.50	3.92	2.21	1.90	4.71	5.82
28	2007-08	2.38	1.30	2.37	0.50	2.62	1.80
29	2008-09	2.44	1.27	4.56	0.60	2.90	1.87
30	2009-10	4.01	1.39	6.81	0.80	4.70	2.19
31	2010-11	2.76	1.25	6.01	1.01	3.36	2.26
32	2011-12	--	1.41	NA	1.03	NA	2.44

Source: Department of Fisheries, Srinagar, Kashmir, India (2011)

Therefore the introduction of carps in the lakes of Kashmir seems to be a case more undone than done (Qureshi and Krishnan, 2014)[5]. A gain in terms of increased fish production seems to have been offset by a sacrifice of a species which is a local favorite. What are the implications of this inadvertent introduction? How do the different stakeholders look at the change it has made to their fish consumption preference schedule? What are their reactions to the major causal factors that are augmenting this decline? Are they willing to sacrifice a portion of their current income for saving their choice species? And what are the institutional arrangements that need to be put in place to help overcome the problem and set the balance of lake fishery in order? These are some of the questions that this paper attempts to answer.

Methodology

Study Area

The Dal and the Wular lakes were purposively selected for the study. The survey was conducted during October 2012 to January 2013. Secondary data were collected from various published sources, officials of Department of Fisheries, Srinagar, Sopore and Bandipore. Data were also collected from LAWDA, Srinagar. The responses of a total sample of 350 stakeholders consisting of fishers, traders, hotels and houseboat owners, fish consumers, tourists, faculty of fisheries, Sher-e-Kashmir University of Agricultural Science and Technology, Kashmir (SKUAST-K) and officials of the DoF, Jammu & Kashmir at Srinagar were sampled.

To arrive at an understanding of the behavior of carps, *Schizothorax* and total fish production in Dal and Wular lake Kashmir, Kane's cross impact simulation model was utilized for understanding the behavior of the data[c].

Therefore based on the hypothesis that introduction of carps and increased pollution and related anthropogenic issues have led to a declining fishery in the Dal and Wular lakes both in terms of total fish production as well as in the composition of catch, the CIA was felt to be the appropriate tool to forecast the future trend in fish production in the Dal and the Wular lakes of Kashmir (Kane 1972[6]; Lipinski,1979[7];Asan 2004[8] and Weimer-Jehle 2006)[9]. Kane's cross impact model was utilized for understanding the future trends in total fish ,carps and *Schizothorax* production in Dal and Wular lakes. The advantage of Kane's CIA is that the cross impacts of one action on another are evaluated which is not the case in trend line analysis where there is only a one to one analysis of one variable against time.

The Kane's cross impact analysis simulation model is given by

$$x_i(t+\Delta t)=\{x_i(t)\}^{p_i(t)} \qquad \text{(Eq.1)}$$

$$p_i(t)=\frac{1+\frac{\Delta t}{2}\sum_{j=1}^{N}\left(\left|\alpha_{ij}\right|-\alpha_{ij}\right)x_j}{1+\frac{\Delta t}{2}\sum_{j=1}^{N}\left(\left|\alpha_{ij}\right|+\alpha_{ij}\right)x_j} \qquad \text{(Eq.2)}$$

where

It can be noted that $p_i(t)$ is

$$p_i(t)=\frac{1+\Delta t\left(\text{sum of negative impacts on } x_i\right)}{1+\Delta t\left(\text{sum of positive impacts on } x_i\right)}.$$

The Kane's matrix was then prepared and a graphical representation of the impact was obtained[d].

Qureshi *et al*. (2013)[4] used logistic regression to estimate the willing to pay of eight different stakeholders for the restoration of *Schizothorax* fishery in the Dal and Wular lakes of Kashmir. The logistic regression has inherent weaknesses[e]. Classification and regression trees (CART) has a number of advantages over other classification methods, including multivariate logistic regression. It is a non-parametric approach. No assumptions are made in respect of the underlying distribution of values of the predictor variables.Therefore, CART is configured for numerical data that are highly skewed or multi-modal, as well as categorical predictors with either ordinal or non-ordinal structure. This is an important feature of CART, as it saves the time of the analyst spent in determining whether variables are normally distributed, and making transformation if they are not (Lewis, 2000)[10]

The tree based statistical model CART (Breiman *et al.*,1984)[11] was used for the analysis of the binary (dichotomous) responses. Merler and Furlanello (1996)[12] used CART for risk assessment of encephalitis in Italy. De'ath and Fabricus(2000)[13] used CART for ecological data analysis from the Australian Central Great Barrier Reef. CART reduces the computational complexity of exhaustive search methods (Shih, 2001)[14]. Kim and Loh (2001)[15] used univariate split methods and linear combination split methods for construction of classification trees with multiway splits, which enhanced the computational speed and classification accuracy of future observations.

Spruill *et al.*(2002)[16] used CART for determining the sources of nitrate contamination in ground water. Olden and Jackson (2002)[17] have compared logistic regression analysis, linear discriminant analysis and artificial neural networks (ANN) to model fish species distribution. It is interesting to note that classification trees and ANN greatly out perform traditional approaches. The regression tree models are able to capture important non linearities and interactions more appropriately than traditional linear models (Lobell *et al*. 2004)[18]. Recently, techniques such as bagging and boosting are being increasingly discussed by many workers (Sutton, 2005)[19] for improving the accuracy of the predictions using the tree based methods.Yet, unlike the case for other nonparametric methods for classification and regression, such as kernel-based methods and nearest neighbor methods, the resulting tree-structured predictors can be relatively simple functions of the explanatory variables which are easy to use.

Soil hydrological predictions were made by Selle and Huwe (2005)[20] for environmental management purposes. CART has also been used for modeling the distribution of number of tree species under future climatic scenarios by Prasad *et al* (2006)[21]Waheed *et al(* 2006)[22] used CART for investigating the potential of hyperspectral remote sensing data of experimental corn plots.

Regression trees as a statistical technique were used for exploring, describing and predicting relationships between multispecies data and environmental characteristics. In India, Devi *et al.* (2013)[23] used ANN for assessment of synergy in ornamental fish markets. There are no other references to data mining methodologies used in fisheries data analysis in India. This work is thus unique in this attempt.

Results and Discussion

Qureshi (2013)[1] used trend lines to describe the behavior of the data on fish production in Kashmir. When a series of measurements of a process are treated as a time series, trend estimation can be used to make and justify statements about tendencies in the data, by relating the measurements to the times at which they occurred.

Here, in order to capture impact of the introduction of carps into the lakes of Kashmir, the Cross Impact Analysis was initially used for making this preliminary assessment. The OLS regression coefficients of simple linear regression of one variable on another after dividing the data values by the corresponding assumed maximum values was used to develop the Kane's Cross Impact matrix to capture the impact of introduction of carps on *Schizothorax* and total fish production (Kane, 1972)[6](Table 2)

Table II: OLS Regression Coefficients of Data Values Proportioned on Assumed Maximum Values

DAL LAKE			
Fish catch in tonnes	Carp catch X_1	*Schizothorax* catch X_2	Total catch X_3
Carp catch(X_1)	-	-0.07	0.65
Schizothorax catch (X_2)	-5.40	-	4.23
Total catch (X_3)	0.33	0.03	-
WULAR LAKE			
Fish catch in tonnes	Carp catch X_1	*Schizothorax* catch X_2	Total catch X_3
Carp catch(X_1)	-	0.79	1.25
Schizothorax catch (X_2)	0.53	-	0.85
Total catch (X_3)	0.74	0.75	-

Table 3 indicated that *Schizothorax* production which had reached about 90 percent of its maximum yield capacity, was negatively affected by an increase in production of carps and had a complete positive impact on total fish catch in the Dal lake. On the other hand the impact of *Schizothorax* on carp production was nil and carp had a positive impact on total fish production. Total catch was positively influenced by carp production while *Schizothorax* on total catch had no impact. Carp production and total catch were positively influenced by external (other) factors in the Dal lake.

Table III: Interaction Matrix of Species Wise Fish Production in Dal Lake

	Present level	Carp catch X_1	*Schizothorax* catch X_2	Total catch X_3	External factors
Carp catch(X_1)	60%	0	0	1	2
Schizothorax catch (X_2)	90%	-3	0	3	0
Total catch (X_3)	50%	1	0	0	1

The cross impact analysis matrix (interaction matrix) for the Wular lake (Table 4) is significant in the sense that the interaction values were all positive. Carp production did not exhibit an adverse impact on *Schizothorax* and vice versa. Both total as well as carp production were positively impacted by external factors.

Table IV: Interaction Matrix of Species Wise Fish Production in Wular Lake

	Present level	Carp catch X_1	*Schizothorax*catch X_2	Total catch X_3	External factors
Carp catch(X_1)	30%	0	1	2	2
*Schizothorax*catch (X_2)	50%	1	0	1	0
Total catch (X_3)	30%	1	1	0	1

Fig 1 and 2 represent the graphs indicating the flow of information in respect of the cross impact analysis interactions. In the case of the Dal lake, the plots indicate a perceptible drop in *Schizothorax* production and the total catch is being held up by increasing contribution from carp.

In the case of Wular lake the plots indicate the vastness of the lake (being the largest freshwater lake in Asia), still offers scope for the co-existence and growth in both *Schizothorax* as well as carps. But a tendency for the carp production reaching a plateau is also discerned given the heavy siltation rates reported in the Wular. This could have a negative impact on the *Schizothorax* in the immediate future.

It can be seen from Fig 1 that the total fish production in Dal lake is being sustained by increasing contribution of carp while at the same time the local species *Schizothorax* is seen to be declining. The figure also indicates the threshold of *Schizothorax* has been reached with the proportion at 90 per cent. The declining *Schizothorax* curve also indicates that the performance of the species in future could be declining at a faster rate. Fig. 2 gives the CIA of fish production in Wular lake. While the total fish production in the Wular lake is increasing, this increase is being contributed by increase in carp production as well as a steady increase in *Schizothorax* production. It may be noted that owing to the vast area that the Wular lake occupies, the proportion of percentage increase in *Schizothorax* to total fish production appears to be still increasing.

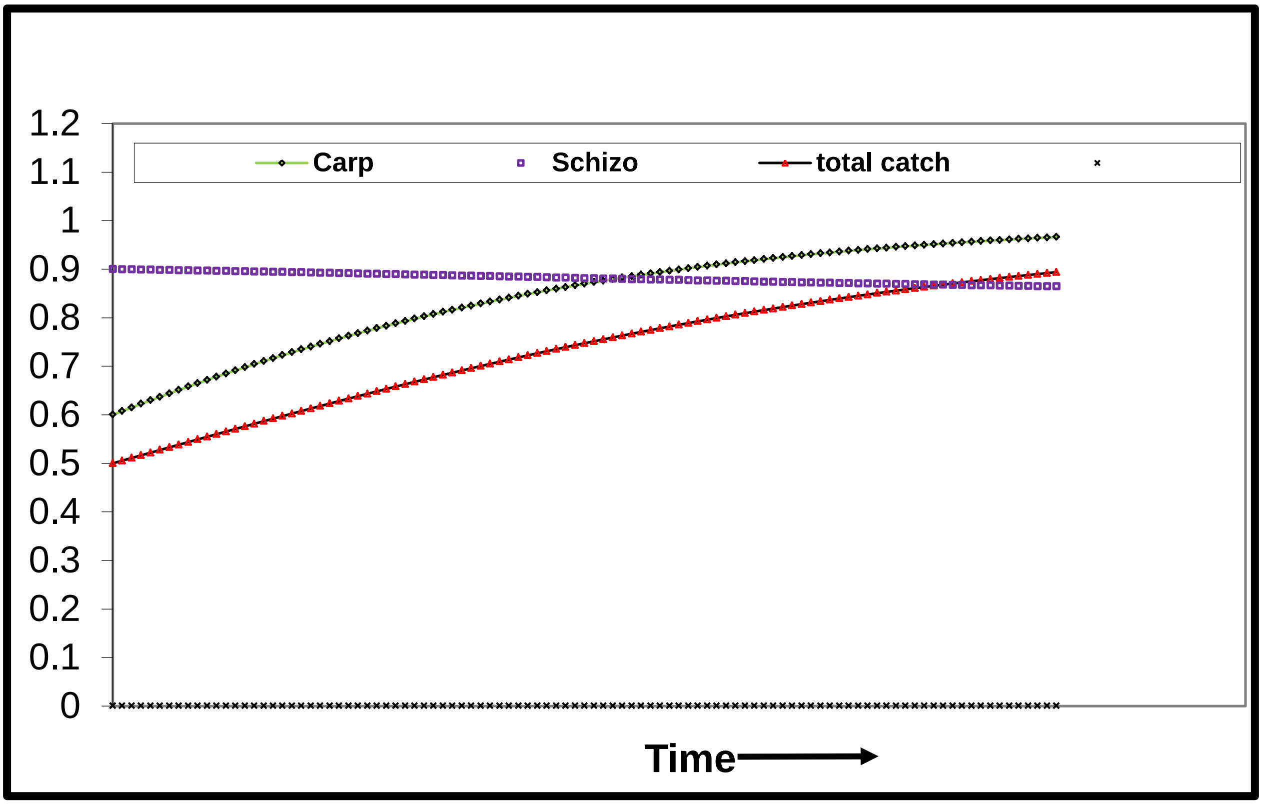

Fig 1: CIA Plot of Fish Production in Dal Lake

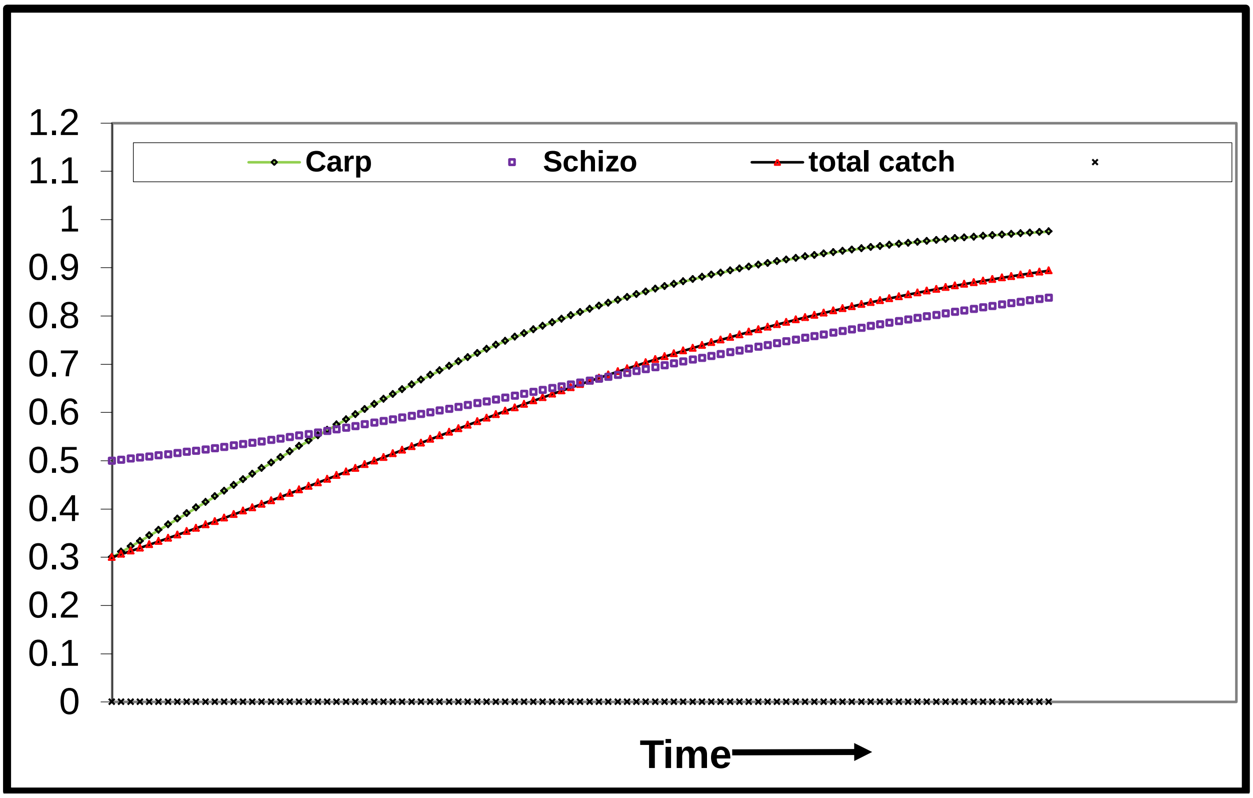

Fig 2: CIA Plot for Fish Production in Wular Lake

In order to establish the factors that determine the willingness of the stakeholders to pay for restoring the composition of fish production in the light of declining *Schizothorax* production the CART tree was developed. The regression tree was developed by using the R- software version 3.0.2. The CART tree was built on the premise that the stakeholders were either WTP or unwilling to pay for the restoration of the *Schizothorax* fishery in the lakes of Kashmir based on their age, time spent fishing by stakeholders on the lakes, income of the stakeholders in log terms and the type of stakeholder[f]. These variables were the ones that were common across the sample size of 350 stakeholders and hence were selected for building the CART tree.

The CART was used to analyse the relationship of the stakeholders WTP or otherwise in terms of their age, time spent by stakeholders on the lakes for earning their respective livelihoods, income of the stakeholders and the type of the stakeholders. Qureshi (2013)[1] had used contingent valuation for the same set of data across 8 stakeholder groups and the Tobit results indicated that income was the predominant factor that determined the WTP of the stakeholders. The CART enables us to examine the intricate relationships amongst variables and based on binary responses asked at each level of partitioning of the tree, helped to establish the root nodule as time spent in hours primarily responsible for WTP. This recursive partitioning originates in its root nodule with time spent in hours at 1.5hours/day. Based on the classification procedure further partitioning indicated that stakeholders with income more than INR 4000 were WTP for the restoration of *Schizothorax* fishery in the lakes of Kashmir. This yielded the terminal leaf.

It can again be noted that people in the senior age group and with income levels more than INR 4000 were also WTP for the restoration of the ecosystem. It may also be noted that those stakeholders in the younger group were also WTP for the restoration of the fishery as indicated by the emergence of this variable in the subsequent child nodes.

Now looking at the right hand side of the tree it can be seen that the WTP for the cause branches out to stakeholder, time spent in the lakes and those belonging to certain age groups who are WTP for restoration of fisheries in lakes of Kashmir. The relative importance of the variables that effect WTP in the order of hierarchy as depicted by the CART model are time spent, income, stakeholder type and age.

Multi- Institutional Framework for Restoration of *Schizothorax* Fishery

The carps in the lakes of Kashmir were accidentally introduced in 1957. Within the theoretical framework of CBD (2011)[24], this introduction was done without taking cognizance of the adverse impact of this introduction on the local indigenous species, *Schizothorax*. It must also be borne in mind that the Dal lake is more famous for its tourism attraction with the availability of houseboats on it and its location being ideal in the midst of Srinagar. Therefore fisheries have always played a secondary role in the order of importance for which the Dal lake is identified with. The introduction of carps in the Wular has not yet perpetuated the situation as far as the composition of fishery is concerned. Nevertheless the data as well as the responses of stakeholders indicate that the problem is festering into a big issue.

The WTP for the conservation and development of *Schizothorax* fishery in Kashmir as proved by the models depends not only on time spent on earning their livelihood but also on their total income, the type of stakeholder in the fishery and age of the stakeholder. The model also show that a balanced approach is required to be taken by the Government of Jammu and Kashmir, India to make a decision in respect of income, social welfare, socio-economic implications and interactive roles played by different dimensions of the lakes of Kashmir. The real value of maintaining an ecosystem in its pristine form far outweighs the monetary gains that would accrue to the government resulting from the exploitation of the ecosystem.

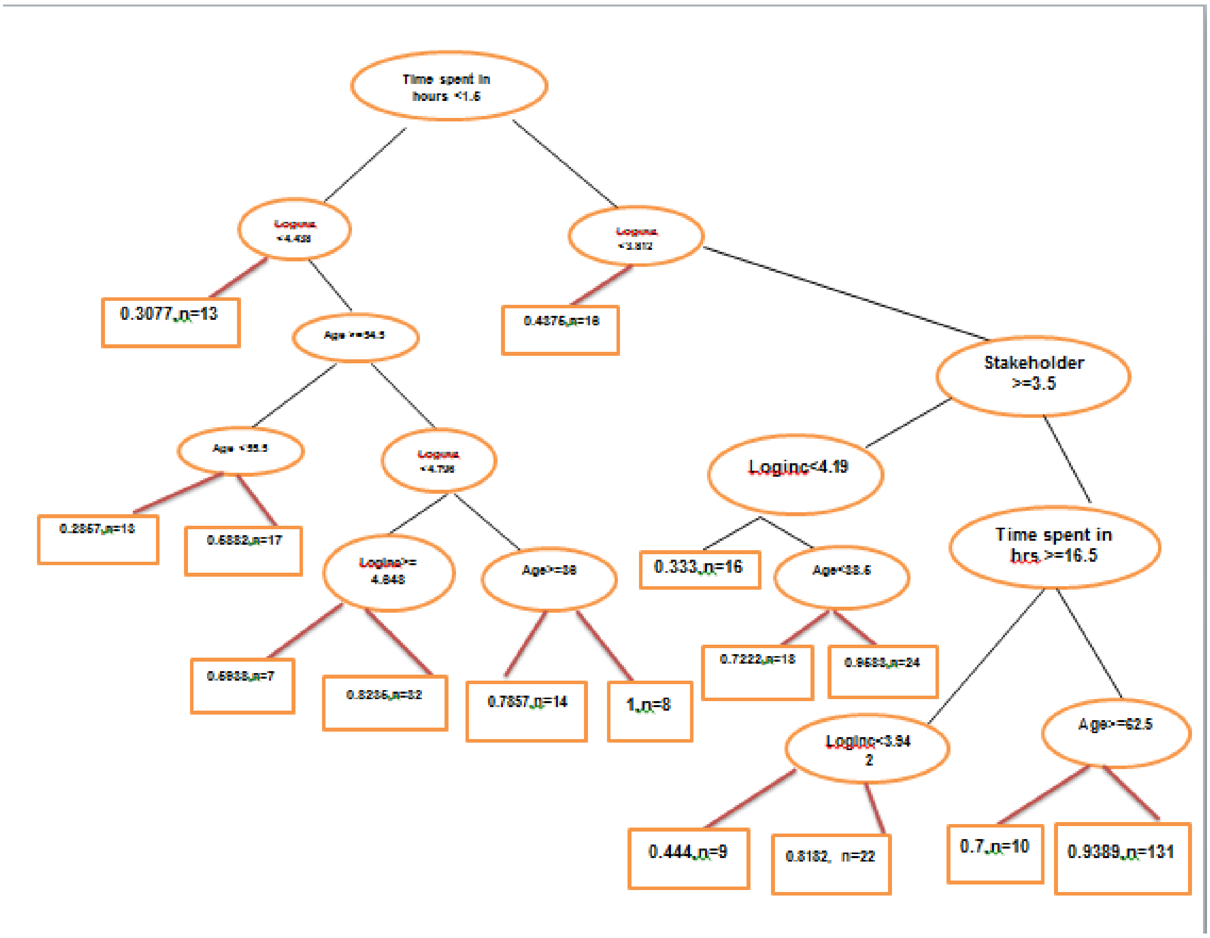

Fig 3: Classification and Regression Tree for WTP of Multiple Stakeholders in Lakes of Kashmir

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[a]Lakes and waterways development authority is an agency under Government of J&K which has been formed with the core aim of developing and reducing the pollution in lakes of Srinagar. More information available on: http://jklda.org

[b]Fish production in Kashmir lakes has been declining over time. The decline in fishery of the local species *Schizothorax* has been marked. The introduction of common carp to a large extent has been responsible for shoring up fish production in Kashmir lakes but since 2004-05 there has been a dramatic fluctuation in total fish production in Kashmir lakes and this can be attributed largely to increase in pollution in these lakes. Qureshi (2013), hypothesized that there were sufficient grounds for stakeholder animosity in this matter and that the multiple stakeholders are willing to pay (WTP) for alleviation of pollution and enhancement of fish production in lakes of Kashmir.

[c]Cross-impact analysis is a methodology developed by Theodore Gordon and Olaf Helmer[25] in 1966 to help determine how relationships between events would impact resulting events and reduce uncertainty in the future (Gordon 1994) Cross Impact Analysis (CIA) was used by futurists in mid 1970's as a means to predict the probability of specific events and determine how related events impacted one another. CIM analysis matured into a number of related methodologies with uses for businesses and communities as well as futurists and intelligence analysts by 2006.

Nevertheless, Cross Impact Analysis (CIA) is based upon the premise that events and activities do not happen in a vacuum and other events and the surrounding environment can significantly influence the probability of certain events to occur(Gordon,1994).Cross-impact analysis attempts to connect relationships between events and variables. These relationships are then categorized as positive or negative to each other and are used to determine which events or scenarios are most probable or likely to occur within a given time frame

[d] In this study estimated proportion of three variables carp catch (x_1), *Schizothorax* catch(x_2) and Total fish catch(x_3) in Dal and Wular lake were taken and then simple linear regression was run to get the rough estimates whose values will fall between -3 and +3. The range of the values of the coefficients of the linear regression model were tabulated and based on the Kane's classification the values falling close to -3 were assigned value -3 in the matrix and those values close to zero as zero, close to 1 as 1 and close to +3 as +3. Based on these values Kane's matrix was prepared and a graphical representation of the impact was obtained

[e] The weaknesses of logistic function include the restrictions on the dependent variable, size of the sample, assumption of linearity and can be used for only between subject designs

[ff] The stakeholders were coded from 1 to 4, as 1 for fishers and fish traders, 2 for fish consumers and tourists, 3 for hotels and houseboats and 4 for faculty of fisheries, Sher-e-Kashmir University of Agricultural Sciences and Technology, Department of Fisheries, Jammu and Kashmir