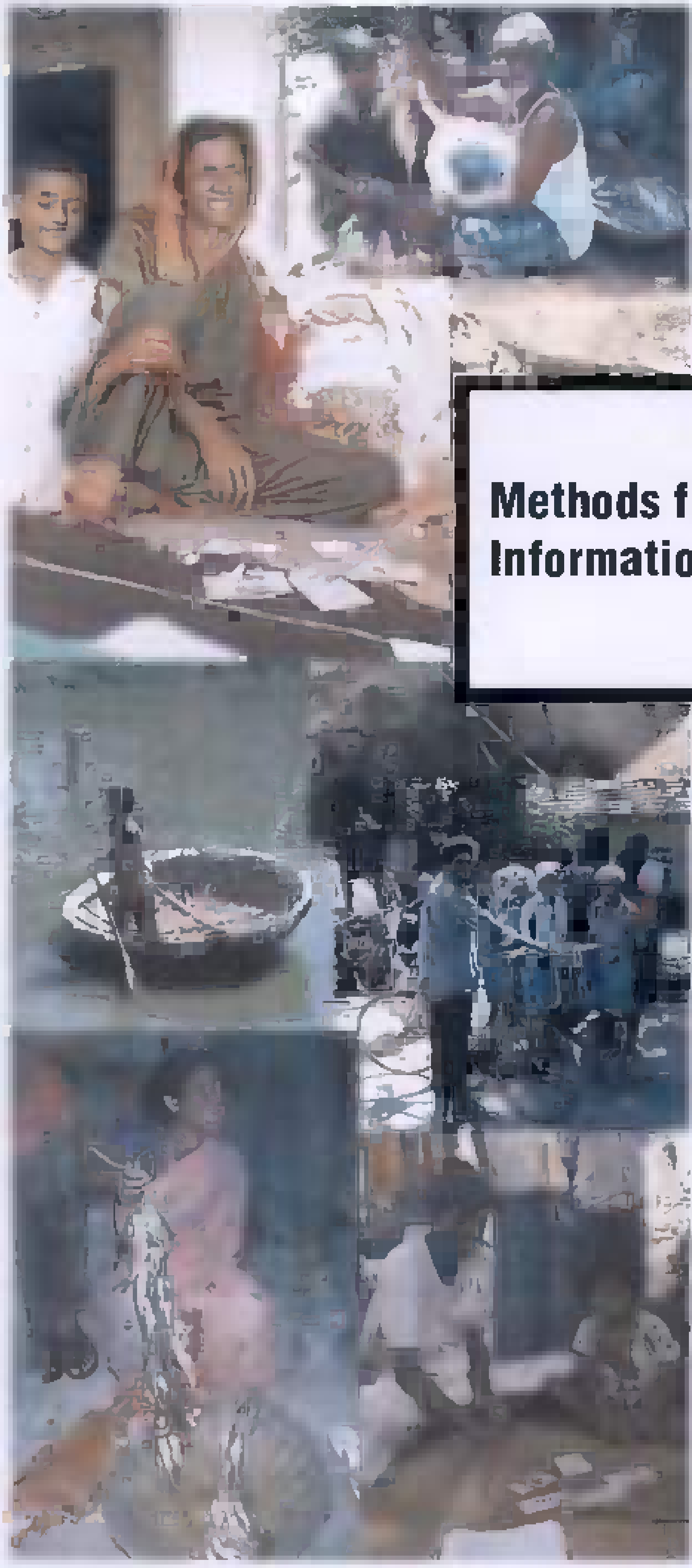

Working Paper No. 2
(July 1998)

Methods for Participatory Information Gathering

Aquaculture in Small-scale Farmer-managed Irrigation Systems
Funded by DFID Aquaculture Research Programme

Institute of Aquaculture
University of Stirling
Scotland, UK

Working Paper No. 2
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Methods for Participatory Information Gathering and Analysis

Aquaculture in Small-Scale Farmer-Managed Irrigation Systems
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List of Working Papers

Project Summary Report
1. Raichur District: Site for a Study of Aquaculture Development in the Semi-arid Tropics
2. Methods for Participatory Information Gathering and Analysis
3. Socio-economic Analysis of Villages in Relation to Aquaculture Potential in Raichur District, Karnataka, India
4. Investigation of Gender Issues in Relation to Aquaculture Potential in Raichur District, Karnataka, India
5. On-farm Resources for Small-scale Farmer-managed Aquaculture in Raichur District, Karnataka, India
6. Inland Fisheries Resources and the Current Status of Aquaculture in Raichur District and Karnataka State, India
7. An Investigation of Aquaculture Potential in Small-scale Farmer-managed Irrigation Systems of Raichur District, Karnataka, India
8. Indigenous Freshwater Fish Resources of Karnataka State and their Potential for Aquaculture
9. Institutional Linkages of Relevance to Small-scale Aquaculture Development in Karnataka State, India
10. Fisheries Marketing, Demand and Credit in Raichur District, Karnataka, India

Project background

The arid and semi-arid tropics are areas in urgent need of development. As a home to a large proportion of the world's poor these regions face a future of scarcity of food and insufficient water for consumption and irrigation of crops. It has been predicted that India and Sri Lanka will face a fresh-water crisis in the near future, and as much water is currently wasted due to inadequate management and conservation practices there is a need for more integrated approaches to water management. The majority of India's surface water bodies are used primarily for irrigation. Although large-scale irrigation systems cover more surface area and supply a greater area of farmland, more farmers are dependent on small-scale systems for their daily livelihood. Irrigation systems are often very inefficient water distribution systems, and studies suggest that the efficiency of water use could be improved. The integration of aquaculture (which can be non-consumptive in terms of water use) has the potential to increase food production and improve the efficiency of the use of small-scale irrigation water resource.

These Working Papers are the first stage of the research project 'Small-scale farmer-managed aquaculture in engineered water systems' (DFID project R7064). The project aims to investigate the potential for integration of aquaculture into small-scale farmer-managed irrigation systems in arid and semi-arid regions of India and Sri Lanka. Intended beneficiaries include the rural poor, which in India belong to the Scheduled Castes (SCs)[1] and Scheduled Tribes (STs)[2]. This part of the project focuses on Karnataka State on the south west of the Indian peninsular.

During the research, the economic and technical feasibility and the social acceptability of the production of fish in such systems of arid and semi-arid regions of Karnataka were investigated. Field research took place from 6 April to 21 May 1998 and included a 'Rapid Rural Appraisal' of four villages in Raichur District, Karnataka, and semi-structured interviews with representatives from the Government Department of Fisheries, marketing organisations, academics and other relevant institutional sectors within the state.

All fieldwork was undertaken in collaboration with the NGO Samuha, an organisation undertaking wide-ranging activities in the arid and semi-arid areas of Karnataka State. Samuha has extensive experience within participatory development and its initiatives range across health, disabilities, women's development, HIV/AIDS, education, animal husbandry, drinking water and sanitation, irrigation and watershed development (Pradeep, 1994). The majority of the work of Samuha is carried out in the districts of Koppal and Raichur with a smaller project in Bangalore. The activities of Samuha are supported by a number of bodies: ActionAid; OXFAM; the Swiss Development Cooperation; the Government of Karnataka and the Government of India as well as individual donors.

The results and analysis are presented in the ten Working Papers listed above. For an overview of the content of each of the Working Papers, see the Summary Report. This series of working papers have been produced principally as a resource for a stakeholder workshop to be held in Coimbatore, 19th - 20th November 1998. Conclusions and the research agenda are therefore preliminary.

[1] SCs: lower castes identified by the Indian government as a means of classifying castes for the allocation of benefits.
[2] STs: all tribals. SCs and STs together constitute the 'socially and educationally backward classes of citizens'. The terms form the basis for policies of protection and positive discrimination.

Glossary

DFID	Department for International Development (formerly ODA).
ODA	Overseas Development Agency (now DFID)
ODI	Overseas Development Institute
PRA	Participatory Rural Appraisal
RRA	Rapid Rural Appraisal
Rs	Indian unit of currency
SAT	Semi Arid Tropics
SC	Scheduled Caste
ST	Scheduled Tribe
UNICEF	United Nations Children's Fund
1ha	2.4 acres

Summary:

1. The participatory approaches favoured by donors and the Indian Government aim to empower beneficiaries by involving them as far as possible at all stages of the development process. Participatory Rural Appraisal (PRA) and Rapid Rural Appraisal (RRA) are two such methodologies, which aim to produce a swift overview of resource availability, local perceptions and priorities which can immediately be fed back to the community. PRA places the greatest emphasis on community participation, whilst RRA is more 'extractive' but less time consuming. Because of time constraints RRA techniques were predominantly used in this situation analysis. Participatory tools used include semi-structured interviews, ranking and scoring of priorities, wealth ranking, maps and diagrams and daily activity charts.

2. A common criticism of participatory research is the lack of quantitative data and statistical analysis of results. Quantification of the importance of different parameters can be obtained by the use of ranking and scoring techniques, which are tools widely used in participatory information gathering. In order to increase the rigour of the data analysis, a number of authors recommend the development of guidelines for the statistical analysis of ranks and scores. Other authors recommend increasing the rigour of data collection and checking of data for reliability.

3. In the project fieldwork, group meetings were first arranged in each village. In order to encourage participation, meetings of men and women were arranged in different venues. At meetings, villagers were asked to identify their selection criteria for fish, which types of meat were consumed in the village, what the different uses for the water in village water bodies were, and what they thought were the major constraints to aquaculture in the region.

4. The parameters identified were ranked and scored by participating villagers individually during subsequent interviews. Both men and women, landed and landless, and people from all social groups were included amongst the respondents. Initially parameters were both ranked and scored, in order to crosscheck the information. However carrying out both exercises was considered by villagers to be too time-consuming and tiring, and in subsequent interviews only scoring was done. Scoring was chosen over ranking because more information is contained in scores, however farmers seemed to find it conceptually more difficult to understand scoring than ranking.

5. From ranked and scored data the level of agreement between respondents as well as the relative importance of the ranked parameters can be obtained by using nonparametric statistics such as the Mood's median test, the Kendall coefficient of concordance and the Friedman Test.

6. The Mood median test can be used to test whether there are significant differences between the medians of the ranks of the different parameters, and is suitable for both ranked and scored data. This test does however assume that the samples are unrelated, so more suitable to use is the Kendall coefficient of concordance or the Friedman Test. The Kendall coefficient of concordance assesses the level of agreement between villagers and can be used on both ranks and scores, but if scores are used they must be converted to ranks first. Where this test can establish that there are significant differences between the ranks assigned to different parameters, it cannot be used to assess which parameters are significantly more important than others. The Friedman two-way analysis of variance is linearly related to the Kendall coefficient of concordance, but an extension to the test allows for multiple comparisons between different parameters. This allows us to establish which parameters are significantly more important than others.

7. All three tests are suitable for analysing ranked or scored data. However because the Mood's Test does not take into account the relatedness of the samples, and individual parameters cannot be compared using the Kendall's coefficient of concordance, it is recommended that the Friedman's Test is used for analysis. Again this test can be used for both ranks and scores, but like the Kendall coefficient of concordance, scores must be converted to ranks before analysis. Thus the benefits of scoring over ranking are lost when the Friedman Test is used for analysis. Suggestions for how to carry out ranking and the analysis of results are made.

Methods for Participatory Information Gathering

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1 Introduction

The benefits of encouraging the participation of the local community in development and research projects are well established (see e.g. Chambers, 1992; Gosling & Edwards, 1995; ODA, 1995). And after decades of poor returns on inflexible 'top down' development packages, Indian Government policy is now focusing on more 'bottom up' participatory approaches. These aim to empower beneficiaries by involving them as far as possible at all stages of the development process, with the aim of making initiatives more sustainable (Chambers, 1992). Commonly techniques from Rapid Rural Appraisals (RRAs) and Participatory Rural Appraisals (PRAs) are used for the assembly of information with communities, either in conjunction with more formal survey techniques (such as questionnaires) or as the sole means of data collection. Whereas there is general agreement that the qualitative data collected using RRA and PRA techniques is essential for gaining an understanding of local situations (e.g. Chambers, 1992; Gill, 1993), several authors have expressed a need for more rigorous methodology regarding the collection and analysis of qualitative data (e.g. Fielding & Fielding, 1986; Farrington, Shaxson & Gordon, 1997; Martin & Sherington, 1996).

In this Working Paper practical recommendations regarding participatory data collection are outlined supported by analytical techniques from the literature. The tools and techniques used in the project are detailed and a methodology for the collection and analysis of data is suggested. Particular emphasis is placed on the use of ranks and scores in information assembly and non-parametric analyses are described.

2 Participatory information gathering and analysis

2.1 Participatory methods

Participatory development can be defined as a process by which people take an active and influential hand in shaping decisions that affect their lives (ODA, 1995). It is based on the philosophy that outsiders need to learn about situations from the insiders, and that insiders can analyse their own problems (Gosling & Edwards, 1995) often involving frameworks developed in conjunction with outsiders. Thus in a community, all those with an interest (stakeholders) can play an active role in defining the key issues important to them, in decision-making and in the consequent activities carried out. This is in contrast to a conventional development approach, where the scope, content and expected outcome of a project is commonly decided upon by the planning organisation before any fieldwork commences. Participatory methods were developed in the 1970s and 1980s as a reaction to the failure of many conventional development programmes in reaching the rural poor (Townsley, 1996).

For initial appraisals in conventional projects, data is most often collected via surveys using questionnaires. In participatory projects, distinct tools and techniques have been developed and are systematically used in what is called Rapid Rural Appraisals (RRAs) or Participatory Rural Appraisals (PRAs). In RRAs a variety of tools and techniques are used to organise information and stimulate the interest of villagers. Data collected are analysed by outsiders (with feedback to community) who also make decisions about development. In contrast, in PRAs villagers themselves define what topics should be the focus of the exercise, and how they should be addressed. In PRAs the community plays an active role in the analysis of data with outsiders acting as facilitators for process only (Townsley, 1996). Because of the extensive participation of the local community in PRAs these tend to involve longer periods of fieldwork than RRAs.

2.2 The need for statistical analysis of participatory data

Tools used in participatory information gathering generate outputs such as interviews, maps and diagrams of resources and activities, and ranks and / or scores of parameters of importance to the community. Often such quantitative information is not analysed to any great depth. Thus Riley & Alexander (1997) reviewed 60 papers on participatory farming systems in a range of agricultural journals and found that statistical methodology was often poorly defined and inadequately used. Discussion of collected data was often the only method of data summary, particularly when data were qualitative. The authors only considered published material and presumably this problem is similar in unpublished work. The review also pointed out the lack of readily accessible documentation of all but basic methods aimed at researchers working in participatory research. According to Martin & Sherington (1996), simple statistical techniques are well documented in many contexts, but more advanced topics are generally available only in specialist textbooks or papers. This is partly because the more advanced topics require a level of statistical experience and expertise, which is beyond the usual introductory level. Furthermore, until very recently, statistical software for implementing the more advanced techniques has only been available in specialist packages. Considering the field-based nature of most participatory information gathering as well as the need for rapid analysis for swift feedback to the community, it would seem preferable to keep statistical analysis of data simple and easy to carry out, i.e. to avoid the use of complicated and expensive statistical software.

Critics of participatory research often question the usefulness of the data collected using participatory methods. Qualitative data in particular is often seen as 'subjective', haphazard or unstructured and there appears to be a conflict between approaches based on quantitative data and those seeking the qualitative understanding of a situation, based on assessments by the local community (Martin & Sherington, 1996). Therefore rural appraisal data (like that of the present project) collected using participatory methods is often perceived to lack scientific rigour, mainly because the data generated is difficult to quantify (Farrington, Shaxson & Gordon, 1997). To date very little material has been published on the statistical analysis of data generated from participatory research. Maxwell & Bart (1995) recommend the use of scores in preference to ranks as these contain more information and are easier to analyse, and suggest that further research is carried out on different techniques of ranking and scoring and their analysis. Martin & Sherington (1996) outline an approach for the analysis of ranks representing farmers' evaluation of different tree species. In this analysis a logistic model is used to find significant differences between groups of farmers.

As a response to the criticism of participatory methodology, Martin & Sherington (1996) recommend that the relevance of existing statistical techniques be evaluated for different participatory research situations. They suggest that relevant reference material be produced, e.g. by providing a set of case studies of detailed analyses, using a range of statistical ideas and techniques, and data from a range of participatory studies. In particular these authors recommend the development of guidelines on the analysis of ranked observations and hierarchical data / multi-level models. Farrington, Shaxson & Gordon (1997) also suggests more statistical analysis of field data, mentioning new developments in statistical method capable of handling unbalanced data, uncontrolled factors, ranking scores from on-farm trials, binary data and qualitative indicators.

2.3 The need for triangulation and avoiding bias

A further criticism of participatory analysis is the common lack of quality control and validation of information (Fielding & Fielding, 1986; SPPRGA, 1997). To improve the quality and reliability of the data collected, Fielding & Fielding (1986) recommend the rigorous use of triangulation techniques, and Farrington, Shaxson & Gordon (1997) suggests means to overcome any bias in information gathering. Recommendations regarding triangulation techniques are shown in Box 1.

Box 1: Different types of triangulation used to validate data. Source: Denzin (1970).

- Data triangulation: (1) time triangulation, exploring temporal influences by longitudinal and cross-sectional designs; (2) space triangulation, taking the form of comparative research; and (3) person triangulation, variously at the individual level, the interactive level among groups, and the collective level.
- Investigator triangulation: where more than one person examines the same situation.
- Theory triangulation: examining a situation from the standpoint of competing theories.
- Methodological triangulation: where there are two variants: 'within-method' approaches (same method used on different occasions. Researcher takes one method and uses multiple strategies with a view to increase reliability. Check on data quality and attempt to confirm validity) and 'between-method' approaches (different methods applied to the same subject in explicit relation to each other).

The aim of the process of triangulation is ultimately to ensure that the bias of the data collected is minimal. Commonly recognised sources of bias are listed in Box 2.

Box 2: Recognised sources of bias in rural participatory research. Adapted from Chambers (1983).

- spatial biases (urban, tarmac and roadside biases);
- project bias (contact with tiny atypical sites, where a project is in hand);
- person biases (the elite, the men and the users or adopters);
- dry season bias (in areas of marked tropical seasons field work is often carried out during the dry season);
- diplomatic biases (politeness and prudence inhibit awkward questions and contact with the poorest)
- professional biases (specialisation makes it hard for observers to understand the linkages of deprivation).

Following is an outline of the methodology used for the collection of ranks and scores in the project fieldwork.

3 Project fieldwork

All fieldwork was carried out in collaboration with the NGO Samuha (see Working Paper 10 for details about Samuha). Rapid Rural Appraisal (RRA) was conducted in four villages in Raichur District, Karnataka. These villages are listed in Box 3 and their location shown in Figure 2. Villages were selected on the basis of the number of small-scale farmer-managed water bodies with potential for aquaculture (for details of water body classification, see Working Paper 7) as well as on socio-economic characteristics such as the number of people belonging to the ST and SC categories and literacy levels. RRA was carried out rather than PRA because of time constraints. Figure 1 shows the research framework.

Box 3: Research villages in Raichur District.

Village name	Taluk[3]
Jumlapur & Ainapur	Kushtagi
Chikkawankalakunta	Yelbarga
Pai Doddi	Lingsugur
Mallapur	Deodurg

Following the recommendations of Shah *et al.* (1991) and Gosling & Edwards (1995), group meetings and discussions were arranged (at times suitable for villagers) as the first activity in all villages. The function of these meetings was to introduce the research team and to facilitate group discussions on topics such as the history of the village, the common crops and livelihood strategies of farmers and the indigenous knowledge of fish and aquaculture. This information could then be triangulated with data from individual interviews. Another aim of the group meetings was to identify criteria, which could be used for ranking and scoring exercises with individuals later. Establishing these criteria at the village level ensured that no important parameters were left out and enabled all villagers to rank / score the same parameters, which facilitated later statistical analysis.

Despite efforts to ensure that all social groups were represented at meetings, often only key opinion creators of the village (members of the village committees and the women's self help groups (see Working Paper 9)) were present. The relatively poor representation of the rest of the villagers in these initial meetings was considered a problem, but in villages with more than 200 households, it would not be possible to hold a meeting with all farmers present. Furthermore although both men and women would be invited to the meeting, often only men would attend. Women would sometimes turn up and sit on the outskirts of the meeting place for 10 to 15 minutes before leaving. To avoid this problem, the group was initially separated into men and women groups sitting in two different areas of the meeting place. However even then the men would often interrupt the discussion in the women's group and to overcome this bias it was decided to hold separate men and women's group meetings (with male and female researchers and translators respectively), so that both groups could be heard. At the group level a local facilitator from the NGO Samuha was assigned the special task of encouraging everybody present to participate in discussions. Box 4 presents an outline of the participatory methods used during the project fieldwork.

Box 4: Explanation of RRA tools used in the project field research. Adapted from Townsley (1996).

Secondary data sources:
Used as in conventional research.

Semi-structured interviews:
Rather than using a formal questionnaire, interviewers use a checklist of questions related to each topic of interest. Flexible method for following up interesting topics arising out of a discussion.
Interviews can be conducted with key informants (people with particular knowledge about a topic), with individuals or with groups.

Ranking and scoring:
Issues or items placed in order of importance (ranking) or allocated a proportion of a limited number of points (scoring). Helps identifying priorities of community, and if carried out with individuals can reveal differences within a population.
Wealth ranking is used to investigate local perceptions of wealth groupings within the community. Parameters used in the classification identified by villagers, thus revealing local indicators and criteria of wealth.

Diagrams and maps:
Used to simplify and present complex information in a format easy to understand. Often used to increase participation by villagers and to stimulate their interest.
Resource flow diagrams show the flow of resources (e.g. water, crops, animals, money) between the different components of a system.
Watershed[4] maps show the ownership of land holdings and water bodies within a watershed.
Seasonal diagrams show the patterns of rainfall, food availability, workload, credit etc. over a year.
Venn diagrams show the relationships of and connections between different individuals and institutions etc. in a society.
Social maps show all village households along with details of the number of men, women and children, the caste and wealth status of the family, the amount of land owned, literacy levels etc.
Activity charts outline the activities carried out by individuals or groups within a set time period.

The questions put to village groups for identification of parameters to be ranked or scored by individuals are shown in Box 5.

Box 5: Questions put to villagers at village meetings during field research.

- What types of meat do you eat?
- What characteristics do you consider important in fish?
- What are the major uses of the water in farmer-managed water bodies?
- What do you consider to be the key constraints to the development of aquaculture in this area?

Individual villagers willing to participate in more detailed research were identified at the group meetings. According to Fernandez *et al.* (1995), wealth ranking is most successful when carried out in private by knowledgeable individuals of middle income. In this project older influential men and women were asked to wealth ranks households of the community, since only these had sufficient knowledge about the community to be able to do so. For individual farmer interviews efforts were made to reduce person biases by including the different castes present in the village, men and women, landed and landless as well as large and small farmers. Farm walks and semi-structured interviews were carried out with these individuals, who were also asked to rank and / or score the parameters identified at the village group level (Box 5). Before each exercise the interviewee would be asked the questions that were put to the community at the village level meeting. This was to ensure that no important parameters had been left out from the group discussions, and also to stimulate thought about the importance of different issues in the person being interviewed before ranking exercises were carried out.

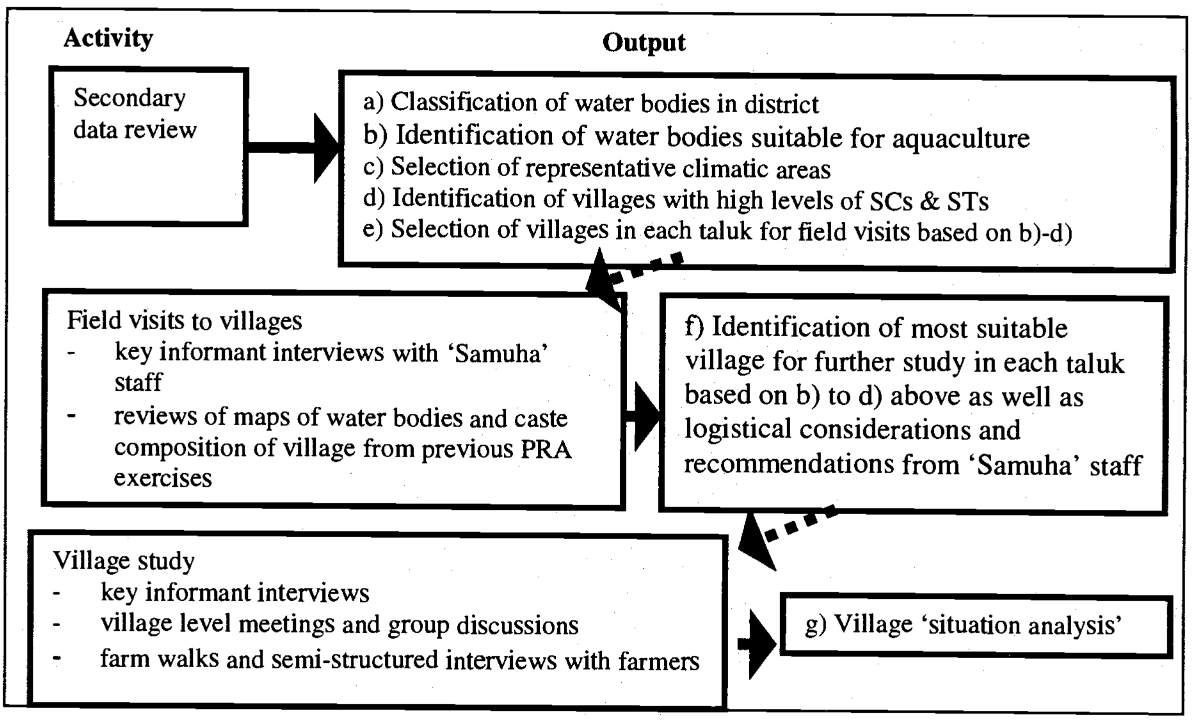
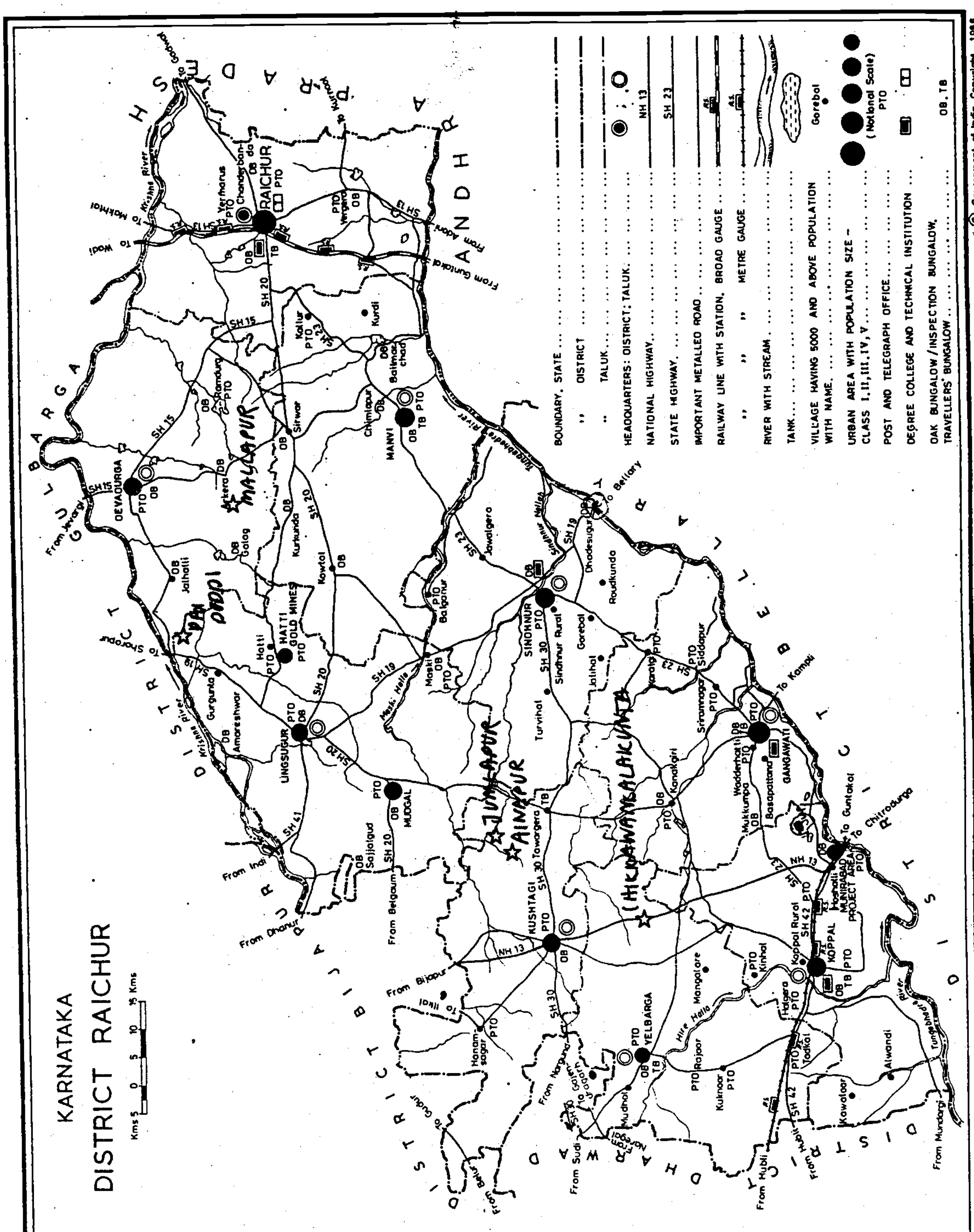


Figure 1: The research framework. Activity denotes research focus at each successive level and output the intended results of the activities (⟶). Each level had to be completed before progress to the next level could be made (-----▶).

Figure 2: Map of Raichur District (source: Government of India, 1981)



In the initial research, all the parameters identified by the villagers in group meetings were both ranked and scored by individuals. This was done in order to triangulate the ranks and scores, which would provide a useful indicator of the level of the farmer's understanding of the exercises. If the ranking and scoring methods both were understood they should correspond to each other and reflect the same trend of order of importance of the different parameters to the farmer. Any confusion or lack of understanding of the exercises should thus be detectable by comparison of the ranking and scoring results, and these results could then be discarded.

However, during the village research, several farmers commented on the fact that the same questions were asked again and again, that the interviews took too long, and personal observation showed villagers to get tired and lose concentration towards the end of the interviews. Following the suggestions of Gosling & Edwards (1995) and Farrington, Shaxson & Gordon (1997), who recommend that individual interviews should not be too long and questions not repeated, the strategy was changed in the latter stages of research, and only scoring was carried out.

Scoring was chosen over ranking because it contains more information (Maxwell & Bart, 1995; Lawrence *et al.*, 1997). However there was a general feeling in the team that the farmers found it conceptually more difficult to assign values to parameters by dividing a number of stones between the criteria than to sort the parameters in order of importance. Ranking on the other hand has the distinct disadvantage that farmers are forced to chose one over the other between parameters that may have the same importance; an issue often raised during the exercises. A possible alternative is to use midranks for tied ranks if villagers indicate that a number of parameters are of similar importance. Although an important opportunity to triangulate the information provided by the farmer was lost by only carrying out scoring, the advantages of interviews of shorter duration were great.

4 Statistical analysis

Ranks and scores provide an excellent opportunity for analysis of the opinions of villagers and the identification of what the priorities of sub-groups are. Statistical tests can determine the level of agreement between the farmers as well as identify which parameters are significantly more important than other for the community or different interest groups within the community.

In order to establish if the different parameters are assigned the same importance (ranks or scores) by the villagers, the Mood median test can be used. This tests the null hypothesis that all medians are equal, by determining if the distribution of values either side of a common median differs for two or more unrelated samples (Cramer, 1997). To carry out the median test, the overall median of all ranks or scores is computed. For each parameter the number of observations less than or equal to the overall median, and the number of observations greater than the overall median are recorded. A Chi-square test for association is done on this table, and large values of Chi-square indicate that the null hypothesis is false. The test can be used on both ranks and scores, and no modification for tied ranks is needed. Only groups containing two or more observations (ranks or scores) can be included in the analysis. An example of the computation of the Mood median test on ranked data is shown in Appendix 1.

The Mood median test is quick and easy to perform using either a pocket calculator or a statistical program such as Minitab. However this test assumes that the samples are unrelated, whereas in fact the same villagers rank or score all the parameters, i.e. the samples are related. Two statistics that can determine the level of agreement between villagers for related samples are the Friedman two-way analysis of variance by ranks and the Kendall coefficient of concordance.

research team. If possible aim to include people from all social (income and caste) groups. For this a facilitator specifically assigned to the task of engaging more quiet individuals in the discussion may prove useful.

1. Identify parameters for ranking and scoring exercises at group meetings. Carry out wealth ranking with individuals knowledgeable of the village households. Also identify villagers willing to participate in individual interviews, and ensure that all geographic areas, social groups, castes etc. are represented amongst these individuals.
2. Rank criteria identified at group meetings with individual villagers. If a villager indicates that several parameters have the same importance, use midranks for the tied ranks.
3. Analyse ranks using the Friedman's statistic, outlined in Appendix 3. Use equation (1) for ranks with no ties and equation (2) for tied ranks. If significant differences are found, use inequality (3) to determine which differences are significant. If no agreement amongst villagers is found, try the Friedman test for different sub-groups (e.g. gender, caste, wealth groups) to test for agreement within these.
4. Triangulate information obtained (e.g. group meetings versus individual interview, husband versus wife, ranking versus interviews etc.)

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Appendix 1: Mood's median test

Mood's median test determines whether k independent groups (not necessarily of equal size) have been drawn from the same population or from populations with equal medians. A summary of the procedures for using the median test is outlined below.

1. Determine the common median of the ranks or scores in the k groups (ranking parameters)
2. Assign pluses to all scores above that median and minuses to all scores below, thereby splitting each of the k groups of scores at the common median. Cast the resulting frequencies in a $k \times 2$ table.
3. Using the data in that table, compute the value of χ^2 as given by formula (1). Determine $df = k - 1$.
4. Determine the significance of the observed value of χ^2 by reference to Table A4.1, Appendix 4. If the associated probability given for values as large as the observed value of χ^2 is equal to or smaller than $\propto$, reject H_0 in favour of H_1.

Box A1.1: Mood's median test. From Siegel & Castellan (1988).

$$\chi^2 = \sum_{i=1}^{r} \sum_{j=1}^{k} \frac{(O_{ij} - E_{ij})}{E_{ij}} \qquad (1)$$

Where O_{ij} = observed number of cases categorized in ith row of jth column
E_{ij} = number of cases expected under H_0 to be categorized in ith row of jth column

$\sum_{i=1}^{r} \sum_{j=1}^{k}$ directs one to sum over all cells.

If one or more scores fall at the common median, then the scores may be dichotomized by assigning a plus to those scores, which exceed the common median and a minus to those, which fall at the median or below.

An example of the computation of the Mood Test on ranked data can be seen below.

11 inhabitants from the village Pai Doddi were asked to rank the frequency of the consumption of different foods, namely fish (F), chicken (C), goat or sheep (G) and wild animals (W). The resultant ranks are shown in Table A1.1.

Table A1.1: Ranks for the frequency of the consumption of different types of meat in the village of Pai Doddi. Ranks were allocated from 1 to 4, with 1 denoting very infrequent consumption and 4 denoting very frequent consumption. R_j or R_i denotes the column totals (R_j is the term used for calculation of the Friedman Statistic, whereas R_i is used for computing the Kendall coefficient of concordance).

Villager	Fish	Chicken	Goat/sheep	Wild animals
a	1	3	4	2
b	2	3	4	1
c	2	3	4	1
d	2	4	3	1
e	1	4	3	2
f	3	4	1	2
g	1	4	3	2
h	1	3	2	4
I	1	3	4	2
j	1	2	4	3
k	3	2	4	1
R_j/R_i	18	35	36	21
Total ranks	11	11	11	11

The overall median = 2.5.

The distribution of the ranks for the four different food types is shown in Table A1.2.

Table A1.2: The number of villagers in Pai Doddi (represented by number of x) assigning the ranks from 1 (eaten least frequently) to 4 (eaten most often) to the different types of food eaten in the village. N denotes total number of villagers ranking.

Rank	Fish	Chicken	Goat/sheep	Wild animals
4		xxxx	xxxxxx	x
3	xx	xxxxx	xxx	x
2	xxx	xx	x	xxxxx
1	xxxxxx		x	xxxx
N	11	11	11	11

The data was cast in a $k \times 2$ table:

Table A1.3: Expected (top, italics) and observed (bottom) frequencies of observations (ranks) above and below the common population median of 2.5 for the different types of food ranked in order of consumption frequency in Pai Doddi village

	Fish	Chicken	Goat/sheep	Wild animals	Total
No. of observations below common median (2.5)	*5.5* 9	*5.5* 2	*5.5* 2	*5.5* 9	22
No. of observations above common median (2.5)	*5.5* 2	*5.5* 9	*5.5* 9	*5.5* 2	22
Total	11	11	11	11	44

To test the null hypothesis that the k samples have come from the same population with respect to medians, the value of χ^2 should be computed. Substituting the values into equation (1) we get:

$$\chi^2 = \sum_{i=1}^{r}\sum_{j=1}^{k}\frac{(O_{ij}-E_{ij})^2}{E_{ij}} \qquad (1)$$

$$\chi^2 = \frac{(9-5.5)^2}{5.5} + \frac{(2-5.5)^2}{5.5} + \frac{(2-5.5)^2}{5.5} + \frac{(9-5.5)^2}{5.5}$$
$$+ \frac{(2-5.5)^2}{5.5} + \frac{(9-5.5)^2}{5.5} + \frac{(9-5.5)^2}{5.5} + \frac{(2-5.5)^2}{5.5}$$

$$= 2.227 + 2.227 + 2.227 + 2.227 + 2.227 + 2.227 + 2.227 + 2.227$$
$$= 17.816$$

$df = k - 1 = 4 - 1 = 3$

From Table A4.1 in Appendix 4 it can be seen that under H_0 a χ^2 equal to or greater than 17.816 for $df = 3$ has probability of occurrence below .001. Since this p is smaller than a significance level of $\propto$ = .05, on the basis of these data, the null hypothesis that there are no significant differences between the consumption frequency of the four different types of meat can be rejected.

The χ^2 test requires that the expected frequencies (E_{ij}s) in each cell is not too small. When this requirement is violated, the results of the test are meaningless. Cochran (1954) recommends that for χ^2 test with $df > 1$, fewer than 20% of the cells should have an expected frequency of < 5, and no cell should have an expected frequency of < 1.
The test can be used on both ranked and scored data, and no modifications for tied ranks are needed. Mood's Median test is available on Minitab.

Appendix 2: Kendall's coefficient of concordance

The Kendall's coefficient of concordance, *W*, is a test statistic which can be used to measure the communality of judgements for observers (Kendall, 1970). It ranges between 0 and 1, with 1 designating perfect concordance, and 0 indicating no agreement or independence of samples (Gibbons, 1971). The procedure for the use of *W* is outlined below:

1. Construct a $k \times N$ table, where *N* represent parameters being ranked and *k* the number of farmers assigning ranks.
2. For each column, calculate the sum of the ranks, R_i,.
3. Calculate the square of each of these sums, R_i^2.
4. If there are no ties, calculate *W* using equation (4).
5. If the ranks have ties, assign midranks and compute *W* using equation (5) or (6).
6. If $N \leq 7$, Appendix 4 Table A4.2 gives critical values of *W* for significance levels $\alpha = .05$ and $\alpha = .01$.
7. If $N > 7$, use equation (7) to compute X^2, which is approximately distributed as chi square. Test the significance of this for $df = N - 1$ by using Table A4.1, Appendix 4.
8. If *W* is larger than the critical value found by using Appendix 4 Table A4.1 or A4.2, reject H_0 and conclude that the rankings are not independent.

In order to find the true ranking of the objects, Kendall (1970) suggests that parameters are ranked according to the sums of ranks.

Box A2.1: The Kendall coefficient of concordance, W. After Siegel & Castellan (1988).

$$W = \frac{12\sum R_i^2 - 3k^2N(N+1)^2}{k^2N(N^2-1)} \qquad (4)$$

where

k = number of judges

N = number of objects being ranked

$N(N^2 - 1)/12$ = maximum possible sum of the squared deviations (the numerator which would occur if there were perfect agreement among the *k* rankings and the average rankings were 1, 2, ..., *N*.

and $\sum R_i^2$ is the sum of the squared sums of ranks for each of the *N* objects or individuals being ranked.

$$W = \frac{12\sum \overline{R}_i^2 - 3N(N+1)^2}{N(N^2-1) - (\sum T_j)/k} \qquad (5)$$

or

$$W = \frac{12\sum R_i^2 - 3k^2N(N+1)^2}{k^2N(N^2-1) - k\sum T_j} \qquad (6)$$

where

$$T_j = \sum_{i=1}^{\vartheta_j} (t_i^3 - t_i) \qquad (7)$$

where t_i is the number of tied ranks in the *i*th grouping of ties, and ϑ_j is the number of groups of ties in the *j*th set of ranks. ΣT_j is the sum of the values of T_j for all of the *k* sets of rankings.

$$X^2 = k(N-1)W \qquad (8)$$

The data shown in Table A1.1 was analysed using Kendall's coefficent of concordance.

$$W = \frac{12\sum R_i^2 - 3k^2N(N+1)}{k^2N(N^2-1)} \quad (4)$$

For the data in Table A1.1, the sum of the squared values may be calculated

$$\sum R_i^2 = 18^2 + 35^2 + 36^2 + 21^2$$
$$= 3286$$

Substituting values into equation (4) we get

$$W = \frac{12(3286) - 3(11^2)(4)(4+1)^2}{11^2(4)(4^2-1)}$$
$$= 0.431$$

showing that the rankings are not independent or that the farmers are applying essentially the same standard in ranking the four parameters.
In order to demonstrate the use of equation (5) or (6) for tied ranks, we can imagine that the data contains two tied ranks, modifying row d and the column total as shown in Table A2.1.

Table A2.1: Modified row d and total column rank (Rj) introducing tied ranks.

d	2	3.5	3.5	1
Rj	18	34.5	36.5	21

Because there are two tied ranks, equation (5) or (6) should now be used for the computation of *W*.

The sum of squared ranks is

$$\sum R_i^2 = 18^2 + 34.5^2 + 36.5^2 + 21^2$$
$$= 3287.5$$

For farmer d, there is one group of ties of size 2 and so $\vartheta_d = 1$ and $t_1 = 2$, and $T_d = 2^3 - 2 = 6$

$$W = \frac{12(3287.5) - 3(11^2)(4)(4+1)^2}{11^2(4)(4^2-1) - 11(6)}$$

$$= 0.438$$

As *W* corrected for ties is larger than the value calculated above, it can again be concluded that there is good agreement among farmers in their ranking of the frequency of consumption of different types of food.

According to Kendall (1970) the best approximation to the 'true' ranking of parameters may be taken to be the order of the various sums of ranks R_i shown in Table A1.1. If this method is used, we can conclude that the order of frequency of consumption is goat/sheep > chicken > wild animals > fish, where > = eaten more frequently than. The closeness of the sum of the ranks for goat/sheep and chicken would indicate a less significant difference than for example that between chicken and fish.

It would be useful to establish which of the different parameters show significant differences in importance. This cannot be done when Kendall's *W* is used. However an extension to the Friedman Test allows the multiple comparison of different parameters. The Friedman and the Kendall statistics are linearly related (Siegel & Castellan, 1988).

Appendix 3: Friedman's two-way analysis of variance:

Below is an outline of the procedure used in the computation of the Friedman statistic, F_r. Equations can be found in Box A3.1.

1. Arrange the ranks in a two-way table having N rows (farmers) and k columns (parameters).
2. Determine the sum of the ranks in each column (R_j).
3. Calculate F_r using equation (1) if there are no ties or equation (2) if there are tied ranks in any row.
4. For small N and k, critical values of F_r can be found in Appendix 4, Table A4.3.
5. For large N and / or k, use Table A4.1 in Appendix 4 to find the associated probability from the χ^2 distribution, with $df = k - 1$.
6. If the probability is equal to or less than α, reject H_0.
7. If H_0 is rejected, use multiple comparisons (inequality (3)) to determine significant differences between parameters.

Box A3.1: The Friedman two-way analysis of variance by ranks. Source: Siegel & Castellan, 1988.

$$F_r = \left[\frac{12}{Nk(k+1)}\sum_{j=1}^{k} R_j^2\right] - 3N(k+1) \qquad (1)$$

where
N = number of rows (farmers)
k = number of columns (parameters ranked)
R_j = sum of ranks in the jth column
$\sum_{j=1}^{k}$ = sum of squares of the sums of ranks over all conditions.

$$F_r = \frac{12\sum_{j=1}^{k} R_j^2 - 3N^2k(k+1)^2}{Nk(k+1) + \dfrac{(Nk - \sum_{i=1}^{N}\sum_{j=1}^{\vartheta_i} t_{i,j}^3)}{(k-1)}} \qquad (2)$$

where ϑ_i = the number of sets of tied ranks in the ith group
$t_{i,j}$ is the size of the jth set of tied ranks in the ith group.

$$|R_u - R_v| \geq z_{\alpha/k(k-1)}\sqrt{\frac{Nk(k+1)}{6}} \qquad (3)$$

where $|R_u - R_v|$ = the differences between all pairs of parameters
and z is found in Appendix 4, Table A4.4, with #c = $k(k-1)/2$. For larger #c values use Table A4.5.

The ranks from Table A1.1 were analysed using the Friedman two-way analysis of variance.

From Table A1.2 it would seem that chicken and goat / sheep are eaten more frequently than fish and wild animals by the respondents. However there is some spread amongst the villagers asked, and it would be useful to establish whether there is general agreement amongst respondents that some types of food are eaten more often than others. For this the Friedman statistic may be used.

F_r may be calculated using equation (1):

$$F_r = \left[\frac{12}{Nk(k+1)} \sum_{j=1}^{k} R_j^2 \right] - 3N(k+1)$$

$$= \frac{12}{(11)(4)(4+1)} (18^2 + 34.5^2 + 36.5^2 + 21^2) - (3)(11)(4+1)$$

$$= 14.24$$

From Appendix 4, Table A4.1 it can be seen that $F_r = 14.24$ when $df = k - 1 = 4 - 1 = 3$ is significant at between the .01 and .001 levels. If a significance level of $\alpha = .05$ is used, H_0 can be rejected, and it can be concluded that respondents agree that there is a significant difference between the frequency of consumption of the different types of food. In order to demonstrate the use of equation (2) for tied ranks, we can imagine that the data contains two tied ranks, modifying row d and the column total as shown in Table A2.3.

Because there are two tied ranks, equation (2) should now be used for the computation of F_r.

$$F_r = \frac{12\sum_{j=1}^{k} R_j^2 - 3N^2k(k+1)^2}{Nk(k+1) + \dfrac{(Nk - \sum_{i=1}^{N}\sum_{j=1}^{\vartheta_i} t_{i.j}^3)}{(k-1)}} \qquad (2)$$

In the above example, there are only two tied ranks in group d. In this case

$$\sum_{i=1}^{N}\sum_{j=1}^{\vartheta_i} t_{i.j}^3 = 1 + 1 + \ldots + 1 + 8 + 1 + \ldots + 1 = 50$$

By using equation (2):

$$= \frac{12(18^2 + 34.5^2 + 36.5^2 + 21^2) - (3)(11^2)(4)(4+1)^2}{(11)(4)(4+1) + \dfrac{(11)(4) - 50}{(4-1)}}$$

$$= 14.45$$

Since this value is larger then the value obtained without the correction, it is clear that H_0 can again be rejected. If the value of F_r had been smaller and H_0 accepted, we would conclude that there is poor agreement between respondents about the frequency of consumption of different types of food. In that case it may be possible to identify sub-groups within the community (e.g. men and women, different castes or wealth groups) within which agreement can be found.

The results indicate that at least one of the food types is perceived by the villagers to be eaten more frequently than at least one other food type. The significance of individual pairs of differences can be tested using inequality (3).

$$|R_u - R_v| \geq z_{\alpha/k(k-1)} \sqrt{\frac{Nk(k+1)}{6}} \qquad (3)$$

The differences between the ranks of the different meat types are as follows:

$\lvert R_F - R_C \rvert$	=	$\lvert 18 - 34.5 \rvert$	=	16.5
$\lvert R_F - R_G \rvert$	=	$\lvert 18 - 36.5 \rvert$	=	18.5
$\lvert R_F - R_W \rvert$	=	$\lvert 18 - 21 \rvert$	=	3
$\lvert R_C - R_G \rvert$	=	$\lvert 34.5 - 36.5 \rvert$	=	2
$\lvert R_C - R_W \rvert$	=	$\lvert 34.5 - 21 \rvert$	=	13.5
$\lvert R_G - R_W \rvert$	=	$\lvert 36.5 - 21 \rvert$	=	15.5

If the $\alpha = .05$ level of significance is used, the number of comparisons $\#c = k(k-1)/2 = (4)(3)/2 = 6$. From Appendix 4, Table A4.4 the value of z can be found to be 2.638, giving a critical difference of

$$= 2.638\sqrt{\frac{(11)(4)(4+1)}{6}}$$

$$= 2.638\sqrt{36.67}$$

$$= 15.97$$

Of the pair-wise differences above, only the first two exceed the critical difference, and it can therefore be concluded that only the difference between the frequency of the consumption of fish and chicken, and that between the consumption of goat / sheep and fish are significant. Thus there is general agreement between the villagers interviewed that chicken is eaten more frequently than fish and that goat / sheep is also eaten more frequently than fish. Despite the evidence from Table A1.2 that both chicken and fish are eaten more frequently than wild animals, this difference is not significant at the $\alpha = .05$ level.

Appendix 4: Statistical tables

Table A4.1: Table of critical values of Chi-square. Source: Siegel & Castellan (1988).

	Probability under H_0 that $\chi^2 \geq X^2$													
df	.99	.98	.95	.90	.80	.70	.50	.30	.20	.10	.05	.02	.01	.001
1	.00016	.00063	.0039	.016	.064	.15	.46	1.07	1.64	2.71	3.84	5.41	6.64	10.83
2	.02	.04	.10	.21	.45	.71	1.39	2.41	3.22	4.60	5.99	7.82	9.21	13.82
3	.12	.18	.35	.58	1.00	1.42	2.37	3.66	4.64	6.25	7.82	9.84	11.34	16.27
4	.30	.43	.71	1.06	1.65	2.20	3.36	4.88	5.99	7.78	9.49	11.67	13.28	18.46
5	.55	.75	1.14	1.61	2.34	3.00	4.35	6.06	7.29	9.24	11.07	13.39	15.09	20.52
6	.87	1.13	1.64	2.20	3.07	3.83	5.35	7.23	8.56	10.64	12.59	15.03	16.81	22.46
7	1.24	1.56	2.17	2.83	3.82	4.67	6.35	8.38	9.80	12.02	14.07	16.62	18.48	24.32
8	1.65	2.03	2.73	3.49	4.59	5.53	7.34	9.52	11.03	13.36	15.51	18.17	20.09	26.12
9	2.09	2.53	3.32	4.17	5.38	6.39	8.34	10.66	12.24	14.68	16.92	19.68	21.67	27.88
10	2.56	3.06	3.94	4.86	6.18	7.27	9.34	11.78	13.44	15.99	18.31	21.16	23.21	29.59
11	3.05	3.61	4.58	5.58	6.99	8.15	10.34	12.90	14.63	17.28	19.68	22.62	24.72	31.26
12	3.57	4.18	5.23	6.30	7.81	9.03	11.34	14.01	15.81	18.55	21.03	24.05	26.22	32.91
13	4.11	4.76	5.89	7.04	8.63	9.93	12.34	15.12	16.98	19.81	22.36	25.47	27.69	34.53
14	4.66	5.37	6.57	7.79	9.47	10.82	13.34	16.22	18.15	21.06	23.68	26.87	29.14	36.12
15	5.23	5.98	7.26	8.55	10.31	11.72	14.34	17.32	19.31	22.31	25.00	28.26	30.58	37.70
16	5.81	6.61	7.96	9.31	11.15	12.62	15.34	18.42	20.46	23.54	26.30	29.63	32.00	39.29
17	6.41	7.26	8.67	10.08	12.00	13.53	16.34	19.51	21.62	24.77	27.59	31.00	33.41	40.75
18	7.02	7.91	9.39	10.86	12.86	14.44	17.34	20.60	22.76	25.99	28.87	32.35	34.80	42.31
19	7.63	8.57	10.12	11.65	13.72	15.35	18.34	21.69	23.90	27.20	30.14	33.69	36.19	43.82
20	8.26	9.24	10.85	12.44	14.58	16.27	19.34	22.78	25.04	28.41	31.41	35.02	37.57	45.32
21	8.90	9.92	11.59	13.24	15.44	17.18	20.34	23.86	26.17	29.62	32.67	36.34	38.93	46.80
22	9.54	10.60	12.34	14.04	16.31	18.10	21.24	24.94	27.30	30.81	33.92	37.66	40.29	48.27
23	10.20	11.29	13.09	14.85	17.19	19.02	22.34	26.02	28.43	32.01	35.17	38.97	41.64	49.73
24	10.86	11.99	13.85	15.66	18.06	19.94	23.34	27.10	29.55	33.20	36.42	40.27	42.98	51.18
25	11.52	12.70	14.61	16.47	18.94	20.87	24.34	28.17	30.68	34.38	37.65	41.57	44.31	52.62
26	12.20	13.41	15.38	17.29	19.82	21.79	25.34	29.25	31.80	35.56	38.88	42.86	45.64	54.05
27	12.88	14.12	16.15	18.11	20.70	22.72	26.34	30.32	32.91	36.74	40.11	44.14	46.96	55.48
28	13.56	14.85	16.93	18.94	21.59	23.65	27.34	31.39	34.03	37.92	41.34	45.42	48.28	56.89
29	14.26	15.57	17.71	19.77	22.48	24.58	28.34	32.46	35.14	39.09	42.56	46.69	49.59	58.30
30	14.95	16.31	18.49	20.60	23.36	25.51	29.34	33.53	36.25	40.26	43.77	47.96	50.89	59.70

* Table C is abridged from Table IV of Fisher and Yates: *Statistical tables for biological, agricultural, and medical research*, published by Longman Group UK Ltd., London (previously published by Oliver and Boyd Ltd., Edinburgh) and by permission of the authors and publishers.

Table A4.2 Critical values for the Kendall coefficient of concordance W.

N = 3

k	α .05	.01
8	.376	.522
9	.333	.469
10	.300	.425
12	.250	.359
14	.214	.311
15	.200	.291
16	.187	.274
18	.166	.245
20	.150	.221

	N = 4		N = 5		N = 6		N = 7	
k	α .05	.01	.05	.01	.05	.01	.05	.01
3	—	—	.716	.840	.660	.780	.624	.737
4	.619	.768	.552	.683	.512	.629	.484	.592
5	.501	.644	.449	.571	.417	.524	.395	.491
6	.421	.553	.378	.489	.351	.448	.333	.419
8	.318	.429	.287	.379	.267	.347	.253	.324
10	.256	.351	.231	.309	.215	.282	.204	.263
15	.171	.240	.155	.211	.145	.193	.137	.179
20	.129	.182	.117	.160	.109	.146	.103	.136

Note: For $N = 3$ and $k < 8$, no value of W has upper tail probability of occurrence less than .05.

* Adapted and reproduced by permission of the publishers Charles Griffin & Co. Ltd., 16 Pembridge Road, London W11 3HL, from Appendix Table 5 of Kendall, M. G. (1970). *Rank correlation methods* (fourth edition).

Table A4.3: Friedman two-way analysis of variance by ranks statistic, F_r*. Source: Siegel & Castellan (1988).

k	N	$\alpha \leq .10$	$\alpha \leq .05$	$\alpha \leq .01$
3	3	6.00	6.00	
	4	6.00	6.50	8.00
	5	5.20	6.40	8.40
	6	5.33	7.00	9.00
	7	5.43	7.14	8.86
	8	5.25	6.25	9.00
	9	5.56	6.22	8.67
	10	5.00	6.20	9.60
	11	4.91	6.54	8.91
	12	5.17	6.17	8.67
	13	4.77	6.00	9.39
	∞	4.61	5.99	9.21
4	2	6.00	6.00	—
	3	6.60	7.40	8.60
	4	6.30	7.80	9.60
	5	6.36	7.80	9.96
	6	6.40	7.60	10.00
	7	6.26	7.80	10.37
	8	6.30	7.50	10.35
	∞	6.25	7.82	11.34
5	3	7.47	8.53	10.13
	4	7.60	8.80	11.00
	5	7.68	8.96	11.52
	∞	7.78	9.49	13.28

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Table A4.4: Critical z values for #c multiple comparisons*. Entries in the table for a given #c and level of significance α is the point on the standard normal distribution such that the upper-tail probability is equal to $\frac{1}{2}\alpha/\#c$. For values of #c outside the range included in the table, z can be found by using Table A4.5. Source: Siegel & Castellan (1988).

	α					
	Two-Tailed .30	.25	.20	.15	.10	.05
#c	One-tailed .15	.125	.10	.075	.05	.025
1	1.036	1.150	1.282	1.440	1.645	1.960
2	1.440	1.534	1.645	1.780	1.960	2.241
3	1.645	1.732	1.834	1.960	2.128	2.394
4	1.780	1.863	1.960	2.080	2.241	2.498
5	1.881	1.960	2.054	2.170	2.326	2.576
6	1.960	2.037	2.128	2.241	2.394	2.638
7	2.026	2.100	2.189	2.300	2.450	2.690
8	2.080	2.154	2.241	2.350	2.498	2.734
9	2.128	2.200	2.287	2.394	2.539	2.773
10	2.170	2.241	2.326	2.432	2.576	2.807
11	2.208	2.278	2.362	2.467	2.608	2.838
12	2.241	2.301	2.394	2.498	2.638	2.866
15	2.326	2.394	2.475	2.576	2.713	2.935
21	2.450	2.515	2.593	2.690	2.823	3.038
28	2.552	2.615	2.690	2.785	2.913	3.125

* #c is the number of comparisons.

Table A4.5: **Probabilities associated with the upper tail of the normal distribution. The body of the table gives one-tailed probabilities under H_0 of z. The left-hand marginal column gives various values of z to one decimal place. The top row gives various values to the second decimal place. Thus, for example, the one-tailed p of $z \geq .11$ is $p = .4562$. Source: Siegel & Castellan (1988).**

z	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
.0	.5000	.4960	.4920	.4880	.4840	.4801	.4761	.4721	.4681	.4641
.1	.4602	.4562	.4522	.4483	.4443	.4404	.4364	.4325	.4286	.4247
.2	.4207	.4168	.4129	.4090	.4052	.4013	.3974	.3936	.3897	.3859
.3	.3821	.3783	.3745	.3707	.3669	.3632	.3594	.3557	.3520	.3483
.4	.3446	.3409	.3372	.3336	.3300	.3264	.3228	.3192	.3156	.3121
.5	.3085	.3050	.3015	.2981	.2946	.2912	.2877	.2843	.2810	.2776
.6	.2743	.2709	.2676	.2643	.2611	.2578	.2546	.2514	.2483	.2451
.7	.2420	.2389	.2358	.2327	.2296	.2266	.2236	.2206	.2177	.2148
.8	.2119	.2090	.2061	.2033	.2005	.1977	.1949	.1922	.1894	.1867
.9	.1841	.1814	.1788	.1762	.1736	.1711	.1685	.1660	.1635	.1611
1.0	.1587	.1562	.1539	.1515	.1492	.1469	.1446	.1423	.1401	.1379
1.1	.1357	.1335	.1314	.1292	.1271	.1251	.1230	.1210	.1190	.1170
1.2	.1151	.1131	.1112	.1093	.1075	.1056	.1038	.1020	.1003	.0985
1.3	.0968	.0951	.0934	.0918	.0901	.0885	.0869	.0853	.0838	.0823
1.4	.0808	.0793	.0778	.0764	.0749	.0735	.0721	.0708	.0694	.0681
1.5	.0668	.0655	.0643	.0630	.0618	.0606	.0594	.0582	.0571	.0559
1.6	.0548	.0537	.0526	.0516	.0505	.0495	.0485	.0475	.0465	.0455
1.7	.0446	.0436	.0427	.0418	.0409	.0401	.0392	.0384	.0375	.0367
1.8	.0359	.0351	.0344	.0336	.0329	.0322	.0314	.0307	.0301	.0294
1.9	.0287	.0281	.0274	.0268	.0262	.0256	.0250	.0244	.0239	.0233
2.0	.0228	.0222	.0217	.0212	.0207	.0202	.0197	.0192	.0188	.0183
2.1	.0179	.0174	.0170	.0166	.0162	.0158	.0154	.0150	.0146	.0143
2.2	.0139	.0136	.0132	.0129	.0125	.0122	.0119	.0116	.0113	.0110
2.3	.0107	.0104	.0102	.0099	.0096	.0094	.0091	.0089	.0087	.0084
2.4	.0082	.0080	.0078	.0075	.0073	.0071	.0069	.0068	.0066	.0064
2.5	.0062	.0060	.0059	.0057	.0055	.0054	.0052	.0051	.0049	.0048
2.6	.0047	.0045	.0044	.0043	.0041	.0040	.0039	.0038	.0037	.0036
2.7	.0035	.0034	.0033	.0032	.0031	.0030	.0029	.0028	.0027	.0026
2.8	.0026	.0025	.0024	.0023	.0023	.0022	.0021	.0021	.0020	.0019
2.9	.0019	.0018	.0018	.0017	.0016	.0016	.0015	.0015	.0014	.0014
3.0	.0013	.0013	.0013	.0012	.0012	.0011	.0011	.0011	.0010	.0010
3.1	.0010	.0009	.0009	.0009	.0008	.0008	.0008	.0008	.0007	.0007
3.2	.0007									
3.3	.0005									
3.4	.0003									
3.5	.00023									
3.6	.00016									
3.7	.00011									
3.8	.00007									
3.9	.00005									
4.0	.00003									

Selected significance levels for the normal distribution

Two-tailed z	.20	.10	.05	.02	.01	.002	.001	.0001	.00001
One-tailed z	.10	.05	.025	.01	.005	[illegible]	.0005	[illegible]	.000005
z	1.282	1.645	1.960	2.326	2.576	3.090	3.291	3.891	4.417