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An Integrated Methodology for Assessment of Agricultural Water Management Technologies from Stakeholders' Perspectives

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Preface

Development of a country is a function of efficient and sustainable production system. Since time immemorial, agriculture sector is dominating the economy of India. The dominance reflects its immense potentiality to provide food, generate income and employment and sustenance to majority of rural people. Historically, the eastern region was the most prosperous agricultural tract of the country as its agriculture maintained a lead over other regions till 1950-51. It is believed that the poverty alleviation from eastern region is possible only by sustainable increase in crop production through increased cropping intensity and productivity. The key to agricultural development in the eastern region is scientific management of water resources with adoption of scientific water management technologies to provide reasonably assured good quality irrigation water during dry season and to remove excess rainwater during monsoon season. A vast networking of infrastructure for the development and dissemination of water management technologies has been designed since the very inception of our planned economic change. Despite these concerted efforts, a large number of recommended technologies are either being adopted in piece-meal or not at all. In this context, present study was conducted to assess some recommended water management technologies from the perspective of stakeholders. An integrated methodology for technology assessment was followed that delineated differential perceptions of personnel of research, extension and farmers' systems and identified significant factors, on the basis of which the technologies can be refined according to resources and needs of the specific farming community leading to wider adoption. The findings of this study are discussed in this bulletin. It is hoped that the information presented in this bulletin will be useful to the researchers, policy makers, development officials and others who want to make further progress in their respective activities related to agricultural water management and thereby benefiting the farmers.

The authors are grateful to the Director General, Deputy Director General (NRM) and Assistant Director General (IWM), ICAR for their support, encouragement and suggestions. Our sincere thanks are also due to all the colleagues and staff members of WTCER, Bhubaneswar for their help at the time of need. Thanks are also due to all the selected respondents including farmers, extension personnel and researchers for their co-operation and responses during the study.

AUTHORS

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Executive Summary

The research and extension systems have been generating and disseminating technologies relating to water management in agriculture. On the contrary, many of the disseminated technologies do not find place in farmers' fields. Therefore, to draw the insights of this non-adoption phenomenon a study was undertaken to assess the technologies from the stakeholders' perspectives following an integrated methodology.

The recommended water management technologies were assessed after their documentation from different organisations working in the field of water management in the states of Orissa and West Bengal, India. Perceptions of the research personnel (n=30) revealed that out of 86 documented recommended water management technologies, 40 technologies were having score ≥ 4.0; 8 technologies with score ≤ 3.0 and rest of the 38 technologies with score in between 3.0 to 4.0 on a scale ranging from 1.0 (not appropriate/feasible) to 5.0 (highly appropriate/feasible).

Research personnel perceived 40 technologies as highly feasible out of which extension personnel (n=50) have perceived 16 and 10 technologies as highly appropriate and feasible, respectively, while six and four technologies were found to be less appropriate and feasible, respectively.

Ten technologies (perceived highly appropriate by both research and extension personnel) were selected for their detail assessment by a sample of 150 farmers representing from irrigated and rainfed areas in the state of Orissa and West Bengal. The study elucidated that farmers' level of perceptions for those technologies were in a decreasing order of appropriateness, feasibility and adoptability. It is found that although farmers have perceived the technologies as appropriate and feasible but they have doubted the adoptability of many of those technologies. Farmers' perceptions with respect to nine indicators of appropriateness revealed that the indicators like cost, physical compatibility, cultural compatibility, simplicity and need were relatively at lower level as compared to other indicators (relative advantage, observability, profitability and production sustainability) in many of the selected technologies. Farmers' perceptions regarding adoptability of selected technologies ranged from below average (0.50-1.00) to above average (1.01-1.50) level on 3-point continuum scale (0 to 2). Appropriateness of technologies significantly and highly influenced feasibility and adoptability of the technologies.

The indicators of appropriateness like physical compatibility, need, profitability, observability and simplicity together contributed 89% variation in feasibility; therefore, these crucial parameters need to be focused to refine the technologies before their dissemination to farmer's system.

Appropriateness, feasibility and knowledge were significantly correlated with adoptability and they together constituted 56% variation in it.

Besides appropriateness and feasibility of technologies there are other factors like socio-economic profile of farmers and various technical, social, economic and infrastructure constraints, which also have significant relationship with adoption phenomena. Evidently knowledge, appropriateness, feasibility, social participation, farm size and extension orientation together constituted 76% variation in adoptability. It is found that technical constraints (uncertain supply of irrigation water in canal command and unpredictable water availability during rainy season, difficulty in maintaining recommended depth of water during irrigation), social constraints (lack of group action and community cooperation), economic constraints (fragmented land holdings, high initial expenditure and high cost of inputs) and infrastructure constraints (injudicious use of water because of abundant availability and not sufficiently priced, difficulty in getting required inputs and lack of training to farmers) have influenced farmers' perceptions towards adoptability of technologies. It is conclusive that the perceptions of researchers, extension personnel and farmers differ considerably and these gaps need to be bridged to find real impact of technological interventions for water management at farm level.

1. Introduction

The key to agricultural development in eastern India is scientific management of water resources with adoption of recommended scientific water management technologies. Over the years, research work and technology generation have been done in the country and efforts have been made to transfer the technologies to the farmers in order to achieve sustained increase in production and productivity. Scientists have developed and recommended technologies to find solutions to most of the problems relating to water management in agriculture. On the contrary, many of the recommended technologies do not find favour with farmers. Experience has shown that in a large number of cases, the farmers do not show much enthusiasm for adopting recommended technologies on account of several factors. They are either being adopted in piece-meal or not at all (Singh and Gill, 1993; Singh and Schiere, 1994; Singh, 1996). Further, in many cases, while the technology is quite suitable and simple, it is still unacceptable to the ground level, which hinders its adoption.

In India, agro-technologies inclusive of water management technologies generated so far have been readily accepted by the resource-rich farmers and in resource rich areas. But a vast complex, diverse and risk prone (CDR) areas, i.e. area under the rainfed agriculture encompassing millions of small and marginal farmers, are left outside the realm of technological development (Das, 1996). To take the benefits of scientific and improved farm technologies to the millions of small and marginal farmers it is required to look at technology more from the point of view of appropriateness and overall feasibility (Chambers and Jiggins, 1986; Osten, 1989; Bernadas, 1991).

The analyses of several studies conducted in India on the reasons of non-adoption of the technology have revealed very interesting trends. During the period of 1950s-60s, the reasons for non-adoption were explained in terms of 'farmers' ignorance' while during 1960s-70s, the explanation for non-adoption was in term of 'various farm level constraints'. However, during 1990s non-adoption of technologies has been explained by 'lack of appropriateness of technologies' (Chandrakanandan *et al*, 1995; Das, 1996; Hansra, 1996). An International Workshop on "Alternative and Cost Effective Extension Approaches for Sustainable Agriculture: Methodological Issues" organized jointly by the Ford Foundation, Food and Agricultural Organization (FAO) and Tamil Nadu Agricultural University (TNAU), India recommended that any technology to be appropriate needs to be simple, convincing, need-based, location specific, socially and economically acceptable and environment friendly leading to sustainability (Anonymous, 1995). The technology must be able to create the need to initiate the process of thinking in the farmers followed by the adoption (Rogers, 1983). Appropriateness of a technology is a pre-requisite for its transfer and adoption (Choudhary, 1995 and Singh, 1996).

Researchers, extension personnel and farmers are the stakeholders because of their involvement during the process of technology generation, dissemination and operation at the fields. Farmers are the producers of agricultural outputs, however, they often receive the least attention during any assessment or evaluation process. Technology assessment from the stakeholders' perspectives is not substitute for careful agronomic and economic evaluation of technology, but is an essential component that provides feedback to research and extension systems in refining existing recommended technologies to make them appropriate according to the needs and the resources of specific farming system.

In this context, present study was conducted to assess some recommended water management technologies with respect to their feasibility, appropriateness and adoptability from the perspective of the personnel of research, extension and farming systems following an integrated methodological approach.

2. Location of the Study and Sampling Plan

The states of Orissa and West Bengal in India were selected for the study. Personnel of research, extension and farming systems formed the universe of the study.

After enlisting the recommended water management technologies on the basis of published documents of different organisations working in the field of water management in the states of Orissa and West Bengal, it was aimed to assess the feasibility of those technologies as perceived by the researchers; therefore, responses were taken from randomly selected 30 personnel of the research system.

Feasibility as well as appropriateness of selected recommended water management technologies, which were already perceived highly feasible by research personnel, were assessed from the perspective of extension personnel. A sample of 50 extension personnel was selected. This sample consisted of 20 extension personnel, 10 each from Directorate of Extension Education, Orissa University of Agriculture and Technology and Bidhan Chandra Krishi Viswavidyalaya, West Bengal; 20 personnel of State Department of Agriculture, Orissa and 10 personnel of State Department of Agriculture, West Bengal.

Technologies perceived highly appropriate and feasible by both personnel of research and extension system were screened for their assessment from farmer's point of view. Stratified random sampling method was followed for selection of respondents representing from different areas. Accordingly, a total of 150 farmers were selected as respondents representing areas under tube-well irrigation in West Bengal (50 farmers) and lift irrigation (25 farmers), canal irrigation (50 farmers) and rainfed area (25 farmers) in Orissa.

3. Variables, their Operationalisation and Measurements

3.1 Feasibility of technologies

Feasibility of recommended water management technologies was assessed with the help of a developed feasibility questionnaire from the perspective of research personnel first followed by extension personnel. Feasibility refers to possibility of a technology to be adopted in the farmer's situation. Responses were taken from 30 research personnel regarding their perceptions with respect to feasibility of recommended water management technologies. Responses were taken on a feasibility continuum ranging from 1.0 (not feasible) to 5.0 (highly feasible). However, interview schedule survey method was followed to gather the farmers' responses on this variable on a 3-point scale ranging from 0.00 to 2.00.

3.2 Appropriateness of technologies

Unlike research personnel, extension personnel being grass root level workers are supposed to be more familiar with the farming system as they maintain close contact with the farmers. Therefore, besides feasibility of technologies they were asked to perceive the appropriateness of the selected technologies as well. Appropriateness of technology was assessed with respect to nine indicators selected on the basis of review of literature and already laid down criteria of attributes of innovation. Indicators of appropriateness have been operationalised as follows:

i) *Simplicity-complexity:* The simplicity dimension of the technologies is referred as the degree to which a technology is easy to understand and operate, whereas, complexity refers to the degree to which a technology is difficult to use and understand.

ii) *Relative advantage:* The degree to which the technology is perceived as better than the idea it supersedes.

iii) *Observability:* The degree to which the result of adoption of a technology is visible. The visible impact of a technology facilitates its diffusion.

iv) *Cost of the technology:* It refers to the investments in purchase plus recurring cash expenses on it and cash expenses on other associated activities necessary for putting the technology into practice.

v) *Profitability:* Profitability of each technology is referred as the farmer's perception of additional monetary and physical returns obtained by adopting the technology as compared to that one it substitutes.

vi) *Physical compatibility:* It is the degree to which a technology is in conformity with the existing situation of the farming community. In other words, to be more specific, physical compatibility refers to how well a technology fits into the working conditions of farmers.

vii) *Cultural compatibility:* It is the degree to which a technology is consistent with the existing beliefs, values, attitudes, living patterns, habits, cultural norms and past experiences of the farmers. For the purpose of this study, it refers to what extent a technology is compatible with the existing norms, values, beliefs and past experiences of the respondents.

viii) *Need of the technology:* Need of the technology is referred as the farmer's perception of the requirement as well as cruciality of the technology in his / her setting.

ix) *Production sustainability:* It is referred as the successful management of resources maintaining the quality of environment without any deterioration of farmer's production system.

With the help of a questionnaire developed for the study, responses of the extension personnel were recorded for each selected recommended technology with respect to each of the above-mentioned indicators on a continuum ranging from 1 to 5 i.e. unfavourable (poor/low) to favourable (best/high). Farmers' responses on nine indicators of appropriateness gathered on a scale ranging from 0.00 to 2.00 following interview schedule survey method.

3.3 Awareness and adoptability of technologies

Awareness refers to the level of knowledge of the farmers about certain recommended technology while adoptability is the perception of farmer towards possible adoption of the selected technology in his specific farming condition. Interview schedule survey method was followed to take the farmers' responses on these variables on a 3-point scale ranging from 0.00 to 2.00.

3.4 Characteristics of farmers

Characteristics of the farmers refer to socio-personal, economic, communicational and psychological traits, which were explored through interview schedule survey. Socio-personal variables included age, education, caste, social participation, etc. and economic variables were income, land holding, farm size, household condition, etc. Communicational and psychological traits of the selected farmers were explored with respect to their scientific and extension orientation, mass media participation and attitude towards recommended scientific water management practices. The responses were quantified and analysed to understand their relationship with adoption dynamics of recommended technologies.

3.5 Perceived constraints

Explanations for the non-feasibility/lower feasibility of technologies as perceived by the experts were also recorded and many of which were in terms of several anticipated constraints in the farmers' settings. Farmers being fundamental stakeholders for putting the recommended technology into practice were asked to mention different social, technical, administrative and infrastructure constraints those hinder the adoption of recommended water management technologies. It was studied with the help of a semi-structured interview schedule.

4. Findings of the Study and Discussion

4.1 Feasibility of technologies as perceived by the research personnel

A total of 86 water management technologies were selected on the basis of published documents of different organisations working in the field of water management in the states of Orissa and West Bengal. The feasibility of all these technologies as perceived by different personnel of research system was assessed. Primarily, the weighted mean score and standard deviation were derived for each technology on the basis of responses of all 30 personnel of the research system. It was thought to be a crude method as the weighted mean scores might have affected due to scared or biased responses of few personnel. Therefore, further statistical analyses were carried out to reduce the biases through elimination of personnel with scared or biased responses. Correlation analyses were done and a correlation matrix was formed, on the basis of which degree of agreement with respect to the responses of each research personnel with others was found out at 5 and 1 per cent level of significance; frequency of agreement of each personnel with others and standard deviation was derived (Annexure). Finally, the research personnel having negative correlation with majority of other personnel and the personnel having disagreement with large number of other personnel along with relatively higher value of standard deviation were discarded. Accordingly, 23 personnel of research system (personnel having agreement with more than 25 per cent of total number of personnel) were screened. On the basis of their responses mean feasibility score and standard deviation for each technology were worked out. It was found that 40 technologies were having mean feasibility score ≥ 4.0 while eight technologies were having score ≤ 3.0 and rest of the 38 technologies were with mean feasibility score in between 3.0 to 4.0 on a feasibility continuum ranging from 1.0 (not feasible) to 5.0 (highly feasible), where 3.0 indicates the neutral point.

The respective feasibility scores and explanations of non-feasibility / lower feasibility as mentioned by the research personnel with respect to 46 technologies (8 technologies with feasibility score ≤ 3.0 followed by 38 technologies with feasibility score in between 3.0 to 4.0) are indicated in Table 1. It is revealing that there are several constraints, which may be responsible for the non-feasibility / lower feasibility of technologies in the farmers system. Mostly plot sizes of the farmers are too small to use technologies related to mechanisation like tractor drawn implements. Moreover, it requires high initial investment. Farmers do not like to adopt those technologies, which do not show any visible increase in production. The technologies like irrigation scheduling, irrigation interval, alternate drying and wetting, drainage, etc. suffer from non-adoption in farmers' systems due to uncertainty of irrigation water. It is perceived to be difficult to manage water judiciously in the areas where field to field irrigation through flooding method is prevailing with rice as predominant crop.

It is evident that the research personnel opined 40 out of 86 recommended technologies as highly feasible. According to Amir and Knipscheer (1989) and Jain *et al* (1993), it is essential to know which technologies are suitable or likely to be adopted by the farmers. It is in this context that screening of technologies by the personnel of research system is the first step in technology assessment process. In present study research personnel have anticipated several reasons for lower feasibility of some recommended water management technologies, which were small field size and fragmented holdings of small-marginal farmers restricting farm mechanisation, high initial investments, lack of visible effect and existence of irregular irrigation delivery system. Ghosh *et al* (2003) reported that unassured supply of irrigation water have resulted into a gap between the potential created and potential utilized in canal command area at Balipatna block in Khurda district of Orissa. Utility of irrigation service under Nimapara branch canal command area in orissa is found to be lowest for the factor predictability in water supply followed by convenience and tractability of water supply which compelled farmers to use water injudiciously without adoption of scientific recommended practices for agricultural water management (Ghosh *et al*, 2004). According to Singh (1996), researchers have developed technologies to find solutions to the problems relating to water management in agriculture; however, experiences have shown that in a large percentage of cases, feasibility is bottlenecked by the factors such as high initial investments, high operational costs, high maintenance costs, and high technical input requirement.

Table 1. Reasons for non feasibility/lower feasibility of some recommended water management technologies/practices as perceived by the research personnel

Recommended agricultural water management technologies / practices	Mean feasibility score	Perceived reasons for non feasibility / lower feasibility of the technology / practice in the farmers' fields
1. During transplanting rice fields should be puddled through puddler or disc harrow to seal the pores.	2.93	Farmers find no visible increase in yield. High cost of implement. Field size is too small to operate. Good / lesser weight puddler is not available. Mostly plot sizes are too small to use tractor drawn implements.
2. Irrigation schedules in rice that alternate wetting and drying or saturation till tillering followed by maintenance of 5-8 cm of water thereafter could save 50% of water as compared to continuous submergence without affecting the yield.	3.00	There is no surety of getting frequent water supply in canal command. Weed infestation will be more and consequently yield will reduce resulting lowering of water use efficiency. Drying at tillering is required but before that it adversely affects tiller and crop yields. Laborious job. Soil-cracks, often developed during field drying cycle, cause heavy percolation loss of irrigation water.
3. Drainage for 7-10 days is necessary in rice at tillering stage as it increases yield.	2.29	Drainage is not feasible due to unassured irrigation. Lowlands are difficult to drain. Nonexistence of drainage channel makes it difficult to practice. Drainage is practically difficult during wet season.
4. Maintaining 2-5 cm standing water up to flowering stage followed by saturation instead of continuous submergence of 2-5 cm water in *boro* rice does not decrease grain yield significantly.	2.93	No visual difference in yield. Even after flowering shallow submergence is required. Uncertainty of available irrigation water. Saturation after flowering may be harmful.
5. There is not any significant yield loss in rice under continuous ponding upto 12 cm. Surface drainage should be designed to drain out water only in excess of this depth. Maximum allowable ponding depth is 15% of the maximum plant height.	2.79	Nutrient loss may occur in the event of drainage. Ponding depth should match with ponding duration, otherwise not feasible. Drainage is problem due to difficulty in having drainage channel in most of the farmer's fields.
6. About 8-9 irrigations at 8-9 days interval is found optimum in potato. Initially irrigate 5-7cm water and gradually increase upto 10-12cm.	2.85	Difficult to maintain irrigation depth. Frequent irrigation is hard to practice due to uncertainty of availability of water. Interval of irrigation can be extended at early stages and reduced at later stages as increase of irrigation water up to 10-12 cm hampers crop yield during tuber bulking stage.

Recommended agricultural water management technologies/ practices	Mean feasibility score	Perceived reasons for non feasibility / lower feasibility of the technology / practice in the farmers' fields
7. Groundnut responds best with irrigation schedule of IW/CPE = 1.2 along with application of mulch @ 5 t/ha. Mulching helps to minimise the water requirement.	2.93	Unavailability of mulching material. The farmers use mulching material like straw for thatching, fodder, etc. Incurred extra cost of cultivation. In groundnut earthing-up is required, therefore, mulching may not be always feasible. Mulches are quickly damaged by the termites. Sometimes, it leads to pest infestation in crop. It is uneconomic to practice.
8. Lining of tanks with compressed mud blocks.	3.00	Requires high initial cost. Difficulty in availability of required material for preparation of blocks locally.
9. The recommended varieties of irrigated rice	3.86	Abundant availability of local seeds. Seeds of recommended varieties are not always readily available to farmers.
10. After 30 days, field should be drained out for a week for top dressing of fertilizer in case of irrigated rice.	3.29	Farmers are not assured to re-irrigate after drainage due to uncertain availability of water. Availability of irrigation water is not always under the control of farmer. Drain out for a day or two is possible, otherwise weed infestation will occur. It's not feasible where the existence of field-to-field irrigation is followed.
11. In case of irrigated rice, field must be drained gradually 15 to 20 days after full flowering stage. This helps in achieving higher milling.	3.79	Drainage is not a practical practice as it depends on the field situation and other factors.
12. Cultivation of recommended varieties of rice in rainfed unfavourable lowland situation (40-75 cm).	3.83	Farmers face difficulty in availability of seeds.
13. Adoption of soil and water conservation measures such as bunding and contour terracing, storage of rainwater, specially surface run off, in a micro or macro-watershed on a community basis in sloppy lands, may help giving one or two life saving irrigation at critical stages of crop growth (rainfed upland rice) in the event of terminal drought.	3.93	Initial investment is high. Farmers are too poor to adopt such expensive practice. This is to be a community approach, which is still not in practice as response of community is poor.

Recommended agricultural water management technologies / practices	Mean feasibility score	Perceived reasons for non feasibility / lower feasibility of the technology / practice in the farmers' fields
14. In case of rainfed upland rice, deep ploughing and sub-soiling across the slope help in conserving moisture in wet season that enables enhanced root growth and extraction of soil moisture from deeper layers. It facilitates line sowing and deep seeding.	3.64	No visible change in yield. Needs high investment. It helps only in sloppy areas. During land preparation deep ploughing is difficult to accomplish due to poor soil moisture. Not suitable for shallow soils. Mechanisation is not satisfactory. Availability of required implement with farmers is questionable.
15. Cultivation of recommended varieties of rice in deep water (75-120 cm) and floating (>120 cm) condition.	3.93	Availability of the seeds is not easy. No variety is perfectly suitable for flood-affected lowlands.
16. Some recommended cropping sequences : Under irrigated uplands: Rice-Rajmash-Maize; Rice-Cucumber-Maize . Under irrigated medium lands: Rice-Maize-Cowpea; Rice-Rajmash-Okra; Rice-Tomato- Okra; Rice - Sweet potato. Under rain-fed lowland: Maize for cobs-Tomato; Rice - Tomato.	3.29	Rice-rice is preferred where irrigation facilities are available. Unavailability of the seeds on time restricts farmer to go for such cropping system. In case of upland and medium land, farmers can grow vegetables during dry season after wet season rice with assured irrigation facilities; however, it's not possible to grow any crop other than rice in case of lowland situation.
17. In rice based cropping environment, tomato as vegetable and groundnut as oilseed crop are attractive possibilities after rice with less amount of water or with residual moisture.	3.71	Many a time the harvesting of rice crop gets delayed and in such cases delayed sowing of tomato gives poor yield. Groundnut in summer requires 8-9 irrigations; hence, it is not desirable with out assured irrigation facilities.
18. Rice-Mustard-Mung sequence is found to be best alternative for maximum return per unit investment per unit drop of water in medium land situation under irrigation command area.	3.36	Free flooding (where field to field irrigation exists) does not permit such cropping sequence. Supply of excessive water (uncontrolled supply under irrigation command area) does not permit cultivation of any crops other than rice. Rice-rice sequence is generally followed.
19. Irrigation at 1.2 IW/CPE ratio for maize (*Rabi*) with 5 cm of irrigation water requiring 5 irrigation is optimum in rice based cropping system.	3.93	Farmers' knowledge about IW/CPE ratio is very poor, rather recommendations on number of irrigation at different stages can help to minimise loss of water use. It is difficult to adopt 5 cm depth in surface irrigation.

Recommended agricultural water management technologies / practices	Mean feasibility score	Perceived reasons for non feasibility / lower feasibility of the technology / practice in the farmers' fields
20. Maize, sesame, soybean, groundnut and pigeonpea are found to be good substitutes for rainfed rice in uplands in humid and sub-humid regions. These crops are observed to be good associate crops in rice in the pair cropping system under micro-watershed system of rainwater management.	3.79	All these crops may substitute the rainfed rice but may not give equal result. Marketing of the products is questionable.
21. Irrigation with 7 cm water 3 days after disappearance of ponded water in *kharif* rice.	3.71	Irrigation only when soil surface starts hair cracking should be given; however, availability of water needs to be ensured.
22. Tractor driven rotary puddler reduces 6 cm of percolated water in *kharif rice* compared to any animal driven puddling implements.	3.57	Requires higher cost. Field size is too small to operation. Restricted availability of the implement. Tractor is not available to many farmers. Costly and uneconomic.
23. For transplanted rice crop in *Kharif* season, continuous submergence gives at par yield with continuous saturation treatment. The later condition requires 40% less water than the former.	3.69	Water is abundantly available and moreover not sufficiently priced. Under saturation condition weed growth can not be controlled. During *kharif* continuous saturation is not feasible because of the occurrence of rain.
24. Irrigation with 7 cm water through field channels one day after the disappearance of ponded water in *summer* rice.	3.69	More water is required. Construction of field channels may not be possible as it depends on field situation; moreover, it incurs extra expenditure and requires community cooperation.
25. Continuous submergence 5 ± 2 cm of ponded water in light soil and same quantity of ponded water one day after disappearance in medium land situation is optimum for *summer* rice production.	3.86	Light soil is not suitable for cultivation of summer rice for more water requirement.
26. In *summer* rice maintaining ponded water of 2-5 cm depth with drainage for 3-4 days at maximum tillering stage is found better in terms of better yield and water use efficiency compared to continuous ponding.	3.64	Unassured irrigation restricts the practice of drainage. Strongly depends on soil property. Such practice may cause yield decline as well if re-irrigation becomes difficult / delayed due to uncertain water supply.

Recommended agricultural water management technologies / practices	Mean feasibility score	Perceived reasons for non feasibility / lower feasibility of the technology / practice in the farmers' fields
27. Intermittent ponding at the vegetative stage (0-30 DAT) followed by continuos ponding during growth stage may be recommended for *summer* rice that reduces 3 to 4 irrigations in complete crop growth cycle with a little reduction of yield compared to continuous submergence.	3.43	Unassured irrigation facility. Weed problem during initial stage of intermittent ponding. Cracks in the soil develop.
28. The grain yield (45.0 q/ha) of *boro* rice is found to increase by 32.65% over control (34.0 q/ha) after maintaining submergence of 2-5 cm of water level in three stages i.e. transplanting to tillering stage; flowering and grain filling stage.	3.57	It's difficult for farmers to practice in case of unassured irrigation facilities.
29. Land leveling in rice field with 1% slope helps in the conservation of moisture.	3.43	Initial investment increases cost of cultivation.
30. Phasic soil submergence from transplantation to initial tillering and from panicle initiation to post flowering stages are observed to be critical for wetland rice. Soil saturation during the remaining period is found beneficial for yield with saving of substantial amount of water.	3.93	Soil saturation may not be well accepted by the farmers due to weed growth. In wetland rice, scheduling of irrigation is not possible.
31. Lysimetric (drum culture) studies indicate that about 35 per cent irrigation water could be saved if rice is grown under soil saturation in lateritic loam soil. The water use efficiency of the crop is also improved by 59 per cent under this situation.	3.43	Frequent irrigation is difficult; moreover water is cheap and not / lowly priced. Weed growth becomes high in saturation. Difficult to achieve it under open field condition. It is difficult to maintain saturation in lateritic loam soil for rice.
32. Irrigation at 1.2 IW/CPE ratio with 3 cm of irrigation water requiring 6-7 irrigation is optimum for potato in West Bengal.	3.38	Potato requires about 10 to 12 irrigation. Irrigation with 3 cm depth cannot be applied.

Recommended agricultural water management Technologies / practices	Mean feasibility score	Perceived reasons for non feasibility / lower feasibility of the technology / practice in the farmers' fields
33. Application of irrigation at 3 different growth stages (a) germination to stolon initiation (b) stolon initiation to early bulking (c) early bulking to maturity stage enhances tuber yield in potato.	3.93	Potato requires about 10 to 12 irrigation.
34. Maintenance of soil moisture at 60-100% available moisture regime is found adequate for obtaining better yield of maize.	3.38	Difficult to maintain required moisture content. Available soil moisture above 50% can be maintained only after flowering. The recommendation should be in term of irrigation interval for farmers to helping them to understand and follow.
35. During *pre-kharif* season, irrigation scheduling at 0.9 IW/CPE ratio is found to be optimum for groundnut.	3.71	Difficult to maintain such irrigation scheduling. The farmers cannot get the data of pan evaporation; moreover IW/CPE is difficult to understand by the farmers rather it would be effective if number of irrigations and stages of irrigation can be mentioned.
36. Application of irrigation at an interval of 20 days gives groundnut yield of 32.8 q/ha.	3.64	Interval should be reduced during hot summer. Only possible where assured irrigation facilities prevail.
37. Optimum schedule of irrigation to rapeseed based on IW/CPE ratio of 0.7 is found as the optimum ratio.	3.62	Difficult to maintain. Farmers unable to follow such irrigation scheduling with respect to specific IW/CPE.
38. Locally available organic materials namely, FYM, straw, etc. are found to be suitable to be used as mulches for soil moisture conservation and improving the productivity of linseed and rapeseed. Straw mulch and polythene mulch increase the seed yield of rainfed crops by 36.4% and 40%.	3.69	Not viable in larger scale due to unavailability of required materials and higher cost of application. Constraints in availability of mulching materials. Polythene mulch is not economic.
39. During non-rainy season, irrigation at 0.8 evaporation rate daily, through drip system to brinjal plant is found to be optimum and saving 200 % irrigation water compared to local practice of surface irrigation.	3.93	Require initial investment. Depends on system performance. It may not be economically viable to the farmers.

Recommended agricultural water management technologies / practices	Mean feasibility score	Perceived Reasons for non feasibility / lower feasibility of the technology / practice in the farmers' fields
40. Irrigations of 3 cm. at 1.5 IW/CPE ratio in cauliflower and at 2.0 IW/CPE in cabbage are found to be optimum.	3.54	Difficult to understand and maintain by the farmers.
41. A mixture of fly ash from thermal plant and potter's clay with 50% cement is found to be suitable lining material for field channels.	3.38	Difficult to practice. Difficult to get the required material.
42. Plastic lining for the field channel enables the farmer to cover 1/10th of area more for vegetable cultivation during dry season.	3.29	Higher cost and damage over the period of time. Rodent damage, bullock and machinery damage. It may not be economically viable.
43. Perpendicular orientation of field channel to main supply is superior to parallel orientation in case of canal irrigation. The interval between outlets should be 425 to 450 m. rotation areas for parallel orientation and 650-700 m. for perpendicular orientation.	3.62	Prevalence of field-to-field irrigation (flooding method) restricts the channel irrigation practice. Farmers are mostly reluctant to prepare channels for high initial cost and unfavourable land situation. Farmers largely cultivate rice with complete submergence.
44. Regulation of excess water through surface drainage with 10 m drain spacing for *rabi* (wheat, mustard) *summer* (mung, til) and *kharif* (rice) crops maximise water use efficiency with maximum yield.	3.79	Construction of the system requires high initial investment.
45. It is proposed to delay the crop growing period up to October where waterlogging is more than 50 cm for a long period and to encourage cultivation of short duration HYVs to avoid peak ponding events.	3.75	It's required cold tolerant varieties. It is not possible to vacate the land by October under such situation.
46. Practical interpretation chart of soil moisture for various soil textures and conditions to helping in estimation of depth of irrigation to be applied in each irrigation application- irrigate when depletion value lies anywhere between 25 % to 75 % to available moisture.	3.57	75% depletion of available moisture will adversely affect the crop yield.

4.2 Appropriateness and feasibility of technologies as perceived by the extension personnel

The extension personnel are supposed to maintain the linkage and feedback mechanism between research and farming systems. As they work in close contact with the farmers in the technology dissemination process, it was thought proper to ask them to anticipate the appropriateness besides the overall feasibility with respect to 40 recommended water management technologies (already perceived highly feasible by research personnel). Primarily, the weighted mean score and standard deviation were derived for each technology on the basis of responses of 50 extension personnel. The categorization of the technologies on the basis of responses was made with the help of pooled standard deviation and pooled mean values in both cases as indicated in Table 2.

Table 2. Overall appropriateness and feasibility of technologies as perceived by the personnel by extension system

Sl. No.	Appropriateness categories	Score	No. of technologies	Pooled mean	Pooled standard deviation
1.	Good / High	≥ 3.83	16	3.57	0.26
2.	Medium	3.32 - 3.82	20		
3.	Poor / Low	≤ 3.31	4		
Sl. No.	**Feasibility categories**	**Score**	**No. of technologies**	**Pooled mean**	**Pooled standard deviation**
1.	Good / High	≥ 3.86	10	3.49	0.37
2.	Medium	3.13 - 3.85	24		
3.	Poor / Low	≤ 3.12	6		

It was observed that 16 and 10 technologies were perceived as highly appropriate and feasible, respectively. While four and six technologies were found to be perceived lowly appropriate and feasible, respectively. Rest of the technologies fall under medium category. An account of the technologies, perceived as highly feasible and appropriate is presented in Table 3.

The overall appropriateness was derived on the basis of responses on nine indicators. Perceptions of extension personnel with respect to 40 technologies on different indicators of appropriateness are depicted in Fig. 1. It is evident that few technologies were lowly perceived with respect to indicators like cost, physical compatibility, cultural compatibility, need, observability and simplicity. In contrast, some technologies were perceived highly with respect to different indicators. Refinement with respect to respective indicators on which a technology perceived lowly will improve the overall appropriateness of that technology.

Table 3. Recommended agricultural water management technologies perceived as highly feasible and appropriate by the personnel of both research and extension systems

Recommended water management technologies	Research personnel		Extension personnel			
	Mean feasibility score	Standard deviation	Mean feasibility score	Standard deviation	Mean appropriate-ness score	Standard deviation
1. In rice, before the beginning of panicle primordial development stage, field must be flooded to a depth of 5 to 7 cm as shortage during this and later stage will result sterility and cause a yield loss.	4.07	1.24	3.96	0.87	3.95	0.82
2. Cultivation of recommended varieties of rice for rainfed upland and rainfed favourable lowland (0-50 cm water) situation.	4.20	0.83	3.83	0.54	3.86	0.85
3. Application of adequate amount of compost or farmyards manure (5 t/ha) for a number of years will improve soil structure increase water retention and soil fertility.	4.39	0.89	3.86	0.65	3.90	1.06
4. On farm irrigation water management through following suitable crop sequence: Rice-Potato-Rice; Rice-Potato-Lentill; Rice-Groundnut-Rice; Rice-Mustard-Rice; Rice-Wheat-Green gram.	4.42	0.69	3.90	0.82	3.86	0.81
5. Bund height of 22 to 30 cm in rice plots under medium land situation is found to be optimum where the losses of sediment and nutrients in runoff water, the irrigation requirement minimize considerably and storage of rainwater maximizes.	4.21	0.80	3.46	0.85	3.89	0.84
6. Under constraints of irrigation water (two irrigation), irrigation at CRI stage and panicle initiation stage is better compared to CRI and flowering stage in wheat.	4.16	0.96	4.03	0.60	3.86	0.67
7. In wheat crop critical physiological stages for moisture are (i) crown root initiation (ii) late tillering (iii) flowering (iv) grain filling stages.	4.68	0.48	4.03	1.05	3.96	0.75

Recommended water management technologies	Research personnel		Extension personnel			
	Mean feasibility score	Standard deviation	Mean feasibility score	Standard deviation	Mean appropriate-ness score	Standard deviation
8. Irrigation in furrows between two pairs produces significantly higher tuber yield in potato with maximum water use efficiency.	4.43	0.81	4.22	0.99	3.87	0.84
9. During dry season, application of water in rice could be delayed till complete disappearance of ponded water in case of irrigated rice.	4.29	0.56	4.10	0.87	3.97	0.91
10. Three irrigations at branching, flowering and pod development stages are found best for sesame crop.	4.35	0.71	4.02	0.67	4.05	0.78
11. The critical physiological stages in summer sesame crop for irrigation are germination, branching, flowering and pod development stages.	4.35	0.65	3.83	0.78	3.94	0.80
12. Two irrigations one at 50% flowering (30 DAS) and other at pod formation stage (55 DAS) improve the grain yield of rapeseed crop.	4.15	0.71	4.00	0.73	3.87	0.78
13. The critical physiological stages in rapeseed crop for irrigation application are branching, flowering and siliqua development stages.	4.52	0.81	3.81	0.93	3.96	0.83
14. The critical physiological stages in summer *mung* (Green gram) for irrigation application are branching, flowering and pod development stages.	4.22	0.85	3.94	0.54	3.86	0.80
15. The fruit yield of tomato is significantly increased after application of irrigation at 25 days interval and in furrows.	4.07	1.17	3.77	0.90	3.84	0.78
16. Water harvesting system (pond/tank) for multiple use of water in cultivation of rice, vegetables, fruit crops on the bunds along with fishery, poultry, duckery, etc.	4.03	0.82	3.53	1.00	4.04	1.05

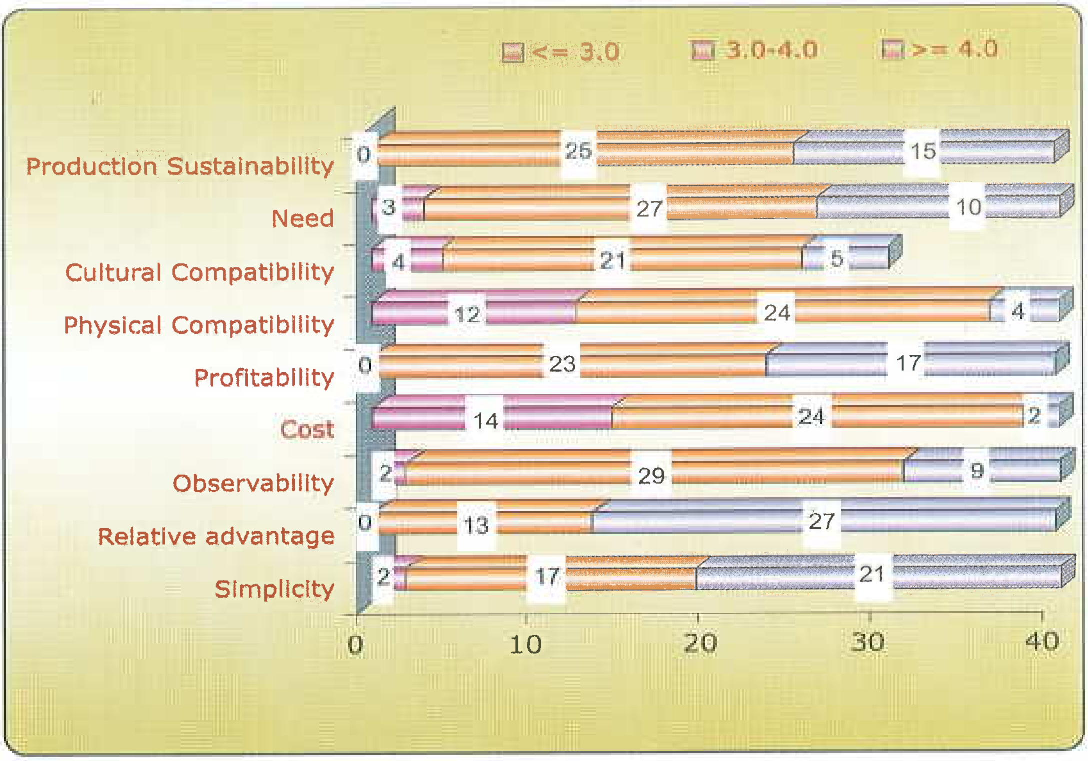


Fig.1. Perception of extention personel towards 40 recommended water management technologies on different indicators of appropriateness

Correlation of different indicators of appropriateness with feasibility of technologies was worked out. It is revealing that all the nine indicators of appropriateness were significantly related with feasibility (Table 4). The data were further put to step-wise multiple regression analysis considering nine indicators of appropriateness as independent variables and feasibility as dependent variable. The result is presented in Table 5.

The step-wise regression has run upto fifth step and included five indicators of appropriateness *viz.* simplicity, physical compatibility, production sustainability, cultural compatibility and cost. These together constituted 36.8 per cent of total variation in feasibility with the 't'

Table 4. Correlation of different indicators of appropriateness with feasibility of technologies

Sl. No.	Indicators of appropriateness	Correlation value
1.	Simplicity	0.498**
2.	Relative advantage	0.383*
3.	Observability	0.348*
4.	Cost	0.314*
5.	Profitability	0.228*
6.	Physical compatibility	0.449**
7.	Cultural compatibility	0.408**
8.	Need	0.377*
9.	Production sustainability	0.413**
10.	Overall appropriateness	0.560**

** Significant at 1% level * Significant at 5% level values and 'F' values being significant. Based on these findings it may be worth concluding that there are other factors or variables besides the indicators of appropriateness, which contribute in the feasibility of technologies as perceived by the extension personnel.

Table 5. Stepwise regression analyses between feasibility (dependent variable) and indicators of appropriateness (independent variables)

	Variables	'b' value	't' value	'F' value	R^2
Step I	Simplicity	0.465	23.114	534.267	0.248
Step II	Simplicity	0.350	16.599	376.475	0.318
	Physical compatibility	0.292	12.831		
Step III	Simplicity	0.290	13.332	288.538	0.349
	Physical compatibility	0.250	11.035		
	Production sustainability	0.220	8.786		
Step IV	Simplicity	0.281	13.030	231.607	0.365
	Physical compatibility	0.169	6.556		
	Production sustainability	0.202	8.126		
	Cultural compatibility	0.154	6.321		
Step V	Simplicity	0.272	12.569	188.326	0.368
	Physical compatibility	0.160	6.167		
	Production sustainability	0.189	7.534		
	Cultural compatibility	0.143	5.851		
	Cost	0.058	3.166		

't' values and 'f' values are significant at 0.01 level ; N=50

It is revealing that extension personnel have perceived 10 technologies as highly feasible out of 40 recommended technologies, already assessed highly feasible by the research personnel. It may be attributed to the differential perception of the criteria for feasibility of technologies. In principle, the standards of farmers, extension and research personnel are complementary, but in practice their formal expression and purpose of application differ considerably (Schiere and de Wit, 1993; Singh, 1996). The perception with respect to the appropriateness of technology was indicated on nine indicators of appropriateness. Many studies used criteria for appropriateness of technology as adaptability, profitability, economic viability, observability, simplicity, cultural compatibility, extent of risk, need based, and sustainability (Amir and Knipscheer, 1989; Jain *et al,* 1993; Singh and Schiere, 1994; Choudhary, 1995). Although extension personnel perceived 16 technologies as highly appropriate, in contrast they assessed 10 technologies as highly feasible. Therefore, it may be worth concluding that not only the appropriateness but also other factors may be responsible for overall feasibility of technology.

4.3 Assessment of technologies from the farmers' perspectives

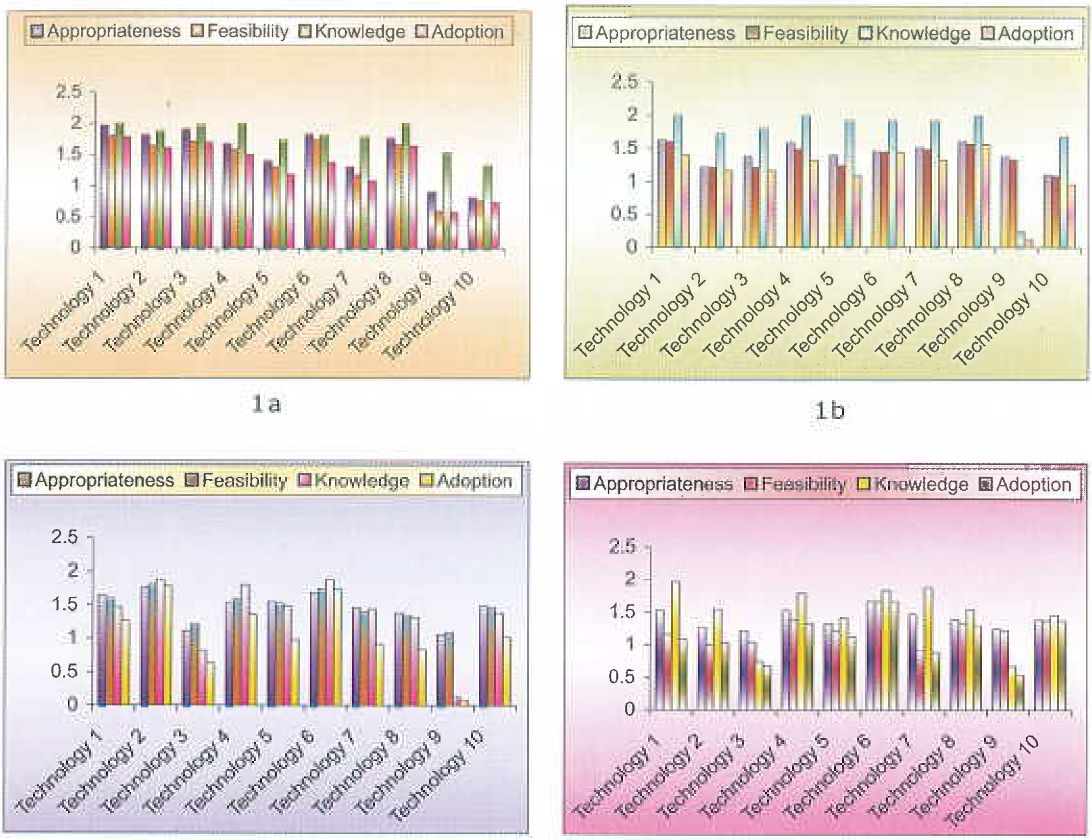
The research system has been generating and recommending technologies followed by their dissemination by extension system, therefore, it was worth to assess the appropriateness and feasibility of recommended water management technologies as perceived by the personnel of research system first followed by extension personnel.

These steps were felt to be precursor to screen the recommended technologies (perceived highly appropriate and feasible by both personnel of research and extension system) followed by their detail assessment in the farmer's system. It was planned to carry out assessment of selected technologies with respect to knowledge, appropriateness, feasibility and adoptability from farmer's perspectives. Simultaneously, the study was also aimed to find out the factors influencing adoptability and delineating the parameters on the basis of which the lowly appropriate technologies need to be refined for increased appropriateness and feasibility leading to their wider adoption in specific farming system. A total of 10 technologies were screened for their assessment from the perspective of farmers (Table 6).

Table 6. Few recommended water management technologies selected for assessment from farmers' point of view

Sl. No.	Selected recommended technology
1.	In rice, before the beginning of panicle primordial development stage, field must be flooded to a depth of 5 to 7 cm as shortage of water during this and later stage cause sterility and yield loss
2.	Cultivation of recommended rice varieties for upland and favourable low land (0-50 cm water) situation
3.	During dry season, application of water in rice could be delayed till complete disappearance of ponded water in case of irrigated rice
4.	Application of adequate amount of compost or farmyards manure will improve soil fertility, soil structure and increase water retention capacity of the soil
5.	On farm irrigation water management through following suitable crop sequences like rice-potato-rice; rice-potato-lentil; rice-groundnut-rice; rice-mustard-rice; rice-wheat-green gram; etc
6.	Construction of bund / dike of 22 to 30 cm height in plots / fields of rice crop under medium land situation is found to be optimum where the loss of sediment and nutrients in runoff water, the irrigation requirement minimize considerably and storage of rain water maximises
7.	Critical stages for irrigation are branching, flowering and pod formation / pod development stages for pulse and oilseed crops
8.	Irrigation in furrows produces significantly higher yield in crops like potato, sweet potato, groundnut, tomato, vegetables (cabbage, cauliflower, etc) with maximising water use efficiency
9.	In wheat crop critical physiological stages for moisture are (i) crown root initiation (CRI) (ii) late tillering (iii) flowering (iv) grain filling stages. Under constraints of irrigation water, irrigation should be applied at CRI stage followed by flowering stage
10.	Water harvesting system (Pond/Tank) for multiple use of water in cultivation of rice, vegetables, fruit crops on the bunds along with fishery, poultry, duckery, etc.

Appropriateness, feasibility, knowledge and possible adoption of selected 10 recommended water management technologies as perceived by farmers of different areas are presented in Figure 2.



1a

1b

1c

1d

Fig 1. Appropriateness, feasibility, knowledge and adoptability of few recommended water management technologies as perceived by farmers of areas under shallow tube well irrigation in West Bengal (1a) and lift irrigation (1b), canal irrigation (1c) and rainfed area (1d) in Orissa

It is evident that farmers' levels of perceptions in a decreasing order were appropriateness, feasibility and adoptability. However, farmers were having awareness about most of the technologies. It is interesting to note that farmers of rainfed areas perceived technology like water harvesting system more favourably as compared to farmers of the areas having irrigation facilities; in contrast their perceptions were relatively lower for those technologies, which require availability of water and irrigation facilities. Farmers' perceptions with respect to nine indicators of appropriateness of recommended water management technologies elucidates that the indicators like cost, physical compatibility, cultural compatibility, simplicity and need were relatively at lower level as compared to other indicators in many of the selected technologies (Table 7). Although perceived overall appropriateness is ranged from above average to high but perceived feasibility and adoptability are ranged from below average to high and low to above average, respectively.

Table 7. Farmers' perceptions towards recommended water management technologies

Sl. No.	Variables	Perceived mean scores*(N=150)									
1.	*Indicators of appropriateness*	*Tech. 1*	*Tech. 2*	*Tech. 3*	*Tech. 4*	*Tech. 5*	*Tech. 6*	*Tech. 7*	*Tech. 8*	*Tech. 9*	*Tech. 10*
	1.Simplicity	1.71	1.59	1.08	1.52	1.20	1.52	1.31	1.44	0.91	1.05
	2.Relative advantage	1.83	1.75	1.53	1.70	1.54	1.87	1.61	1.76	1.31	1.51
	3.Observability	1.67	1.58	1.01	1.72	1.58	1.81	1.46	1.56	1.13	1.18
	4.Cost	1.29	1.33	1.48	1.22	1.21	0.79	1.22	1.24	1.16	0.59
	5.Profitability	1.84	1.70	1.60	1.84	1.81	1.88	1.60	1.67	1.26	1.44
	6.Physical compatibility	1.84	1.43	1.38	1.37	1.36	1.85	1.37	1.60	0.78	0.97
	7.Cultural compatibility	1.86	1.73	1.49	1.33	1.14	1.83	1.38	1.69	0.82	1.29
	8.Need	1.64	1.66	1.70	1.74	1.51	1.81	1.32	1.56	0.72	1.28
	9.Production sustainability	1.88	1.68	1.71	1.89	1.69	1.87	1.58	1.77	0.98	1.24
	Overall appropriateness	1.72	1.60	1.44	1.59	1.44	1.69	1.42	1.55	1.03	1.17
2.	Feasibility	1.59	1.52	1.36	1.54	1.35	1.68	1.26	1.49	0.85	1.14
3.	Adoptability	1.43	1.50	0.99	1.40	0.99	1.46	0.93	1.30	0.34	0.97

* Scale ranges from 0.00 to 2.00, where, 0.00 to 0.50 = Low; 0.51 to 1.00 = Below average; 1.01 to 1.50 = Above average and 1.51 to 2.00 = High

To identify the crucial indicators of appropriateness which influence feasibility, stepwise multiple regression analysis was carried out and it is found that physical compatibility, need, observability, profitability, and simplicity of technology together constituted 89% variation in perceived feasibility of technology (Table 8). The multiple regression has run upto five steps. In the first step physical compatibility contributed about 66% variation in feasibility of technology. Subsequently four more indicators were included. The regression analysis stopped after fifth step that involved total five indicators of appropriateness with 't' values and 'f' values being significant. It is worth concluding that respondent farmers perceived feasibility of technology is highly influenced by above mentioned five indicators of appropriateness. This finding is in contrast with the perceptions of extension personnel as evident from earlier section.

Table 8. Stepwise multiple regression analyses between feasibility (dependent variable) and indicators of appropriateness (independent variables)

Variables	Regression coefficient	't' value	'F' value	R^2
Step I				
Physical compatibility	0.597	8.808	77.572	0.663
Step II				
Physical compatibility	0.491	8.268	70.407	0.781
Need	0.231	4.633		
Step III				
Physical compatibility	0.318	4.372	64.423	0.830
Need	0.230	5.246		
Observability	0.273	3.422		
Step IV				
Physical compatibility	0.446	6.076	66.289	0.870
Need	0.257	6.570		
Observability	0.491	5.240		
Profitability	0.473	3.483		
Step V				
Physical compatibility	0.300	3.480	64.170	0.890
Need	0.260	7.227		
Observability	0.535	6.099		
Profitability	0.387	3.000		
Simplicity	0.101	2.716		

't' values and 'F' values are significant at 0.01 level; N=150

4.4 Characteristics of the respondent farmers

Socio-personal, socio-economic, communicational and psychological profile of farmers, selected as respondents in present study, is presented in Table 9. The sample of farmers selected as respondents have represented areas under shallow tube well irrigation in West Bengal (A) and lift irrigation (B), canal irrigation (C) and rainfed area (D) in Orissa, respectively. Majority of the farmers were middle aged (36-56 years). Educational level of most of the farmers was primary to high school and above. The sample of farmers represented different castes, majority being the general caste (100 out of 150 farmers). They mostly had medium household comprising of 4-6 members. Monthly income of more than 80 per cent of the farmers was upto Rs. 2000 barring the farmers representing areas under lift irrigation, who were relatively better off having monthly earning of Rs. 3000-4000 and above. Majority of the farmers were having land holding of 1.0-4.4 acres. It is observed that farmers used to participate in different activities either as member or office bearer of various social organisations. The farmers representing rainfed area had a poor extension and scientific orientation while that of other farmers was at average/medium level. However, farmers used to get communication or information through mass media. Attitude of the farmers towards scientific water management practices was found to be poor in rainfed and canal irrigation command area. It is relatively better in case of farmers representing areas irrigated through utilization of

Table 9. Socio-personal, socio-economic, communicational and psychological profile of farmers, selected as respondents in study

Sl. No.	Variables	Frequency of farmers, selected as respondents representing areas under shallow tube well irrigation in West Bengal (A), lift irrigation (B), canal irrigation (C) and rainfed area (D) in Orissa						
		A (n=50)	B (n=25)	C (n=50)	D (n=25)	Pooled Mean (N=150)	Pooled SD	Range
1.	*Age (in years)*					46	10	27-68
	Young (<36)	16	1	11	1			
	Middle (36-56)	29	24	24	15			
	Old (>56)	5	-	15	9			
2.	*Education*					-	-	-
	Illiterate	3	-	2	2			
	Functionally literate	18	-	6	7			
	Primary school	9	6	22	6			
	High school and above	20	19	20	10			
3.	*Caste*					-	-	-
	SC/ST	5	3	6	1			
	OBC	13	1	4	17			
	General	32	21	40	7			
4.	*Household*					-	-	-
	Small (1-3 members)	0	7	5	7			
	Medium (4-6 members)	34	16	27	14			
	Large (7-9 members)	8	2	8	3			
	Very large (9 and above)	8	-	10	1			
5.	*Monthly income (Rs.)*					-	-	-
	Less than 1000	27	2	31	12			
	1000-2000	17	-	11	11			
	2000-3000	5	3	5	1			
	3000-4000	1	10	2	1			
	More than 4000	-	10	1	-			

Sl. No.	Variables	Frequency of farmers, selected as respondents representing areas under shallow tube well irrigation in West Bengal (A), lift irrigation (B), canal irrigation (C) and rainfed area (D) in Orissa						
		A (n=50)	B (n=25)	C (n=50)	D (n=25)	Pooled Mean (N=150)	Pooled SD	Range
6.	*Land holding (in acres)*					2.7	1.7	1-10
	Small (<1.0)	14	-	8	2			
	Medium (1.0-4.4)	28	25	37	15			
	High (>4.4)	8	-	5	13			
7.	*Social participation*					-	-	-
	No participations	1	3	12	9			
	Participation as member of social organisations	44	20	27	19			
	Participation as office-bearer of social organisations	5	2	11	2			
8.	*Extension orientation*					3.1	2.6	0-11
	Low (<0.5)	5	1	5	13			
	Medium (0.5-5.7)	30	23	35	12			
	High (>5.7)	15	1	10	-			
9.	*Scientific orientation*					4.7	1.3	1-13
	Low (<3.4)	1	8	4	22			
	Medium (3.4-6.0)	49	16	46	1			
	High (>6.0)	-	1	-	2			
10.	*Mass media participation*					11.7	4.7	0-20
	Low (<7.0)	5	3	8	5			
	Medium (7.0-16.4)	33	22	36	20			
	High (>16.4)	12	-	6	-			
11.	*Attitude of the farmers towards scientific water management practices*					2.1	0.6	2.8-1.2
	Low (<1.5)	-	-	35	25			
	Medium (1.5-2.7)	36	25	15	-			
	High (>2.7)	14	-	-	-			

Small/Low: < (Pooled mean-Pooled SD); Medium: (Pooled mean-Pooled SD) to (Pooled mean+Pooled SD); Large/High: > (Pooled mean+Pooled SD) ground water. This differential attitude may be attributed to the facts that unpredictable water availability during rainy season and unassured supply of irrigation water in canal command often hinder adoption of scientific water management practices while irrigation through exploitation of ground water incurs relatively higher expenditure that leads to judicious use of water following scientific water management technologies in cultivation.

4.5 Constraints perceived by farmers

Farmers have mentioned various constraints that bottleneck the adoption of recommended scientific water management technologies in their specific farming systems. The constraints, which were perceived by more than 80 per cent of farmers, are indicated below:

- Adoption of soil and water conservation measures requires a community approach, which is still not common in practice as response of community is often poor
- Unassured supply of irrigation water in canal command and unpredictable water availability during rainy season hinder adoption of scientific irrigation schedules for different crops
- Free flooding method of irrigation and uncontrolled supply in irrigation command often do not allow to follow scientific water management practices
- High initial expenditure to construct water conservation / harvesting structures
- Farmers prefer to grow rice crop mostly instead of growing low duty crops, which face marketability problems and require better management practices
- Regulation of irrigation / drainage is not feasible at individual level, it requires group action
- Farmers face difficulty to get inputs like mulching material, lining material, etc.

Present study elucidates that technical constraints (uncertain supply of irrigation water in canal command and unpredictable water availability during rainy season, difficulty in maintaining recommended depth of water during irrigation), social constraints (lack of group action and community cooperation), economic constraints (fragmented land holdings, high initial expenditure and high cost of inputs) and infrastructure constraints (injudicious use of water because of abundant availability and not sufficiently priced, difficulty in getting required inputs and lack of training to farmers) have influenced farmers' perceptions towards adoptability of technologies. According to Singh (1996), researchers have developed technologies to find solutions to the problems relating to water management in agriculture, however, experiences have shown that in a large percentage of cases, feasibility bottlenecked by the constraints such as high initial investments, high operational costs, high maintenance costs, and high technical input requirement.

4.6 Factors influencing adoption dynamics of recommended technologies

Farmers go through an innovation / technology decision process in which they pass through different stages (knowledge, persuasion, decision, implementation and confirmation) before adoption or rejection of technology. In all the stages different factors like appropriateness and feasibility of technology, characteristics of farmers, extension and communication support, etc play vital role. Keeping these facts in view an attempt was made to delineate different factors, which influence adoptability of technology. Multiple regression analysis revealed that 56% variation in adoptability (dependent variable) is explained by appropriateness, feasibility, and knowledge (independent variables) of recommended water management technologies (Table 10).

Table 10. Multiple regression analysis between perceived adoptability (dependent variable) and appropriateness, feasibility and knowledge (independent variables) of recommended water management technologies

Sl. No.	Variables	Regression coefficient	't' value	'F' value	R^2
1.	Appropriateness	0.513	2.785	62.162	0.561
2.	Knowledge	0.359	5.430		
3.	Feasibility	0.254	2.555		

't' values and 'F' values are significant at 0.01 level; N=150

Table 11. Correlation of different socio-personal, economic, communication and psychological traits of farmers with perceived adoptability of recommended water management technologies

Sl. No.	Factors	Correlation value
1.	Age	-0.125
2.	Education	0.239**
3.	Caste	0.034
4.	Income	0.176*
5.	Farm size	0.173*
6.	Social participation	0.352**
7.	Household	0.138
8.	Extension orientation	0.402**
9.	Scientific orientation	0.103
10.	Mass media participation	0.331**
11.	Attitude	0.318**
12.	Perceived constraints	-0.234**

** Significant at 0.01 level * Significant at 0.05 level N=150

Therefore, it can be concluded that there are other factors like characteristics of farmers, perceived constraints hindering the adoptability, which have significant relationship with adoption phenomena (Table 11). It is observed that adoptability is negatively and significantly related with perceived constraints. It means that adoptability will be less with an increase in constraints. Multiple regression analysis (backward elimination method) including all factors (total 15 independent variables) was carried out. The regression was included six variables (Table 12) for

Table 12. Significant factors (delineated through multiple regression backward elimination method) influencing adoptability of recommended water management technologies

Variables	Regression coefficient	't' value	'F' value	R^2
Knowledge	0.381	4.437**	25.708	0.759
Appropriateness	0.360	1.923*		
Feasibility	0.304	2.685**		
Social participation	0.039	2.485*		
Farm size	0.017	2.081*		
Extension orientation	0.016	1.915*		

** Significant at 0.01 level * Significant at 0.05 level N=150 which the 't' values and 'F' value were significant. It is found that Knowledge, appropriateness, feasibility, social participation, farm size and extension orientation together constituted 76% variation in adoptability. It implies that any variation or change (positive or negative) in these factors will affect the adoptability accordingly.

4.7 Conceptual model of adoption dynamics

Present study elucidates that besides knowledge, appropriateness and feasibility of technologies there are other factors like socio-economic profile of farmers and various technical, social, economic and infrastructure constraints, which also have significant relationship with adoption phenomena. On the basis of the lessons drawn from this study a conceptual model is presented here that indicates different factors influencing the adoption dynamics of recommended water management technologies (Fig. 3).

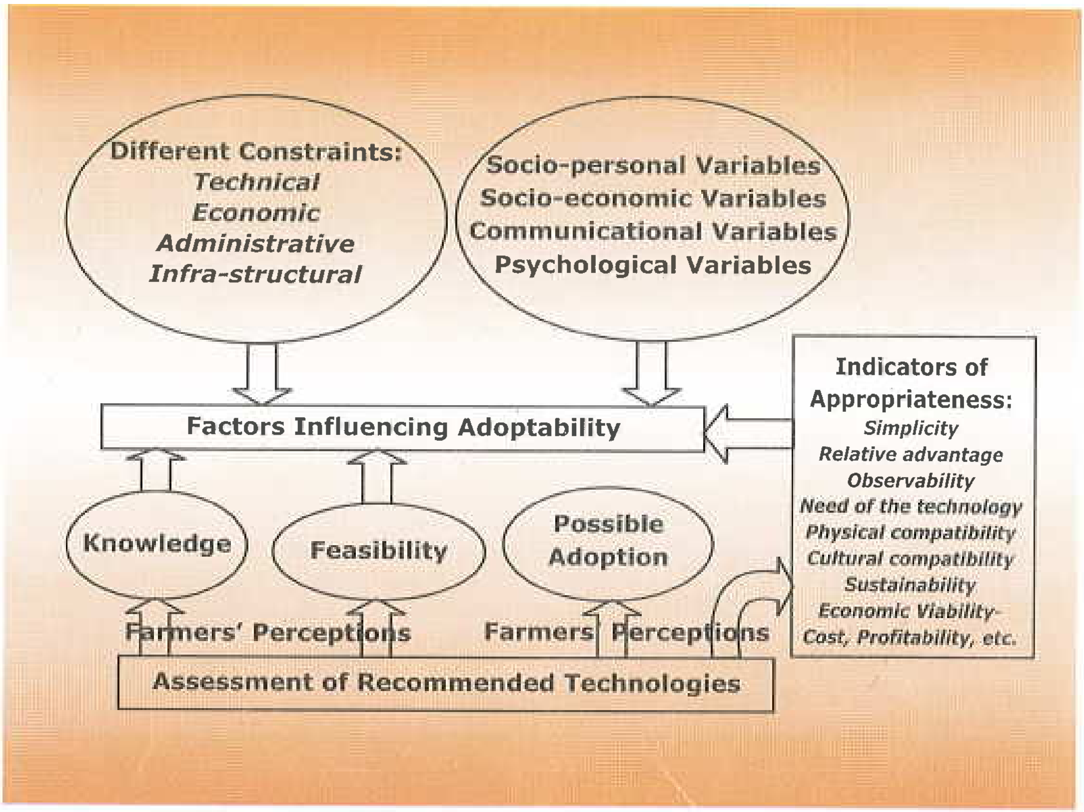


Fig. 3. Conceptual model indicating different factors influencing adoption dynamics

Farmer passes through a series of actions and choices over time through which he evaluates a new idea (technology/practice) and decides whether to follow or not. It starts from first knowledge of an innovation (technology), to forming an attitude toward it, to a decision to adopt or reject, to implementation of the new idea and to confirmation of this decision. It is the perceived newness of the innovation (technology) and the uncertainty associated with it that governs the decision making.

5. Epilogue

Adoption of scientific recommended water management technologies is the key for sustained development of agriculture in the eastern region of India. However, majorities of the recommended technologies do not find favour with farmers. Therefore, technology assessment as perceived by the research personnel first followed by the extension personnel and farmers is of pivotal importance. Since every technology cannot be scale neutral, it is very much necessary to analyse the existing recommended water management technologies about their suitability in the specific farming system. It is also necessary to refine or modify the recommended existing technologies to make them viable and suitable according to the needs and resources of farmers of the specific farming system. Present study has suggested an integrated methodology for technology assessment from stakeholders' perspectives, which delineates differential perceptions of personnel of research, extension and farmers' systems with its importance in technology decision/adoption process, identifies significant factors which influence feasibility and adoptability of recommended technologies and provides feed back from farmers to extension to research system for future planning in technology generation and transfer process.

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Annexure

Correlation matrix showing significant degree of agreement among the experts / personnel of research system

	Expert 1	*Expert 2*	*Expert 3*	*Expert 4*	*Expert 5*	*Expert 6*	*Expert 7*	*Expert 8*	*Expert 9*	*Expert 10*
Expert 1	1									
Expert 2	0.421**	1								
Expert 3	0.216*	0.165	1							
Expert 4	0.138	0.058	0.084	1						
Expert 5	-0.01	-0.036	-0.048	0.082	1					
Expert 6	0.112	0.104	0.084	0.082	0.237*	1				
Expert 7	-0.085	0.059	0.09	-0.083	0.598**	0.405**	1			
Expert 8	0.245*	0.085	0.1	0.067	0.134	0.351**	0.264*	1		
Expert 9	0.16	0.239*	0.012	0.345**	0.004	0.01	-0.018	0.133	1	
Expert 10	0.061	0.165	0.202	0.024	0.067	-0.105	0.136	-0.003	0.176	1
Expert 11	-0.185	0.016	0.253*	0.278**	0.162	0.072	0.213*	0.002	0.137	0.235*
Expert 12	0.239*	0.288**	0.002	-0.093	-0.003	0.091	-0.016	0.196	0.230*	0.136
Expert 13	0.295**	0.213*	0.174	0.034	-0.014	-0.034	0.067	0.112	0.264*	0.195
Expert 14	0.203	0.235*	0.025	0.310**	-0.073	0.08	0.108	0.087	0.125	0.122
Expert 15	-0.14	0.132	0.169	-0.016	0.315**	0.099	0.195	0.06	0.026	0.012
Expert 16	0.078	0.171	0.027	0.389**	0.142	0.074	0.074	0.125	0.363**	0.108
Expert 17	0.270*	0.312**	0.101	0.228*	-0.1	-0.061	-0.011	0.362**	0.206	0.228*
Expert 18	-0.085	0.018	0.155	0.137	0.16	0.186	0.219*	0.132	0.064	0.122
Expert 19	-0.054	0.059	0.145	0.166	0.097	0.225*	0.219*	0.134	0.11	0.115
Expert 20	-0.011	0.192	0.146	0.183	0.027	-0.061	0.005	0.062	0.207	0.176
Expert21	0.361**	0.488**	-0.016	-0.047	-0.241	-0.022	-0.196	0.061	0.041	0.029
Expert 22	0.309**	0.371**	0.169	0.015	-0.137	0.015	-0.161	0.147	0.174	-0.046
Expert 23	0.103	0.245*	-0.263	0.172	-0.072	0.088	-0.121	0.079	0.232*	0.067
Expert 24	-0.123	-0.024	0.023	0.181	0.328**	0.047	0.309**	0.161	0.133	0.298**
Expert 25	0.097	0.116	0.046	0.006	0.005	0.005	0.115	0.209	0.044	0.168
Expert 26	0.208	0.226*	0.214*	0.003	0.098	0.229*	0.179	0.252*	0.071	0.279**
Expert 27	0.048	0.131	0.463**	0.064	0.075	0.317**	0.207	0.12	0.146	0.220*
Expert 28	-0.078	-0.04	-0.154	0.191	0.179	0.001	0.185	0.181	0.234*	-0.142
Expert 29	-0.185	0.016	0.253*	0.278**	0.162	0.072	0.213*	0.002	0.137	0.235*
Expert 30	-0.054	0.059	0.145	0.166	0.097	0.225*	0.219*	0.134	0.11	0.115

** Significant at the 0.01 level * Significant at the 0.05 level N=86

	Expert 11	*Expert 12*	*Expert 13*	*Expert 14*	*Expert 15*	*Expert 16*	*Expert 17*	*Expert 18*	*Expert 19*	*Expert 20*
Expert 11	1									
Expert 12	-0.079	1								
Expert 13	0.018	__0.295**__	1							
Expert 14	__0.379**__	0.122	0.035	1						
Expert 15	0.129	0.043	__0.220*__	__0.229*__	1					
Expert 16	__0.221*__	-0.071	0.05	0.13	-0.083	1				
Expert 17	0.011	0.192	0.111	0.168	-0.1	0.198	1			
Expert 18	__0.339**__	0.165	__0.223*__	0.15	__0.325**__	0.119	-0.143	1		
Expert 19	__0.374**__	0.178	__0.273*__	0.2	__0.274*__	0.147	-0.152	__0.958**__	1	
Expert 20	__0.303**__	0.01	0.09	__0.289**__	__0.315**__	0.156	0.158	__0.367**__	__0.403**__	1
Expert21	-0.214	__0.263*__	0.135	0.042	-0.053	-0.033	__0.345**__	-0.124	-0.097	__0.218*__
Expert 22	-0.05	0.181	__0.412**__	-0.022	__0.230*__	0.07	__0.392**__	-0.02	0.053	0.137
Expert 23	0.017	-0.048	0.03	0.112	0.106	__0.218*__	__0.245*__	-0.174	-0.12	__0.238*__
Expert 24	0.208	-0.065	0.049	0.037	0.158	__0.442**__	0.007	0.192	0.176	__0.274*__
Expert 25	-0.089	0.149	__0.364**__	-0.025	0.165	-0.016	__0.306**__	__0.235*__	0.185	0.147
Expert 26	0.026	__0.217*__	0.04	0.088	0.06	__0.388**__	__0.270*__	0.183	0.198	__0.416**__
Expert 27	-0.056	__0.211*__	__0.282**__	0.199	__0.227*__	0.077	-0.104	0.104	0.158	0.183
Expert 28	__0.291**__	0.018	0.064	__0.213*__	-0.039	__0.287**__	0.013	0.108	0.143	0.209
Expert 29	__0.963**__	-0.079	0.018	__0.379**__	0.129	__0.221*__	0.011	__0.339**__	__0.374**__	__0.303**__
Expert 30	__0.374**__	0.178	__0.273*__	0.2	__0.274*__	0.147	-0.152	__0.958**__	__0.958**__	__0.403**__

	Expert 21	*Expert 22*	*Expert 23*	*Expert 24*	*Expert 25*	*Expert 26*	*Expert 27*	*Expert 28*	*Expert 29*	*Expert 30*
Expert21	1									
Expert 22	__0.290**__	1								
Expert 23	__0.261*__	__0.223*__	1							
Expert 24	-0.244	-0.156	0.07	1						
Expert 25	0.045	0.161	-0.026	__0.312**__	1					
Expert 26	0.104	__0.299**__	0.173	__0.449**__	__0.298**__	1				
Expert 27	0.109	__0.381**__	-0.14	-0.094	0.167	0.118	1			
Expert 28	-0.1	0.016	0.149	0.189	0.128	0.116	0.154	1		
Expert 29	-0.214	-0.05	0.017	0.208	-0.089	0.026	-0.056	__0.291**__	1	
Expert 30	-0.097	0.053	-0.12	0.176	0.185	0.198	0.158	0.143	__0.374**__	1

** Significant at the 0.01 level * Significant at the 0.05 level N=86

Frequency of positively significant degree of relationship (1% and 5% level of significance) of each expert with other experts.

	expert 1	**expert 2**	*expert 3*	*expert 4*	*expert 5*	**expert 6**	**expert 7**	*expert 8*	**expert 9**	*expert 10*
	expert 2	expert 2	expert 1	expert 9	expert 6	expert 5	expert 5	expert 1	expert 2	expert 11
	expert 3	expert 9	expert 11	expert 11	expert 7	expert 7	expert 6	expert 6	expert 4	expert 17
	expert 8	expert 12	expert 26	expert 14	expert 15	expert 8	expert 8	expert 7	expert 12	expert 24
	expert 12	expert 13	expert 27	expert 16	expert 24	expert 19	expert 11	expert 17	expert 13	expert 26
	expert 13	expert 14	expert 29	expert 17		expert 26	expert 18	expert 26	expert 16	expert 27
	expert 17	expert 17		expert 29		expert 27	expert 19		expert 23	expert 29
	expert 21	expert 21				expert 30	expert 24		expert 28	
	expert 22	expert 22					expert 29			
		expert 23					expert 30			
		expert 26								
f	**8**	**10**	5	6	4	**7**	**9**	5	**7**	6
SD	**0.49**	**0.48**	0.57	0.56	0.16	**0.15**	**0.4**	0.33	**0.38**	0.44

	expert 11	***expert 12***	***expert 13***	***expert 14***	***expert 15***	***expert 16***	***expert 17***	***expert 18***	***expert 19***	***expert 20***
	expert 3	expert 1	expert 1	expert 2	expert 5	expert 4	expert 1	expert 7	expert 6	expert 11
	expert 4	expert 2	expert 2	expert 4	expert 13	expert 9	expert 2	expert 11	expert 7	expert 14
	expert 7	expert 9	expert 9	expert 11	expert 14	expert 11	expert 4	expert 13	expert 11	expert 15
	expert 10	expert 13	expert 12	expert 15	expert 18	expert 23	expert 8	expert 15	expert 13	expert 18
	expert 14	expert 21	expert 15	expert 20	expert 19	expert 24	expert 10	expert 19	expert 15	expert 19
	expert 16	expert 26	expert 18	expert 28	expert 20	expert 26	expert 21	expert 20	expert 18	expert 21
	expert 18	expert 27	expert 19	expert 29	expert 22	expert 28	expert 22	expert 25	expert 20	expert 23
	expert 19		expert 22		expert 27	expert 29	expert 23	expert 29	expert 29	expert 24
	expert 20		expert 25		expert 30		expert 25	expert 30	expert 30	expert 26
	expert 28		expert 27				expert 26			expert 29
	expert 29		expert 30							expert 30
	expert 30									
f	**12**	**7**	**11**	**7**	**9**	**8**	**10**	**9**	**9**	**11**
SD	**0.4**	**0.5**	**0.37**	**0.54**	**0.21**	**0.45**	**0.39**	**0.43**	**0.45**	**0.41**

f and SD stands for frequency and standard deviation values, respectivily

	expert 21	***expert 22***	***expert 23***	***expert 24***	***expert 25***	***expert 26***	***expert 27***	***expert 28***	***expert 29***	***expert 30***
	expert 1	expert 1	expert 2	expert 5	expert 13	expert 2	expert 3	expert 9	expert 3	expert 6
	expert 2	expert 2	expert 9	expert 7	expert 17	expert 3	expert 6	expert 11	expert 4	expert 7
	expert 12	expert 13	expert 16	expert 10	expert 18	expert 6	expert 10	expert 14	expert 7	expert 11
	expert 17	expert 15	expert 17	expert 16	expert 24	expert 8	expert 12	expert 16	expert 10	expert 13
	expert 20	expert 17	expert 20	expert 20	expert 26	expert 10	expert 13	expert 29	expert 11	expert 15
	expert 22	expert 21	expert 21	expert 25		expert 12	expert 15		expert 14	expert 18
	expert 23	expert 23	expert 22	expert 26		expert 16	expert 22		expert 16	expert 19
		expert 26				expert 17			expert 18	expert 20
		expert 27				expert 20			expert 19	expert 29
						expert 22			expert 20	
						expert 24			expert 28	
						expert 25			expert 30	
f	**7**	**9**	**7**	**7**	5	**12**	**7**	5	**12**	**9**
SD	**0.49**	**0.46**	**0.43**	**0.23**	0.37	**0.3**	**0.3**	0.56	**0.41**	**0.41**

f and SD stand for frequency and standard deviation values, respectivily