Working Paper No. 2

Extension Research in India

Current Status and Future Strategies

P Sethuraman Sivakumar
Rasheed Sulaiman V

December 2015

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Agricultural Extension in South Asia

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Current Status and Future Strategies

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ABBREVIATIONS

CBAM	Concerns-Based Adoption Model
CGIAR	Consultative Group for International Agricultural Research
CIMMYT	International Maize and Wheat Improvement Center
CT	Computerized Tomography
CTA	Concurrent Think-Aloud
FLD	Front Line Demonstrations
FMRI	Functional Magnetic Resonance Imaging
GMO	Genetically Modified Organisms
ICT	Information and Communication Technology
IJEE	Indian Journal of Extension Education
IPM	Integrated Pest Management
IRJEE	Indian Research Journal of Extension Education
IS	Information System
IV	Instrumental variable
JAEE	Journal of Agricultural Education and Extension
KVK	Krishi Vigyan Kendras
LLM	Local Linear Matching
MAPP	Method for Impact Assessment of Poverty Alleviation Projects
MRI	Magnetic Resonance Imaging
NARES	National Agricultural Research and Education System
NN	Nearest-Neighbour
PCA	Principal Component Analysis
PET	Positron Emission Tomography
PRA	Participatory Rural Appraisal
RDD	Regression Discontinuity Design
RTA	Retrospective Think-Aloud
TAM	Technology Acceptance Model
TOE	Technology, organization, and environment
TPB	Theory of Planned Behaviour
TRA	Theory of Reasoned Action
UTAUT	Unified Theory of Acceptance and Use of Technology

Executive summary

Extension is a multi-disciplinary and field-oriented social science that aims to improve the livelihoods of rural people. Since the 19th century, extension has long served the rural communities by equipping them with critical capacities. Extension has helped the communities sustain their livelihoods by dealing with the vagaries of climate and socio-economic factors.

Extension research has long played a significant role in maximising the utility of socio-technological interventions. Though extension research has evolved by integrating scientific research methods and tools from other social sciences, the methodological evolution has stagnated in the last few decades thereby producing insignificant outcomes.

Keeping in view the significance of outcomes and to suggest "good practices" to improve upon the utility of extension research for the target users, this paper aims to assess the nature of extension research conducted in India in terms of its methodological rigor. In general, the social science research is shaped by four major research paradigms such as (i) postpositivism, (ii) constructivism, (iii) advocacy/participatory and (iv) pragmatism. Though postpositivist approaches (quantitative empiricism) dominated extension research during the 1970s and 1980s, the advocacy/participatory processes (qualitative inquiries) gradually took over in the 1990s, resulting in the decline of "generalisability" and "replicability" of the empirical outcomes of the research.

A critical review of articles published in two major extension research journals in India and an international journal indicated this lacunae. Analysis indicated a rise in the volume of publishing of extension research in India with the focus firmly on the subject matter of extension rather than its applicability to the discipline of agriculture. While Indian journals covered mostly (>50%) survey and ex post facto research works, the international journal had qualitative and descriptive works (>45%). A sizable amount of works were conducted in North India (40%) leaving the rest of the regions unrepresented in these national-level Indian journals. Dominance of research works emanating from educational institutions conducted by students under the guidance of Professors (>60%) has indicated a "narrow focus" and "limited application" of these findings as they were conducted with relatively small samples under time and resource constrained situations. Ironically, the research methods were inadequately described in a majority of papers (>95%) indicating either overuse of known methods or casual way of writing papers.

Reorienting the extension research is the need of the hour which needs a coordinated approach by integrating "state-of-the-art" methods from other sciences to improve the utility and visibility of the extension research outcomes. Adopting several good practices such as the following can enhance the quality of extension research:

- Creative generation of relevant research ideas using intuitive-common sense approach
- Selection of a rigorous and robust research design
- Choice of right variables following alternate criterion-referenced validity assessment procedures
- Selection of appropriate sample sizes to maximise the generalisability
- Estimation of reliability and validity through robust modelling procedures like Structural Equation Modelling

- Deployment of resource and time saving but accurate tools like shortened paper surveys and e-surveys

- Compensation of respondents to maximise the accuracy of the response

- Data cleaning by employing missing value estimation and assumption testing tools, and multivariate data modelling

The research on technology performance and effects is focused on assessing adoption and technology impact on other socio-economic parameters of the society. Adoption research in India has focused only on the diffusion of innovations theory. However, alternate models such as Technology Acceptance Model, Theory of Planned Behaviour, Unified Theory of Acceptance and Use of Technology, Concerns-Based Adoption Model and Technology, organization and environment frame work can provide new insights into the technology adoption processes. Emerging impact assessment paradigms proposed by the World Bank and other International agencies focus on quantification of the effects through micro-economic approach involving experimental and non-experimental approaches such as randomised evaluations, propensity score matching, double difference or difference-in-differences methods, instrumental variable methods, regression discontinuity design and distributional impacts measurements.

Though qualitative methods like participatory action learning are widely practiced, they are criticised for their location-focused nature. Emergence of mixed-method approaches involving ex ante impact assessment, on-farm technology evaluation, adoption and ex post facto impact assessment methods along with GTZ owned MAPP (Method for Impact Assessment of Poverty Alleviation Projects) offer new ways of integrating quantitative and qualitative methods. Forecasting and predicting the technology demand using judgemental methods like Delphi and scenario analysis also help to manage the technology generation and dissemination process.

Understanding the stakeholder attitudes and beliefs helps in assessing the adoption potential of a technology, extent of user participation and utility of a development intervention besides enhancing the effectiveness of organisational processes. Broadly, attitudes, beliefs and opinions are studied through (a) description; (b) measurement; (c) polls; (d) theories and (e) experiments. Though various test theories such as Item-Response Theory and Structural Equation Approach are becoming popular, the extension research is relying on classical test approaches for several decades. Few implicit measures such as projective techniques, physiological reactions, priming and implicit association test can offer alternate ways of measuring attitudes, beliefs and opinions. Traditional way of measuring user perceptions through attitude scales can be expanded by employing alternate methods like arguments, introspection, psychophysical, neuroscience methods, Repertory Grid Method and Means-ends chain analysis.

During the last decade, the growth of information and communication technology (ICT) comprised of media, computing and telecommunication technologies have been phenomenal. The growth has led to significant changes in human communication. ICT has provided new capabilities for Information exchange, networking, capacity building of stakeholders, providing access to information and training besides helping to make rational decisions. Indian ICT research has focused more on the ICT infrastructure at stakeholder systems, coverage of ICT-

enabled education and extension services, usage of ICT technologies in agricultural education and extension, constraints associated with effective ICT use, ICT readiness effectiveness of ICT applications and documentation of success stories. However, there is a need to diversify the areas to get insights into the usability of web portals/ multimedia systems, assess the quality of services offered by cyber-extension companies, user acceptance and continued use of the ICTs and instructional design processes to enhance learning effectiveness.

Research synthesis approaches like meta-analysis, range of effect sizes approach, vote counting, narrative summary, meta-ethnography, thematic analysis, narrative synthesis, meta-narrative review, qualitative comparative analysis, realist synthesis and EPPI-Centre approach can help to identify the patterns in the results of the published empirical research, which will help in generalising and theorizing these works.

Various strategies like developing theories to address the emerging needs and sustain professional development, enriching methodological rigor of the extension research, developing mastery over multivariate analyses and review the role of professional societies in improving quality of extension research are suggested to enhance the quality of extension research in India.

1. Introduction

Extension is a multi-disciplinary social science, which was originally developed as a set of principles to maximise the "utility" of the technologies and processes generated by organised agricultural research.
Owing to its behavioural approach and grassroots focus, extension is considered as a significant social innovation of the 19th century (Jones and Garforth, 1997). Extension science has long served rural communities to apply improved agricultural practices through advising, equipping and organising them. However, the conditions that facilitated extension to evolve over two centuries have changed rapidly in the last two decades. With increasing complexities in the environment, socio-political systems, and emergence of "safe food" movement, extension services are facing several new challenges. They are currently struggling to achieve multiple development goals ranging from livelihood sustenance, environmental conservation, ensuring access to quality and safe food to poverty alleviation. Extension science has to innovate itself to support extension policy and practice in this regard and to do this extension research has a critical role to play.

This paper aims to assess the nature and contribution of extension research conducted in India. It reviews the current status of extension research in India based on a review of research papers published in two major extension journals in India. A critical analysis of the published research papers revealed several lacunae in the conduct of research. Though several research papers are published every year, the research is conducted predominantly by the student researchers, under the guidance of professors, in universities. Most of the research focus is on narrow research domains and are written very casually. There are serious flaws in the appropriateness of research methods used and the quality and relevance of these publications. As the papers submitted for publication are not carefully reviewed and selected, the quality of papers has declined over time. To improve the situation, several suggestions related to enhancing the methodological rigour and integration of new research methods are presented.

This paper begins with an overview of the scientific research and explains various philosophical paradigms that guided evolution of scientific social research in the last few decades (Section 2). The next section (Section 3) deals with the different quantitative, qualitative and mixed method research approaches followed in the extension research. The methodological evolution of extension research in India is presented in Section 4. This section also discusses the current status of extension research in India based on a detailed analysis of articles published in select journals during 2010-2013. The major shortcomings in extension research are discussed in detail in this session. Various strategies for improving the quality of extension research are discussed in Section 5. Major suggestions for implementing these strategies within the Indian context are discussed in Section 6. The conclusions are presented in Section 7.

2. Scientific social research

Scientific social research is the backbone of any professional discipline which is often viewed as a cornerstone of scientific progress. Scientific research is a process of systematic inquiry that is designed to collect, analyse, interpret, and use data. In general, research is conducted for a variety of reasons, including to understand, describe, predict, or control an educational or psychological phenomenon or to empower individuals in such contexts (Mertens, 2009). The purpose of research is to answer questions and acquire new knowledge that helps to improve the social contributions of the discipline. Precisely, research helps a discipline by describing, explaining and predicting phenomenon which contributes to the progress of the society (Box 1).

Box 1: Goals of scientific research

Broadly, the goals of scientific research are to answer questions and acquire new knowledge. Precisely, three goals of scientific research are description, prediction and explanation (Shaughnessy and Zechmeister, 1997).

Description
Description refers to the process of defining, classifying, or categorizing phenomena of interest. For example, a research may conduct study to describe the production systems of rice, which helps to understand the differences in cultivating rice under each system. Alternatively, the relationships among elements of farming systems may be described based on empirical research data.

Prediction
Prediction refers to the prior judgement or estimation of an outcome of a current action or event in the future. In scientific research, prediction is performed using the empirically proven relationships between the variables. For example, the success of self-help can be predicted by using the estimated relationships between group-cohesiveness, decision styles, leadership styles etc.

Understanding/Explanation
Establishing causal relationships among variables using the empirical data helps to understand the dynamics of the phenomenon. For example, the farmers' decision to adopt a variety is contingent upon its success in the front-line demonstrations and seed material availability.

2.1. Major paradigms in research

A paradigm is composed of certain philosophical assumptions that guide and direct thinking and action (Box 2). Four different research paradigms (Mertens, 2009) which are shaping social science research are (i) postpositivism, (ii) constructivism, (iii) advocacy/participatory and (vi) pragmatism. These paradigms reflect the approaches of inquiry based on philosophical thoughts and belief systems.

Box 2: Defining a Paradigm

Guba and Lincoln (2005) identified four basic belief systems characterized by the following questions that help define a paradigm:

1. What is the nature of ethics? (Axiological question)
2. What is the nature of reality? (Ontological question)
3. What is the nature of knowledge and the relationship between the knower and they would be known? (Epistemological question)
4. How can the knower go about obtaining the desired knowledge and understanding? (Methodological question)

Post-positivism

The postpositivist or empirical science approach is a method of inquiry which follows a systematic, objective and controlled approach. The postpositivist tradition comes from 19th-century writers, such as Comte, Mill, Durkheim, Newton, and Locke (Smith, 1983). This approach is essentially a theory-driven, scientific approach, where the researcher begins with a theory and device a quantitative empirical research plan to ascertain the causes of a particular phenomenon with an aim to accept or reject the theory. It is a reductionist approach where the research question is decomposed into small measureable variables and the relationship among them are empirically verified. The knowledge develops through objective and systematic observation or manipulation of a phenomenon.

The Social Constructivism

The social constructivism seeks to understand a phenomenon through subjective experiences of the individuals involved in the process. This approach originated from the ideas of Berger and Luekmann's (1967) narrated in their book "the Social Construction of Reality" and Lincoln and Guba's (1985) book "Naturalistic Inquiry". This approach relies on qualitative and open-ended methods to understand a phenomenon with respect to the persons involved and the context.

The Advocacy or Participatory

The advocacy or participatory paradigm emerged during the 1980s and 1990s as an action-oriented research to deliver benefits to marginalised societies by involving them in the process of inquiry (Neuman, 2000). The beneficiary involvement in the research process helps to advance knowledge while solving their targeted problems. Advocacy research provides a voice for these participants, raising their consciousness or advancing an agenda for change to improve their lives. The participatory extension research approaches fall under the advocacy paradigm.

The Pragmatism

The pragmatism focuses on the research problem and the strategies to devise solutions using a mixed-methods research approach. Pragmatism is derived from the works of Peirce, James, Mead, and Dewey (Cherryholmes, 1992).The pragmatist researchers are concerned with what and how to research based on the intended consequences, rather than focusing on the methodological rigorousness and innovations.

Though these research paradigms depict the evolution of scientific method to match the societal needs to foster development, they reflect how the contextual factors and development philosophies influence the methods of inquiry.

As a social science research that is aimed at improving the quality of life of its stakeholders, extension research also follows similar paradigms.

3. Approaches to extension research

Extension research uses a multi-disciplinary empirical research paradigm, which integrates knowledge from relevant sciences. The purpose of integration is to understand and manipulate the complex phenomenon created by interplay of natural, biological and social forces. However, as a "field-oriented" professional discipline, the extension research differs significantly from its social science counterparts in terms of its focus, approach and tools.

3.1. Extension research process

Extension research is a unique social science inquiry, where the research ideas are gathered from the field problems and put through a systematic cycle of objective investigations that result in significant solutions to solve these problems while advancing the theory (Fig. 1).

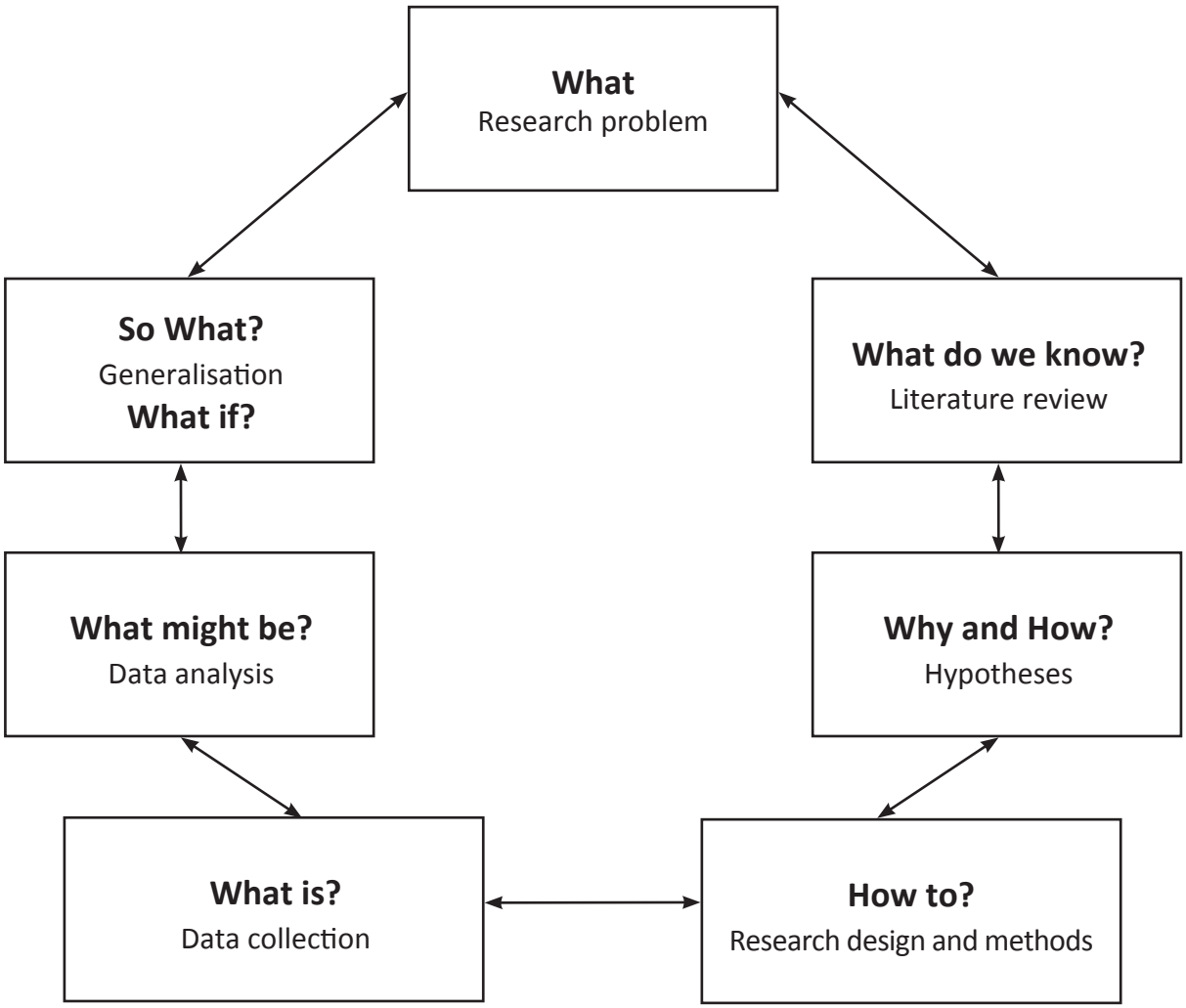

Fig.1. The Extension Research Process (Adapted from Harvey, 2013)

The research is an iterative process where the researchers seek to answer the research questions by checking and rechecking at every stage to bring out the solutions. As an applied social science, it utilises an array of social science research approaches or designs to devise solutions for the field problems. The following section describes various research approaches or designs used in social sciences, including the extension.

3.2. Research approaches and designs in extension research

A research design is the plan or proposal to conduct research which involves the intersection philosophy, strategies of inquiry, and specific methods. Choosing a research design involves various intricate decisions based on the purpose and objectives of the study. Creswell (2009) has suggested a framework for selecting an appropriate research design based on philosophical paradigms as described in the section 2.1, along with strategies of inquiry and research methods (Fig. 2).

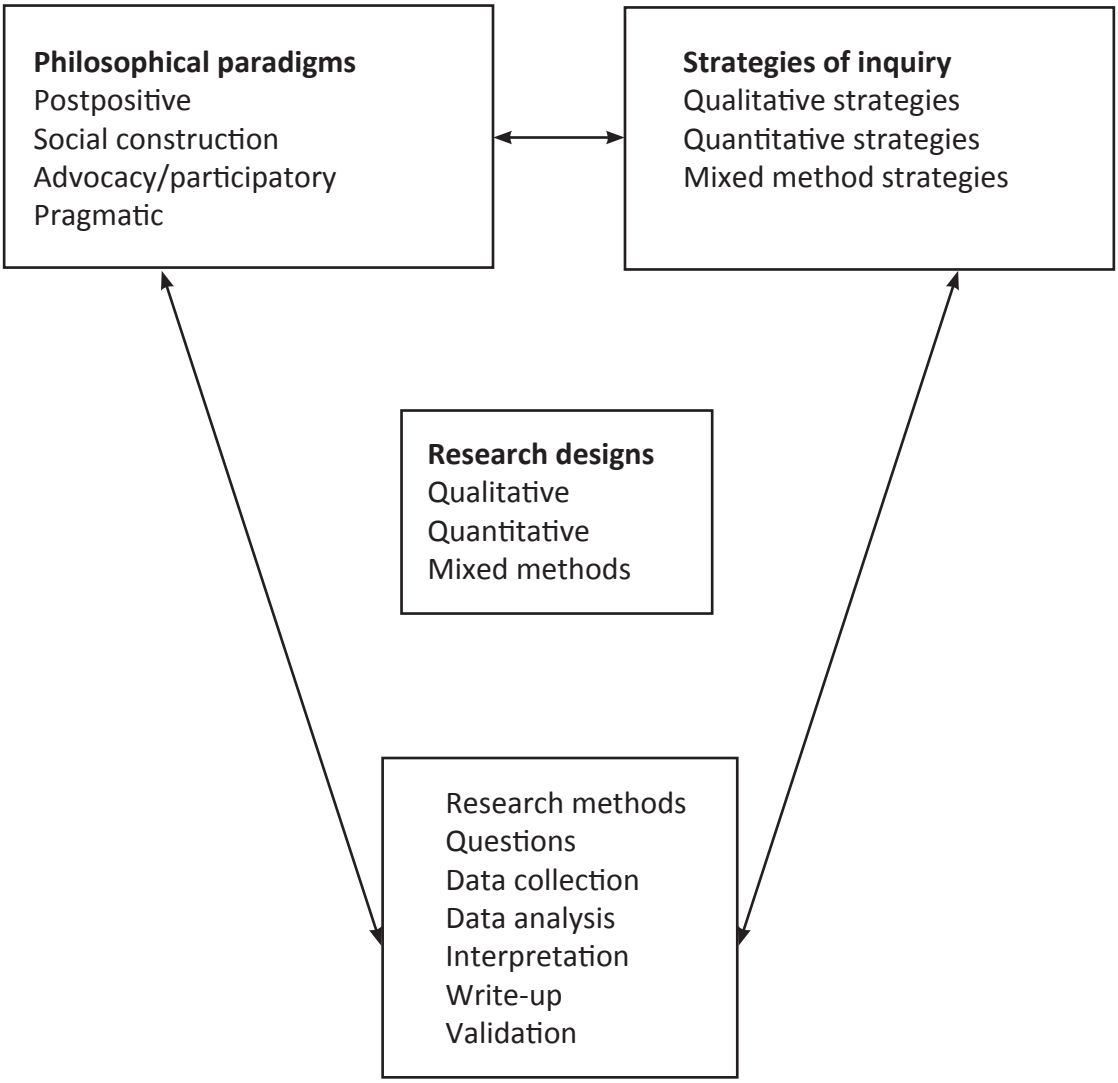

Fig.2. The research design framework (Adapted from Creswell, 2009)

3.2.1. Strategies of inquiry

Strategies of inquiry are types of qualitative, quantitative, and mixed methods designs or models that provide specific direction for procedures in a research design (Creswell, 2009). These three approaches are not as discrete as they represent different ends of a continuum (Newman and Benz, 1998), while the quantitative and qualitative strategies are placed at the ends; the mixed methods reside in the middle of the continuum. Various research strategies are displayed in Table 1.

Table 1. Research strategies used in extension studies.

Quantitative		Qualitative		Mixed methods
Experimental	Non-experimental	Interactive	Non-interactive or analytical	
True experimental	Descriptive	Ethnographic	Concept analysis	Explanatory
Quasi-experimental	Comparative	Phenomenological	Historical analysis	Exploratory
Single-case	Correlational	Case study	Policy analysis	Triangulation
	Survey	Grounded theory		
	Expost facto	Critical research		
	Secondary data analysis	Narrative research		
	Developmental (Trend, Cohort, Panel)			

Adapted from Diem (2002); McMillan and Schumacher (2006).

Experimental strategies

In the experimental strategy, the researcher manipulates the conditions of what the subjects experience by structuring actual situations, introducing or controlling certain variables in order to measure their effect on each other, or by systematically imposing or withholding specified conditions. This strategy helps to compare both manipulated (treatment) and natural settings (control). The three most common types of experimental designs are true experimental, quasi-experimental, and single-subject designs.

True experimental design

Experimental research designs are cause-effect analytical experiments which involves random assignment of subjects and conditions to the subjects for objectively measuring the research phenomenon by controlling external interference and errors. A true experiment contains experimental and control groups, researcher manipulated independent variables and random assignment of subjects and conditions. For example, the influence of technology subsidies on the adoption may be studied by assigning subsidy (experimental group)

and without subsidy (control group) and assessing adoption by comparing both groups.

Quasi-experimental design

Quasi-experiments are non-randomised experiments conducted in non-laboratory situations where independent variables are manipulated to assess their influence on dependent variables. Quasi-experiments differ from true experiments in that subjects are not randomly assigned to conditions.

Single-case research design

Single-case designs are usually single-subject or group research (without control), to evaluate the extent to which a causal relation exists between introduction of an "intervention" and change in a specific dependent variable. For example, a study focusing on the influence of quality seed material provision to single farmer or group of farmers on the livelihood security may be termed as a single-case research design.

Non-experimental strategies

In non-experimental designs, the researcher may examine the relationship between things without manipulating the conditions. Examples include the following:

Descriptive research

The descriptive research provides a detailed summary of an existing phenomenon by assigning numbers to characteristics of objects or subjects involved.

Comparative research

In comparative designs, the researcher investigates the presence of difference between two or more groups on the phenomenon studied. The comparative research is often multi-disciplinary and utilises quantitative techniques to study the phenomenon. The comparative research methods are used extensively in the cross-cultural studies, which seek to identify, analyse and explain similarities and differences across cultures.

Correlational research

The correlational research is concerned with assessing direction and strength of association between two or more phenomena, without manipulating them. A concurrent correlational study examines the relationship between characteristics at the same point in time, while predictive correlational study could predict a later set of data from an earlier set (Babbie, 1990).

Survey research design

The survey research provides a quantitative description of trends, attitudes, or opinions of a population by studying a sample of that population. It includes cross-sectional and longitudinal studies using questionnaires or structured interviews for data collection, with the intent of generalizing from a sample to a population (Creswell, 2009).

Expost facto

Ex post facto study or after-the-fact research is a category of research design in which the investigation starts after the phenomenon occurred, without any intervention from the researcher. It is primarily a quasi-experimental study examining how an independent variable, present prior to the study in the participants, affects a dependent variable. This lack of direct control of the independent variable and the non-random selection of participants are the most important differences between expost facto research and the true experimental research design. Most of the extension research is following ex post facto approaches.

Secondary data analysis

Secondary data analysis involves the analysis of an existing dataset, which had previously been collected by another researcher, usually for a different research question. This strategy is cost-effective and produces good results if used intelligently.

Developmental study

A developmental study is a survey research used to assess progressive changes that occur on a study object or subject over a period of time. It is a longitudinal research, where the surveys are taken at different points of time and then compared to derive inference about a specific phenomenon. For example, a diffusion of agricultural technologies on the user system can be studied effectively using this design.

The development study can be of three forms – trends, cohorts and panels.

(i) In a trend study, surveys are conducted every year on a specific aspect, but with a different sample. However, the sample size remains the same.

(ii) In cohorts, a group of subjects are identified and a specific phenomenon is studied over a period of time to assess the changes. Although the same population is studied each year, the sample from that population is different for each year.

(iii) In a panel study, an identical sample selected at the beginning is used for collecting data every year to assess the changes over time.

Qualitative research strategies

Qualitative designs are concerned with describing or interpreting a phenomenon without manipulating its conditions. It is broadly classified into interactive or non-interactive based on researchers' involvement in the inquiry.

Interactive

Ethnography: Ethnography is a strategy of inquiry in which the researcher studies an intact cultural group in a natural setting over a prolonged period of time by collecting primarily observational and interview data (Creswell, 2009)

Phenomenological research: Phenomenological research is a qualitative research method in which the researcher attempts to understand and explain how an individual or a group of individuals experience a particular phenomenon from the individual's or individuals' own perspective (Kalaian, 2008). The primary method of data collection used in phenomenology is in-depth interviews of individuals who have experienced the phenomenon.

Case study: The case study is a strategy of inquiry in which the researcher explores an event, activity, process or subjects, in depth using a smaller sample. The cases are qualitative inquiries which are time-sensitive and developed using a variety of data collection procedures over a period of time (Stake, 1995).

Grounded theory: Grounded theory is a qualitative strategy for developing theories where the researcher derives an abstract theory of a process, action, or interac-

tion from the views of participants (Chanrmaz, 2006). The data collection process in grounded theory research is usually an ongoing iterative process that starts with collecting and analysing qualitative data that leads to tentative theory development.

Critical research: Critical research challenges those conventional knowledge bases and methodologies that make claims of scientific objectivity. Critical social research attempts to reveal the socio-historical specificity of knowledge and to shed light on how particular knowledge reproduces structural relations of inequality and oppression (Muncie, 2006).

Narrative research: The narrative research is a group of approaches which analyse text, voice and images for generating and analysing stories (e.g., life histories, narrative interviews, journals, diaries, memoirs etc). This research strategy answers both what and how of the narrated stories. The narrative research can be considered both a research method as well as the phenomenon under study. The narrative research can be effectively used in documenting indigenous technical knowledge, develop success stories of agricultural technologies etc.

Non-interactive

Concept analysis: Concept analysis is a research strategy where concepts, their characteristics and relations to other concepts are examined. The purpose of concept analysis is to identify different meanings of a same concept with a view to use them appropriately to the context. For example, the concepts like food security, poverty, livelihood security etc can be assessed by comparing and contrasting the meanings attributed by various stakeholders like farmers, farm women, farm youth, local traders, panchayat (Elected local government in India) officials etc.

Historical analysis: Historical analysis is a method of interpreting and understanding the past through the disciplined and systematic analysis (Gardner 2006). It involves detailed examination of the "traces" of past like artefacts, texts, images and old buildings etc. For example, the indigenous technical knowledge can be collected and elaborated by key informant interviews, village records, artefacts, old photographs and drawings made from elders

Policy analysis: The policy analysis is a research strategy for generating information which helps in formulating and implementing policies and assessing their impact. It uses both quantitative and qualitative methods for collecting and analysing the information related to policy.

Mixed methods

Explanatory research: A mixed-methods research strategy seeks to discover and explain the causal relations among variables governing a phenomenon. In this design, the quantitative data are collected first and qualitative data are gathered at a later stage to elaborate on the findings of the quantitative analysis. For example, the knowledge gain from a training programme is first measured through a teacher-made knowledge test and the inter-group or intra-group variations are explained through qualitative data generated at a later stage.

Exploratory research: Exploratory research design is primarily concerned with discovery and with generating or building theory from empirical data. It begins with qualitative data gathering from subjects to identify themes, ideas, perspectives and beliefs, which are used to design a quantitative survey. For example, the expost facto impact analysis can be effectively conducted by combing focus group discussions to gather possible impact indicators followed

by extensive survey using the indicators identified at the initial phase.

Triangulation: Triangulation is a mixed methods design where quantitative and qualitative data about a phenomenon are collected simultaneously. This strategy helps to overcome weaknesses of using only one approach, with the other approach helping to compliment or supplement to data generated from the former approach.

3.2.2. Research methods

Specific research methods refer to all forms of data collection, analysis, and interpretation used in a research study (Creswell, 2009). It comprises of methods and techniques related to research instrument development and testing, methods of formulating items and questions in a research instrument, data collection techniques (interview or questionnaire), data coding, analysis and interpretation. Various research methods or techniques used for quantitative, qualitative and mixed methods research strategies are presented in Table 2.

Table 2. Research methods and techniques used in quantitative, qualitative and mixed methods designs

Aspect	Quantitative Methods	Mixed Methods	Qualitative Methods
Methods	Pre-determined	Pre-determined and emerging	Emerging
Instruments	Structured instruments - Interview schedule, questionnaires etc	Both structured and partially structured instruments	Partially structured instruments- Checklists, schedules, interview guides
Type of questions	Close-ended	Open and close ended	Open-ended
Types of data collected	Numerical	Numerical and descriptive	Numerical and descriptive
Nature of data collected	Technology performance data, psychological attribute data, economic data, social data and census data	Multiple forms	Technology performance data, observational data, document data, and audio-visual data
Types of analysis	Numerical and statistical analysis	Numerical, statistical, text and image analysis	Text and image analysis
Interpretation	Statistical interpretation	Multiple forms	Themes and patterns interpretation

(Adapted from Creswell, 2009)

4. Extension research in India

4.1. Methodological evolution

Globally, the organised empirical research in extension science began with the famous Iowa hybrid corn study by Ryan and Gross (1943) on the diffusion of innovations paradigm. This study has strongly influenced the approach, methodology, and interpretation of extension research and laid out the foundation for empirical research tradition in extension science. In India, the extension research began with the inception of Masters Programme in extension at the Bihar Agricultural College in 1955, followed by Jabalpur Agriculture College in the year 1957 (Sulaiman, 1996). At the beginning, the extension researchers focused on understanding the phenomenon per se, using a descriptive approach with minimum quantitative methods and tools. Few notable works include the development of popular scales such as socio-economic scale (Trivedi, 1963), and adoption quotient (Bose, 1961; Chattopadhyay, 1963;. Other popular scales like risk preference and economic motivation (Supe, 1969) and economic motivation (Moulik and Rao, 1965) were also developed during this period.

Later the focus shifted to exploring the phenomenon with a view to identify factors which cause or influence the phenomenon. Use of quantitative techniques and experimental research dominated the extension research scenario since 1970s. Few classical works on communication patterns (Ambastha and Singh, 1978) and credit repayment behaviour (Samantha, 1977) which produced market orientation scale were conducted during the 1970s. Exploration of psychological concepts like creativity (Kishore Kumar and Singh, 1993) and multivariate quantitative modelling of adoption phenomenon (Kumar and Singh, 2002) dominated 1990s. The research works on the participatory paradigm to explore farm-level decision processes to customise agricultural technologies to maximise adoption started during late 1990s. Emergence of Information and communication technologies (ICT) has reoriented the research paradigm to explore ICT experiences in other sectors (Meera et al., 2004) and develop user-friendly applications (Anandaraja et al., 2003). Though the methodological evolution in extension research has parallels with the major social science research paradigms described in the previous section, the tools of empirical research in extension remained stagnant for several decades resulting in poor quality outcomes.

4.2. Current status

In India, the extension research is conducted mainly at five levels. These include:

i. Research and education system comprising of agricultural universities, central universities and other deemed universities

ii. Research system with ICAR research institutes

iii. Extension system comprising of state extension departments, Krishi Vigyan Kendras (KVK) (Farm Science Centre), and NGOs

iv. Input and marketing agencies and

v. Credit agencies.

The university system has full-fledged extension education departments which conduct academic programmes (teaching extension courses at the undergraduate and post graduate level) with dissertation/thesis work at the post-graduate level. Besides, they also undertake their university and externally sponsored extension research programmes. In the ICAR Institutes, the extension research is conducted by the subject matter scientists using institutional and external funding. The KVKs are

engaged in the technology assessment and refinement research, capacity development and technology dissemination. While the NGOs are working on baseline data creation for planning their programmes, the input and marketing agencies outsource the field research organisations for generating data to improve effective service delivery.

Though the extension research is conducted at several levels, there is a paucity of information on the nature and type of extension research conducted in these different organisations. The poor quality of extension research in India and the need to improve the quality and contribution of extension research have been articulated recently by Prasad (2014) and Sivakumar (2015).

Keeping these in view, an effort was made to assess the research contribution of these agencies as evident from the research papers published during four years (2010-2013) in the two Indian extension journals viz. Indian Research Journal of Extension Education (IRJEE) (published by Society for Extension Education, Agra) and Indian Journal of Extension Education (IJEE) (Published by Indian Society of Extension Education, New Delhi) as well as one International journal viz. The Journal of Agricultural Education and Extension (JAEE) (published from the Wageningen University, The Netherlands). These journals were purposively chosen based on their (i) popularity among extension researchers, and (ii) their availability as an open access/ subscribed version online. Only the online issues during the period 2010-2013 were chosen to maintain uniformity of time period across the journals. Two special issues of the Journal of Agricultural Education and Extension issues 3 (Special Issue: Systems approaches to innovation and advisory services: selected papers from the 2012 International Farming Systems Association Symposium) and 5 (Special Issue: Gender Inequality and Agricultural Extension) were purposively excluded from the analysis as they are likely to create outliers in specific topic which will disturb the overall assessment. The analysis focused on the number of papers published, subject matter, major research themes, research design followed, locale/region of the research work conducted and agencies involved in those research works. Research designs, which are described in the section 3.2, were used for assessing the research approaches followed in these papers. Only descriptive statistics like frequency and percentage were computed. The findings of this survey are presented in Tables 3 to 8.

4.2.1. Volume of publishing

Analysis of the distribution of research papers in selected journals indicates that the IRJEE published highest number of articles (N=289; 46.46%) followed by IJEE (N=241; 38.75%) and JAEE (N=92; 14.79%) (Table 3).

Table 3. Total number of research papers published in selected journals (2010-2013).

Journal	Year				Total	Proportion of total papers	Yearly average
	2010	2011	2012	2013			
IRJEE	75	55	80	79	289	46.46	72.25
IJEE	54	65	56	67	241	38.75	60.25
JAEE	24	27	25	15	92	14.79	23.00

It indicates that these two Indian journals accounted for over 85% of total papers published in a calendar year, while the international journal produced a meagre 14.79% papers. The average number of papers published in a year in an Indian journal is almost twice than that of their international counterparts, which indicates the magnitude of extension research conducted in India.

4.2.2. Subject of extension research

While analysing the subject matter of research papers, it is found that IRJEE (51.57%) and JAEE (71.74%) published over 50% papers on topics related to extension and social sciences while IJEE produced higher proportion of papers on the agricultural subjects (63.07%)(Table 4).The classification of agriculture and extension and social sciences were based on whether this work applied extension principles in agriculture (e.g., impact of technology, FLD, etc.) or focusing on the subject matter in extension itself (e.g., media exposure or knowledge level).

Table 4. Subject-wise distribution of topics published selected journals (2010-2013).

Subject matter	IRJEE		IJEE		JAEE	
	Frequency	%	Frequency	%	Frequency	%
Crop sciences	59.00	20.42	68.00	28.22	9.00	9.78
Horticulture	17.00	5.88	28.00	11.62	2.00	2.17
Livestock management	32.00	11.07	22.00	9.13	0.00	0.00
Fish farming	10.00	3.46	6.00	2.49	7.00	7.61
Poultry farming	1.00	0.35	4.00	1.66	0.00	0.00
Beekeeping	1.00	0.35	1.00	0.41	0.00	0.00
Agro-forestry	2.00	0.69	4.00	1.66	3.00	3.26
Agricultural engineering	2.00	0.69	10.00	4.15	1.00	1.09
Irrigation and watershed systems	15.00	5.19	9.00	3.73	4.00	4.35
Climate change and environmental concerns	10.00	3.46	4.00	1.66	3.00	3.26
Agricultural disciplines	139.00	48.43	152.00	63.07	26.00	28.26
Extension and social science*	148.00	51.57	89.00	36.93	66.00	71.74
Total	287.00	100.00	241.00	100.00	92.00	100.00

*Topics focusing on the subject matter of extension without any field application

Extension is conceived as an applied social science (Leagans, 1971), aimed to utilise social science principals and tools for improving the practice of agriculture in a sustainable way. In this view, extension research is expected to contribute to agricultural development by creating relevant methods and tools for effective transfer of technology. However, the analysis indicated a “slightly higher” or “almost equal” proportion of research in the subject and application of extension in IRJEE and JAEE and a contrasting result in IJEE. It represents a good trend as research in the core areas of extension is also essential for scientific progress of the discipline. The

research on the subject matter of extension focuses on extension topics (e.g. knowledge level, training need, media exposure) has little utility for the scientists or research managers. For example, if the farmers' knowledge level is less, media exposure is more, it has no utility for scientists. In fact it reflects poor extension intensity. In case of impact studies or farming system works, the results are of direct relevance to research managers. Among agricultural disciplines, majority of the research focused on crop sciences (over 20% in Indian Journals and 9.78% in JAEE) followed by horticulture and livestock (over 11% in each discipline).

4.2.3. Research themes

Among various research themes, technology adoption and impact assessment were the most dominant (over 25% in Indian journals and 14.13% in foreign journal), followed by awareness-knowledge studies (over 8% in Indian Journals), gender roles and issues and training (over 6% in Indian journals) (Table 5). However, the research on innovative extension methods (15.22%) has received equal attention in the JAEE, followed by stakeholder group studies (13.04%). This trend indicates the increasing importance on technology utilisation, as measured through adoption and impact studies.

Table 5. Major themes of the research papers (2010-2013).

Subject matter	IRJEE		IJEE		JAEE	
	Frequency	%	Frequency	%	Frequency	%
Technology Adoption	42.00	12.46	64.00	23.97	13.00	14.13
Impact assessment	51.00	15.13	33.00	12.36	4.00	4.35
Communication research	15.00	4.45	15.00	5.62	9.00	9.78
Gender roles and issues	25.00	7.42	17.00	6.37	0.00	0.00
Organisational processes	24.00	7.12	0.00	0.00	6.00	6.52
Awareness-Knowledge about technology, programme and Institution	28.00	8.31	25.00	9.36	3.00	3.26
Perception and attitude	24.00	7.12	11.00	4.12	2.00	2.17
Information and Communication Technology	19.00	5.64	8.00	3.00	8.00	8.70
Marketing and entrepreneurship	18.00	5.34	11.00	4.12	3.00	3.26
ITK	4.00	1.19	4.00	1.50	0.00	0.00
Livelihood analysis	14.00	4.15	0.00	0.00	0.00	0.00
Stakeholder groups and organisations	23.00	6.82	11.00	4.12	12.00	13.04
Training - need assessment and effectiveness	21.00	6.23	19.00	7.12	5.00	5.43
Environmental issues and concerns including climate change	9.00	2.67	6.00	2.25	3.00	3.26
Agricultural education	0.00	0.00	2.00	0.75	0.00	4.35
Innovative extension methods and systems	0.00	0.00	0.00	0.00	14.00	15.22
Others	20.00	5.93	41.00	15.36	10.00	6.52
Total	337.00		267.00		92.00	

4.2.4. Research design

Assessing the research design of research papers published in extension journal provides insights into the methodological rigor of these works. The analysis showed contrasting trends between national journals and the international journal in using research designs. The national journals predominantly followed a quantitative survey research design (over 37%) followed by expost facto methods (over 18%)(Table 6).

Table 6. Research design followed in extension research papers (2010-2013).

Subject matter	IRJEE		IJEE		JAEE	
	Frequency	%	Frequency	%	Frequency	%
Descriptive	34.00	11.76	9.00	3.73	19.00	20.65
Comparative	14.00	4.84	7.00	2.90	1.00	1.09
Survey research	116.00	40.14	90.00	37.34	18.00	19.57
Developmental studies	4.00	1.38	2.00	0.83	1.00	1.09
Case studies	26.00	9.00	27.00	11.20	25.00	27.17
Concurrent correlational study	32.00	11.07	25.00	10.37	4.00	4.35
Expost facto research	52.00	17.99	70.00	29.05	1.00	1.09
Secondary data analysis	3.00	1.04	3.00	1.24	0.00	0.00
Exploratory	3.00	1.04	8.00	3.32	13.00	14.13
Experimental	2.00	0.69	0.00	0.00	2.00	2.17
Quasi-experimental	0.00	0.00	0.00	0.00	4.00	4.35
Mixed methods		0.00	0.00	0.00	4.00	4.35
Total	289.00		241.00		92.00	

The International journal has published over 40% papers using qualitative methods like case studies (27.17%) and descriptive methods (20.65%). The experimental or quasi-experimental research is one of the promising ways to develop and assess knowledge claims in social sciences (Webster and Sell, 2007), but has received low priority in Indian (<1%) journals, which is slightly more researched in the works published in JAEE (over 6%). This low proportion of using experimental and quasi-experimental design both at the international or national levels is a matter of great concern. The ultimate aim of extension discipline is to modify the human behaviour and experimental or quasi-experimental approaches are proven ways of modifying human behaviour. Besides, the qualitative research designs are contributing only a little for generalising and theorising the extension phenomenon.

4.2.5. Regional distribution

Analysis of regional distribution of research papers published in the two Indian journals revealed that majority of the published works was conducted in North India (about 40%) (Table 7).

Table 7. Region-wide distribution of extension research papers (2010-2013).

Subject matter	IRJEE		IJEE	
	Frequency	%	Frequency	%
International	10.00	3.46	4.00	1.66
North	115.00	39.79	101.00	41.91
South	42.00	14.53	35.00	14.52
East	32.00	11.07	33.00	13.69
North-East	25.00	8.65	8.00	3.32
West	20.00	6.92	15.00	6.22
Central	28.00	9.69	34.00	14.11
Multistate	17.00	5.88	11.00	4.56
Total	289.00		241.00	

*Represents the locale of the research study

Other regions like South (about 14%), East (over 11%) and Central India (over 9%) received low attention in these journals. This trend may probably reflect the regional disparity in extension research as facilitated by fragmented structure of professional societies in India. Only 5% research papers reflect multi-state issues indicating "location-specific" nature of extension research, with limited or no scope for generalising results for a larger society. There is an urgent need to encourage works conducted on topics of national importance and conducted on a large sample size to improve the generalizability of results. With only a small proportion of International papers (1-3%) published in Indian journals, the scope for globalising Indian extension research is becoming narrow.

4.2.6. Sources of extension research

In India, extension research is conducted at five levels comprising of agencies mandated for either research or education or extension or a combination of these functions. From the analysis of research papers, it is identified that educational institutions (Agricultural Universities, Central and Deemed Universities) have contributed majority of extension papers published in Indian extension journals (over 60%) either by themselves (over 40% in both journals) or in collaboration with field extension agencies like KVKs and state extension departments(over 18%)(Table 8).

Table 8. Agencies involved in extension research papers published selected journals (2010-2013).

Subject matter	IRJEE		IJEE	
	Frequency	%	Frequency	%
Research	28.00	9.69	38.00	23.31
Education	133.00	46.02	103.00	63.19
Extension	27.00	9.34	23.00	14.11
Research and education	19.00	6.57	19.00	11.66
Research and extension	12.00	4.15	17.00	10.43
Education and extension	54.00	18.69	36.00	22.09
Research, education and extension	8.00	2.77	5.00	3.07
Total	289.00		241.00	

*Based on the affiliation of all the authors of the study

In the educational Institutions, the research is mainly conducted through student dissertations (PhD and MSc), which are time-bound and conducted in a limited resource environment, thus they follow a tested and popular research approach with limited scope for innovation. Using similar methods for a variety of research problems may bring inappropriate results. For example, the marketing behaviour studies employ same methods for studies across a variety of field and horticultural crops, livestock etc. Though the crops differ in terms of duration, method of cultivation and methods of marketing, the researchers follow same tests, scales and schedules for all these studies. Besides, the extension agencies are entrusted with applied research on technology assessment and refinement. Extension agency collaboration with educational institutions follows a symbolic relationship as extension agencies can utilise the research skills of educational agencies, besides helping them to connect with field realities.

4.2.7. Research methods and tools

A critical analysis of the research papers revealed several significant aspects related to research methods and tools used in these researches.

Titles- About 16% of the research papers published in Indian journals (IRJEE and IJEE) used irrelevant or misleading titles which are not conceptually matched with the objectives and methods of the study. There is a tendency to use catchy jargons to attract the reader's attention, although they don't reflect the essence of the topic discussed in the paper.

Methods- Another serious issue is that over 95% of the papers published in the Indian Journals failed to specify the research approach, variables studied, name and source of scales or instruments used to measure variables, data analytical procedures and statistical software used etc in the "Methods" section. This situation reflects either "over adoption" of known variables for long period or casual approach is measuring variables without following specified scientific procedures.

Scales-Over 75% of the papers on perception and attitude have followed outdated scale construction procedures, which are developed 50-60 years ago. In most cases, the validity and reliability of the instrument were not reported. The psychometric procedures has grown tremendously in the last decade and

resulted in many "state-of-art" tools for scale construction and validation, But these are not used in research papers published in the selected extension journals.

About 63% of the research papers of Indian Journals had misused the statistical procedures as follows:

(i) Using Pearson correlation for assessing linearity among nominal (e.g. Gender, caste) and ordinal (e.g. education) independent variables: Pearson correlation coefficient is suitable only for ratio scales and using nominal and ordinal variables will either inflate or distort the results

(ii) Applying multiple regression for nominal and ordinal variables: Most statistical software follows least square estimation for calculating multiple regression coefficients for the ratio data. This procedure is applied by default (unless the variables are specified as nominal or ordinal in the data sheet) and it requires a normally distributed data without multicollinearity and autocorrelation. Most of the papers didn't specify if the data met these assumptions. Using multiple regression with nominal and ordinal data leads to distortion of results.

(iii) Using principal components analysis (PCA) for social science variables is inappropriate as most social variables are related to each other. This aspect is discussed in detail later in this document (Section on Attitudes, Beliefs and Opinions)

To sum up, analysis of research papers published in extension journals indicate the following

- Indian journals publish almost twice the number of papers than their international counterparts, indicating the magnitude of extension research conducted in India.
- The subject of agriculture and extension are given equal importance as the Indian journals published slightly over 50% papers on topics related to extension and social sciences.
- Among various research themes, technology adoption and impact assessment were well-covered.
- Among research designs, the Indian journals followed a quantitative survey research design (over 37%) followed by expost facto methods (over 18%). However, the international journal has published over 40% papers using qualitative methods like case studies (27.17%) and descriptive methods (20.65%).
- The research in the majority of the published works was conducted in North India (about 40%) with little importance assigned for other states.
- Since extension research is conducted in a small universe, which results in "location-specific" evidence, there is limited scope for generalising results for a larger society.
- The educational institutions (agricultural universities, central and deemed universities) have contributed to the majority of extension papers published in Indian extension journals (over 60%).
- The research methods and tools are inadequately explained in many research papers. Large scale misuse of statistical procedures like Pearson correlation and multiple regression is also recorded.

Though the analysis was conducted covering a limited time period and that too on only three research journals, this exercise has revealed several significant aspects of extension research in India. The increasing complexities of agriculture (influenced by climate change, food safety, marketing and livelihood vulnerabilities) have thrown several new challenges to extension professionals. In this context, there is a need to reform extension research to develop innovative themes, approaches and strategies for delivering sound extension methods and tools to help the field extension to address these challenges

5. Extension research strategies

To address the increasingly complex agricultural challenges and to cater to the needs of a pluralistic extension system, research in extension needs to be strengthened in India and elsewhere. As discussed earlier, most of the extension research tools that were borrowed initially from core disciplines such as sociology, social psychology, educational psychology, cultural anthropology etc, are currently outdated. These core disciplines have witnessed considerable evolution in terms of their research tools and techniques, but extension research still use some of the outdated tools developed 50-60 years ago. Integrating new research methods from psychology, sociology, computer science, cultural anthropology, engineering, etc will help to restructure research framework used in extension to produce tangible and generalizable results. The quantitative techniques are growing with size and variety while the qualitative research is becoming more systematic. In this context, the extension research in India can be improved by following two-fold strategies

- Conducting research in a systematic and objective way – Implementing few good practices can help to improve the way of conducting extension research
- Integrating state-of-art research methods from other disciplines to improve the quality of output in extension research
- Improving the quality of extension research publications

These strategies are discussed in detail in the following sections.

5.1. Good practices for achieving methodological rigor in extension research

Methodological rigor is a crucial aspect of extension research which determines its objectivity and utility of its outcomes. In general, methodological rigor refers to the strength of the design's underlying logic and the confidence with which conclusions can be drawn (Braverman and Arnold, 2008). It is specifically related to conceptualisation of research problems, research design, outcomes specification, and measurement strategies. The following approach is proposed to increase the methodological rigor in extension research

5.1.1. Choosing a research topic – relevance and utility

While choosing a topic for research, it should be based on the field realities, organisational mandate and demands and future requirements. Integrating creative thoughts with commonsense approach will help to develop relevant topics. Working on problems which need immediate attention like farmer suicides, climate change, sustainable farming etc will help the researcher to produce relevant outputs that help in solving the issue or improving conditions. Integrating the individual's urge for professional excellence with the mandate of an organisation is the key for conducting quality research. Techniques like brainstorming, focus groups, key informant interviews etc., helps in choosing a right topic. Wentzel (2011) has outlined three specific strategies for finding interesting ideas: challenging theoretical assumptions, documenting the published literature, and generating new variables (Box 3).

Box 3: Three strategies for finding interesting research topics

Challenging theoretical assumptions

Challenging the existing theoretical assumption to create new research questions is a more personalised way of identifying the research idea. In this method, the researcher identify a specific research area to identify theoretical assumptions through an extensive review of past literature., Then intuition and common-sense are used to interpret possible causes of a problem, or devising new method etc and discussing it with others for elaboration and confirmation. This method is very effective in theoretical research, but demands extensive background knowledge of the researcher to guide the idea generation process.

Documenting Published Findings

An effective method for finding a research idea is to document what has been done in the past on a specific topic, with whom, and how. This process begins with stating a broad question on to guide the research. Once the research question is well stated, it is necessary to read research papers to compile them into a master table containing source, objectives, research design, locale, sampling, independent and dependent variables, measures, experimental designs, data collection procedures and relevant findings. For an experimental study, it is essential to calculate the effect sizes of the hypotheses tested in past studies to decide on the sample size. Once a basic overview of the field has been achieved, the master table can be used to formulate specific research questions.

Generating New Variables

In this approach, a researcher develops a broad research question followed by an extensive literature review in the form ofa master table and finally research questions are formulated. This process helps the researcher to identify variables from published literature and also creates new variables from his/her intuition, commonsense and logical thinking. Generating new variables to formulate interesting ideas requires the same basic review of the literature that is necessary to document published findings. However, this strategy is especially useful for elaborating about why associations among variables exist.

Once a research idea is formulated, it is transformed into a problem statement followed by research questions explaining gaps. Kerlinger (1973) has prescribed three criteria for selecting a good research problem. According to him, a research problem should specify a relationship between two or more variables, which is usually written in a question form and must be capable of being tested empirically.

Source: Wentzel (2011)

5.1.2. Selecting a right research design

In general, social research aims to answer research question through categorization, explanation, prediction, creating a sense of understanding, providing potential for control and evaluation (Reynolds, 1971) from a set of variables. Research designs provide the foundation for systematic data gathering for assessing a social phenomenon in an objective way. Various research designs are described in section 3.2.

Choosing a right research design is a tricky process as its success is contingent upon the nature of research problem, researchers' ability to conduct quality work, resources and time availability etc. Quantitative methods are effective in

assessing a phenomenon in an objective and structured way, which in turn helps in advancement of knowledge and theory building. However, it requires very large sample size (over 300 numbers) for deriving any reasonable generalisation out of the data. Besides, they are rigid enough to offer little flexibility to respondents to answer in their own way. The qualitative methods offer an open-ended and flexible approach to study the problems. These approaches provide flexibility to both researchers and respondents to interact in their own way to generate useful data. However, the qualitative methods per se offer little for generalising data across the contexts. For example, the participatory rural appraisal (PRA) is an appropriate research technique to identify the problems of the stakeholders in an interactive way. However, the data generated from PRA is often subjective which offer very little to assess the uniform patterns in the data. Mixed methods offer robust solutions to problems of both quantitative and qualitative methods by integrating them in an intelligent way. Choosing a right research method is a tricky task, which depends on various factors.

Choosing or developing an appropriate research method/instrument helps to maximise the impact of research. Our analysis of Indian journals has revealed that over 78% research works are conducted through personal interviews using researcher designed instruments. Prasad (2014) noted that "extension research followed in India follows a linear process where a researcher design the research, collects the data and disseminate results for fellow researchers, with little participation from other stakeholders in the process. In most cases, the farmers and extension personnel are only used as subjects and crop/farming system as settings of the study".

The research instrument is normally chosen based on the research problem, nature of variables and proposed analytical methods. The self-report measures like personal interviews and questionnaires, where the respondents indicate an approximate opinion or value for an unobservable phenomenon, are popular among extension researchers. However, these measures are criticised since the respondents may deliberately or accidentally deceive the researchers. Their inability to quantify their opinion and attitudes accurately creates validity issues (Paulhus and Vazire, 2007). For example, the farmers' perception and achievement motivation are often measured with a specifically construed Summated Rating scale, which is not a right method. Using Thematic Apperception Test is the appropriate method to measure achievement and economic motivation.

Our analysis of extension journals revealed that most extension research (>50%) followed either survey or expost facto approaches leaving few experimental works. There is a need to integrate other research designs/methods to improve quality of extension research.

5.1.3. Selection of variables

Selecting right variables and specifying the relationships is a skilful task which demand mastery over the subject and researcher's ability to visualise relations based on past experience and creativity. The nature of variables differ with the purpose of research and research design, which also influence the selection and use of appropriate statistical methods. For example, categorical variables like nominal and ordinal variables are not suitable for analysing with parametric statistics. However, recent advancements in statistical procedures yielded hybrid methods for analysing categorical dependent and independent variables.

In extension research, "judges rating" is a popular item analysis procedure used for identifying suitable variables for specified research objective or sub-scale. Using content experts as "judges" is one of the criteria–referenced test item validity assessment method. This method is suitable for the multi-dimensional research problems that are relatively new and less researched. However, judges' rating method is widely used in all types of extension research problems irrespective of the developmental stage of a specific research area. Using Item-Objective congruence method is one of the alternatives to traditional "judge's rating" method. (Box 4)

Box 4: Item-Objective Congruence Method

The item-objective congruence procedure was proposed by Rovinelli and Hambleton (1977) as a criterion-referenced item analysis. This procedure estimates an index of the validity of an item based on the ratings of two or more content specialists.

Procedure

1. Select the content specialists who are known to be an expert in the relevant subject matter.
2. Prepare a schedule comprising of items (in rows) and the competing objective/ sub-scale in the columns.
3. The content specialists are directed to assign a value of +1, 0, or –1 for each item, depending upon the item's congruence/agreement with the measure's objective or subscale. Whenever an item is judged as a definite measure of the specific objective or subscale, a value of +1 is assigned. A rating of 0 indicates that the judge is undecided about whether the item is a measure of the objective or subscale. The assignment of a –1 rating reflects a definite judgment that the item is not a measure of the objective or subscale.
4. The judge's rating data are used to compute the index of item-objective congruence or item-subscale congruence using the following formula (Martuza, 1977)

$$I_{ik} = (M-1)S_K - S'_K/2N(M-1)$$

Where

Iik- Index of item-objective congruence
M-Number of objectives or sub-scales
N- Number of content specialists
Sk– Sum of ratings assigned to item k
S'k - the sum of the ratings assigned to all objectives, except objective k

5. The limits of the index range from –1.00 to +1.00. The threshold value (cut-of) for selecting items for each competing objective or sub-scale is decided by the researcher. A value of 0.75 is usually selected as threshold and items with Item-Congruence value above 0.75 for a specific objective/sub-scale is selected while others are discarded.

Our analysis of research journal papers revealed that over 75% of the papers failed to specify how the variables are selected and measured. Such practices will adversely affect the quality of the research work besides masking the essential information which is required to replicate the same work or in modified form by the fellow researchers and students. Conceptual clarity and clear specification of relationships are

essential pre-requisites for quality research. Selecting too many independent variables (e.g. demographic, social and personal characteristics) with different measurement levels (e.g. nominal, ordinal, interval and ratio) for single or few dependent variable increases the time spent on conducting research, create respondent fatigue during data collection, difficulties in entering the data, and create problems in choosing right statistical methods for analysis.

5.1.4. Sampling methods

Sampling and sample size are essential aspects that determine the generalisability of research results. In our analysis, we found that most researchers sampled 10% or 20% of the universe for conducting research. In reality, the sampling population chosen in extension studies were relatively small (e.g. beneficiaries of a specific development programme; users of an improved technology which is still in the initial stages of diffusion process) who were selected mostly from a one or two states. Choosing adequate number of samples is a complex task which demand several considerations including nature and size of recommendation domains (e.g. types of farming systems or target group), nature of research or statistical method used (e.g. multivariate statistical methods demand five samples per item or statement in the instrument), and effect size (measure of the strength of the relationship between two variables) and statistical power. As a thumb rule, any extension research work conducted, with a sample size below 300, is not generalised across populations and contexts. A simple procedure for estimating sample size can be found at http://success.qualtrics.com/rs/qualtrics/images/Determining-Sample-Size.pdf

5.1.5. Reliability and validity

Since the interview schedules contain several scales to measure a particular concept, it is essential to report reliability and validity coefficients. Our analysis indicated over 90% scales didn't report reliability or validity, which adds element of randomness or unreliability to research work (Nunnally and Bernstein, 1994). While Cronbach alpha (Composite reliability) is a widely used measure, there are several other methods like KR-20, Kappa and RCC which are used in a variety of contexts. Assessing face validity and content validity is a common practice in extension research, however the factorial and construct validity are popular in the international context. Advanced multivariate methods like Structural Equation Model can help to estimate convergent, divergent, criterion related validities to improve accuracy of the instrument.

5.1.6. Data collection

Collecting data in a systematic and unbiased way is one of the essential requirements for quality research. The interview schedule or questionnaire length is a critical factor which determines the respondent engagement and response rate. Long interview schedules create fatigue among the respondents. Short forms help to sustain respondents' interest besides increasing the accuracy of data. However, recent studies indicated no significant relationship between questionnaire or schedule length and response rates (Rolstadet al., 2011). However, they stressed the need for organising the content in a simple and comprehensible way. Providing snacks/food, small gifts etc helps in improving the response rate. The respondents are treated with dignity, and their rights to participate or not to participate in the data collection are protected. The funnelling approach, where the questions are arranged with an open-ended descriptive mode to specific close-ended questions helps to gather the data accurately.

Online surveys are gaining significant popularity among social scientists in the

recent years. Though Google forms is the popular free survey management system, other paid web survey management systems like Qualtrics and Survey Monkey offer a variety of services to create, distribute, code and analyse surveys. Compared with the traditional modes of surveys, online surveys have several advantages, including shorter transmitting time, lower delivery cost, flexible design options, matching users' convenience and less data entry time (Fan and Yan, 2010). Despite these advantages, online surveys often face challenges such as losing participants who do not have Internet competency and access and lack of interest among respondents to complete the survey leads to low response rates that could lead to biased results. A recent analysis revealed that online surveys recorded 11% less responses than traditional surveys (Manfreda, et al., 2008). Providing incentives through lucky draw and honorarium for respondents' participation in the online survey has increased response rates.

5.1.7. Data preparation

Cleaning and classifying the raw data aids in easy decision making. Examining the data for errors like duplicates, missing data, outliers, and testing statistical method's assumptions are essential steps before conducting statistical analysis. Substituting the missing data or transformations rectify the normality issues. Several parametric statistical inference techniques can be used only when the assumptions are satisfied. For example, the categorical data involving nominal and ordinal measurements can be analysed mainly through non-parametric methods However, many extension research studies employed Pearson correlation and multiple regression to analyse the categorical independent variables. Besides, many popular statistical software programmes perform Ordinary Least Square estimation as a default method for multiple regression analysis. This method requires the data to satisfy several assumptions like normality, absence of multicollinearity, auto correlation etc., which are usually skipped by a majority of the researchers while analysing the data.

5.1.8. Analysis

The goal of scientific research is to identify the hidden patterns in the observed data to make generalisations on the phenomenon under study. The knowledge and use of statistics helps in this. Quantification of relationships among a social phenomenon provides several leads for further research, besides explaining the research questions under the study. There is a widespread perception among extension scientists that quantitative studies using statistics are theoretical in nature and that they do not lead to any meaningful interpretation. Using statistics is often perceived as a "suffix" phenomenon i.e. performing the statistical analysis after collecting the data. However, statistics provides us with the knowledge and tools for assessing complex natural phenomenon in a systematic and objective way.

Choosing and right analytical method is a necessity for deriving appropriate interpretations from the raw data. In our analysis of extension research papers, we found over 72% research papers have used nominal variables like gender and caste in the Pearson correlation and multiple regression, which violate the mandatory assumptions for using these methods. Using the analytical methods depends on the nature of research problem, methods used and expected outputs or outcome of the experiment. With the advent of multivariate statistical methods, the social science research has witnessed a radical transformation. Traditionally, the data analysis is performed after collecting the data. These multivariate methods are not merely tools of data analysis, but they form integral part of every stage in data collection. For example, structural equation

modelling, which is a combination of correlations, confirmatory factor analysis, path analysis and goodness-of-fit tests, provides detailed steps in constructing an attitude scale beginning from collection of statements to assessing reliability and validity. It is an integrated tool where all the analyses related to constructing an attitude scale are inbuilt and it reduce the researchers' effort and time considerably. Limited dependent models like logistic regression can be used to assess the effect of nominal and ordinal independent variables on a nominal dependent variable. For example, adoption studies (adopted/ not adopted) or acceptance of a food product (accepted/ not accepted) etc can be well-researched using these models. Multi-nominal and ordinal regressions can add one more category i.e. partially adopted into the logistic model.

5.2. Integrating new research methods for conducting quality extension research

Most of the research methods used in extension science are borrowed from other social science disciplines such as psychology, cultural anthropology, sociology, economics, marketing and communication. Though the research practices in these disciplines witnessed a sea change in the last two decades with the emergence of state-of-art techniques, the extension researchers continue to use out-dated methods from these disciplines. Though the extension research themes became diverse over the years with wider scope, the research methods continue to be old and obsolete. This phenomenon resulted in poor quality research as indicated by stereotypical publications and duplicating results. The extension research can be improved by applying advanced theories and methods developed in other related disciplines. This section provides a comprehensive view on the new theories and models that are integrated with existing research themes. Few dominant research themes like assessing technology performance and effects, measurement of attitudes/ beliefs/ and opinions, measuring perceptions, Information and Communication Technology research and research synthesis are presented here.

5.2.1. Assessing the technology performance and effects

Assessing the technology performance and their effects on the socio-economic and natural systems is crucial for sustainable agricultural development in a long-term. The technology performance assessed by their extent of adoption i.e. degree to which a technology or a cluster of technologies are used by the target users, and their impact i.e. the effects (positive and negative) of using a technology or a cluster of technologies on the individual, group and on the social system. This assessment helps to improve the efficiency of technology generation, assessing the effectiveness of technology transfer, setting research and development priorities, demonstrating the impact of investing in technology generation as well as formulating strategies and policy decisions to facilitate technology generation, transfer and utilisation for the future (CIMMYT Economics Program 1993).

Adoption of agricultural technologies

In extension research, the adoption studies were conducted largely based on Rogers' Diffusion of Innovation Paradigm (Rogers, 1995), which assesses diffusion and adoption at the institutional and societal levels over a period of time. Our analysis of research papers published in extension journals indicate that adoption studies focused on measuring extent or level of adoption of an agricultural technology or cluster of technologies, factors influencing adoption of agricultural technologies, and constraints in adopting agricultural technologies and role of extension agencies and other supporting agencies in adopting

technologies. Over 98% of the studies are cross-sectional works conducted at the micro-level by documenting farmer's production systems, analysing their decision making processes by relating actual adoption with individual, technology, production system and societal variables, and predicting farmers adoption of these technologies. The constraints in adopting technologies and farmers suggestions for improving adoption facilitation process were also documented.

Theories of technology adoption

The technology performance is often assessed at the individual, institution and societal levels (Box 5).At the individual level, technology adoption can be assessed using theories or models like the technology acceptance model (TAM) (Davis, 1989), theory of planned behaviour (TPB) (Ajzen, 1991), unified theory of acceptance and use of technology (UTAUT) (Venkateshet al., 2003) and Concerns-Based Adoption Model (Hall and Loucks, 1978). Technology, organization, and environment (TOE) framework (Tornatzky and Fleischer, 1990) is applied to assess the adoption at the institute level while Diffusion of Innovations paradigm (Rogers 1995), is used for adoption assessment at both the institute level and in the social systems.

Box 5: Assessment of technology performance at different levels

A. Individual level

a. Technology acceptance model (TAM)

Technology acceptance model developed by Davis (1989) is the most popular adoption model used to predict acceptance and use of a technology by individuals (Fig. 3). This model is an extension of Ajzen and Fishbein's theory of reasoned action (Ajzen and Fishbein, 1980). TAM postulates that users' decision to use a new technology is influenced by its' perceived usefulness and perceived ease of use. While perceived usefulness refers to the degree to which a person believes that using a particular system would enhance his or her job performance, the perceived ease-of-use indicates the degree to which a person believes that using a particular system would be free from effort (Davis, 1989). These variables are synonymous with innovation attributes of relative advantage and complexity in Rogers Diffusion of Innovations Model (Rogers, 1995) respectively. TAM was successfully used to predict farmers' information usage intention in China (Zhang et al., 2009) and farmers' adoption and use of dairy farming technologies in New Zealand (Flett et al., 2004).

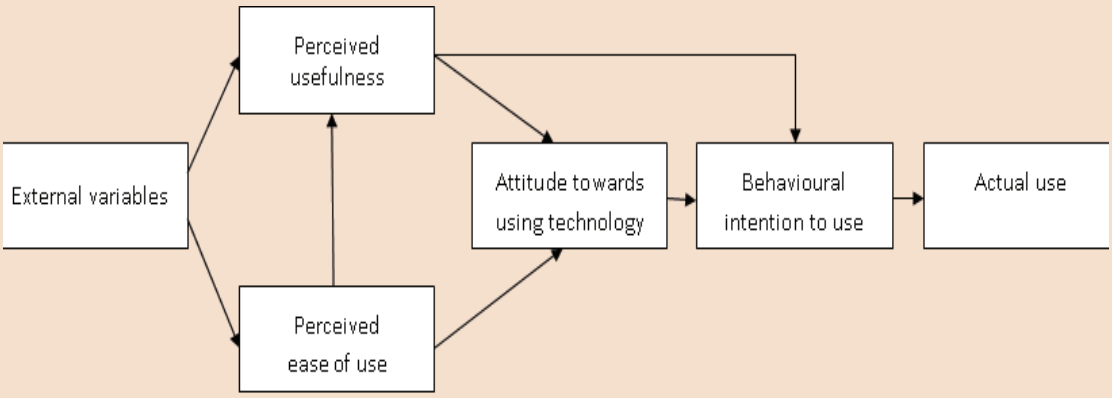

Fig. 3. Technology acceptance model (Adapted from Davis, 1989)

b. Theory of planned behaviour

The Theory of Planned Behavior (TPB) was proposed by Icek Ajzen in 1985 (Ajzen, 1985) as an improvement over the Theory of Reasoned Action, which was developed during the 1980. This theory postulates that a person's intention (i.e. cognitive readiness) to perform behaviour is the most important determinant of that action (Fig. 4). According to this theory, intentions or behaviour are depend on three determinants- attitude towards behaviour, subjective norm and perceived behavioural control. The more favourable the attitude and the subjective norm, and the greater the perceived control the stronger should the person's intention to perform the behaviour in question. Theory of planned behaviour was applied in assessing agricultural climate information use behaviour of Wheat farmers in Iran (Sharifzadeh et al., 2012) and targeting agricultural safety and health interventions in USA (Petrea, 2001).

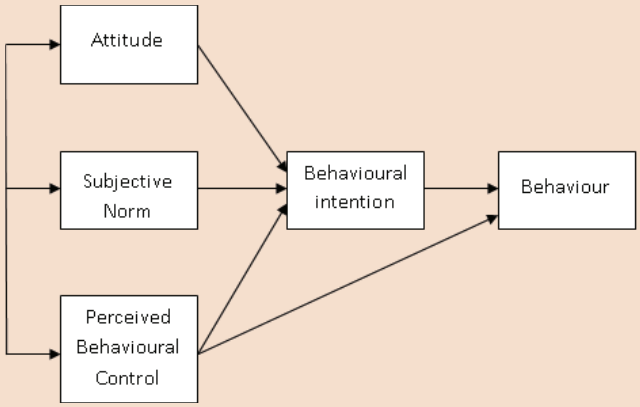

Fig. 4. Theory of planned behaviour (Adapted from Ajzen, 1985)

c. Unified theory of acceptance and use of technology (UTAUT)

The unified theory of acceptance and use of technology (UTAUT) is a technology acceptance model formulated by Venkatesh et al. (2003) to explain user intentions to use an information system and subsequent usage behaviour. According to UTAUT, performance expectancy, effort expectancy, and social influence are theorized to influence behavioural intention to use a technology, while behavioural intention and facilitating conditions determine technology use. Individual difference variables like age, gender, and experience are posited to moderate the impact of the four key constructs on usage intention and behaviour. Several studies employed UTAUT to analyse the impact on farmers' adoption of information technology in China (Liang, 2012) and farmers' use of mobile phones in Tanzania (Malima et al., 2015).

d. Concerns-Based Adoption Model

The Concerns-Based Adoption Model (CBAM) model was developed by researchers at the University of Texas at Austin, USA (Hall and Loucks, 1978) which measures the concerns expressed by employees or users when they learned to use new practices and implemented few innovations. Implementing ICT based instructional system in an educational Institution and Enterprise resource planning (ERP) for office management are few examples of the situations CBAM can be used to assess preparedness and use of the innovative systems.
The CAMB uses three tools to collect data from the users (i) Stages of Concern – Awareness, Informational, Personal, Management, Consequences, Collaboration and Refocusing, (ii) Levels of Use - non-use, mechanical, integration, orientation, routine, renewal, preparation and refinement and (iii) Innovations Configurations (IC) (Hall and Loucks, 1978). This model helps the managers/ policy makers to understand (i) the dynamics of change in an organisation, (ii) how individuals respond to change and (iii) how to ensure that the correct measures are

implemented to ensure the success of a new change initiative. The Concerns Based Adoption Model was implemented to understand the adoption of alley farming technology by Yoruba women in Nigeria (Cashman, 1990) and adoption of innovative teaching strategies among Egyptian agricultural technical schools instructors (Barrick et al., 2015).

B. Organisational level

Technology, organization, and environment (TOE) framework
The Technology, organization, and environment (TOE) framework was developed by Tomatzky and Fleischer (1990) to describe how the organizational components affect an organisation's adoption decisions. This framework uses three elements that influence technological adoption i.e. (i) the technological context – both internal and external technologies relevant to the organisation, (ii) the organization context – aspects related to organisation like size and scope, organizational structure and resources, and (iii) the environmental context – the arena with which the organisation conducts its activities. The TOE framework was extensively used in Information Technology adoption studies (Kuan and Chau, 2001; Zhu and Kraemer, 2005)

C. Social system level

Diffusion of Innovations paradigm
The adoption and diffusion research in extension has focused mostly on the Classical Normal Distribution Model following s-shaped curve proposed by Rogers (Rogers, 1995). It is a well-known theory and widely used by extension professionals to study adoption. Though past studies have fostered the understanding of innovation diffusion in agriculture, several research gaps remain. Very few research works focused on the technology diffusion over time linking the innovation diffusion with new technology performance. Besides, the Roger's model is simplified representations of the reality of diffusion processes (Roling, 1988) which has little ability to predict future adoption of innovations (Mahajan et al., 1990). Research studies conducted on high-tech products (Moore, 1991), environmentally sound manufacturing technologies (Sroufe et al., 2000) and classroom response systems (Towns, 2010) reported the presence of a "chasm" between early adopters of the technology and rest of the adopter groups.

Measuring adoption

Measuring a technology adoption is a multi-faceted process involving several choices and decisions to be made based on the research questions, resource availability, expertise of the researchers etc. In a global analysis of micro-level adoption research studies, Doss (2006) has identified three major trends in adoption viz. 1) using innovative econometric and modelling methodologies to understand adoption decisions, 2) Analysing the process of learning and social networks in adoption decisions and 3) micro-level studies based on local data collection intended to shed light on adoption decisions in particular contexts for policy purposes. Some of these approaches are illustrated in Box 6.

Box 6: Approaches to measure adoption

Econometric studies

The econometric studies on adoption are conducted mostly by agricultural economists, which focus on developing new methodologies to understand and predict adoption (Doss, 2006).An innovative study conducted by Smale et al., (1995), has modelled adoption as three choices –to adopt the components of the recommended package, the decision of how to allocate different technologies across the land area, and the decision of how much of input to use. Dorfman (1996) has used multivariate approach to assess how different technologies like improved irrigation techniques and IPM, could be adopted in different combinations for maximising production. Using econometric methods helped the researchers to derive new insights into the adoption process using cross-sectional approach at the micro-level.

Social networks and adoption

Few studies focused on analysing the process of learning and social networks and their influence in individual farmer's adoption decisions. A study conducted in Ghana by, Conley and Udry (2000) found that social learning is an important component in the spread of the new technologies. Another work by Foster and Rosenzweig (1995) demonstrated that farmers' own experience and neighbours' experiences with high-yielding varieties in India significantly increased the profitability from these varieties.

Location-specific micro-level studies

The location-specific works are conducted to devise or improve agricultural technology policy, by understanding how and why the technologies are adopted or not adopted by the farmers (Doss, 2006). Most of the adoption studies conducted by extension personnel in India are location-specific and are micro-level studies conducted to improve the research practice. In general, adoption is measured for a single (e.g. crop variety or animal breed) or cluster of technologies (e.g. package of practices of a crop or Integrated Pest Management (IPM) package) in three ways (i) Asking the farmers to indicate adoption in a two point (adopted or non-adopted) or three point scales (adopted/ not adopted / adopted, but discontinued). This data is analysed by calculating proportion of farmers using the technology or clusters and state the response for non-adoption or indicating constraints in adopting those technologies. Farmers' suggestions for improving the adoption process are also indicated.

In India, an early pioneering work on adoption by Chattopadhyay (1963) has developed an adoption quotient for measuring adoption of agricultural technologies. It is a ratio scale that measures a farmer's behaviour on dimensions of applicability, potentiality, extent, time, consistency and different nature of innovations. In the 1990s, an adoption index was developed by Karthikeyan (1994) by dividing respondents total adoption score by total possible score and multiplying by 100. This index is widely used to measure adoption behaviour of farmers towards draught bullocks in South India (Akila and Mahesh Chander, 2012), adoption of mung bean (green gram) technology in Rajasthan (Singh, 2011) and pig farmers in Ghana.

In the next level, the farmers' decision making behaviour on adoption is assessed by estimating probabilities of adoption or non-adopting by combining various personal, social, technology and supporting factors through binary logistic regression modelling. This approach was successfully used to assess adoption of maize varieties in Ethiopia (Kassa et al., 2013) and Bt cotton in India (Padaria et al., 2009). The three level adoption data can be analysed through ordinal logit or probit models. The study on adoption of soil conservation practices in

Iran (Haghjou et al., 2014) is an example of using ordered logit for adoption studies. Agbamu (2006) proposed Sigma method of assessing adoption. He stated that the Sigma scoring method involved converting frequency counts to normal scores. Imbur et al., (2008) divided the adoption stages into not aware, aware, interest, evaluation, trial, using adoption and rejection and measured each of these stages as percentage of the total respondents.

Guidelines for conducting adoption studies with farmers

The CIMMYT Economics program (1993) has developed few guidelines for assessing adoption at the farmers' field.

- Among the recommendations that are developed as cluster or package, the farmers are likely to adopt some components of the package earlier than others and few components may be rejected. A research study conducted in Mexico by Byerlee and de Polanco (1986) demonstrated that farmers adopt improved varieties, fertilizer, and herbicide in a step-wise manner, rather than as a package. Therefore the adoption surveys should recognise the time dimension involved in adoption or rejection of the technology or components
- The farmers' are likely to modify a technology or component based on their needs and conditions and an adoption study needs to pay careful attention to this type of farmer innovation
- The adoption researcher may foresee the consequences of adopting a new technology like replacement or extinction of old technology and creation of inequalities among social groups in the user system
- The farmers land is often fragmented and located at different agro-ecosystems in a contiguous area. Researchers need to decide whether to assess adoption on all fields or only the largest field, or on fields that have characteristics relevant to the new technology (e.g., examining soil conservation practices only on sloping fields).
- Seasonal variations, socio-economic conditions of the farmers, input availability, marketing system and adoption facilitation are likely to influence the farmers' decision to adopt or reject a technology. The adoption studies may include them as variables to estimate their effects on farmers' decision behaviour.

Impact assessment

Assessing effect of an intervention on the user group is a crucial component for assessing the utility of a technological intervention. According to World Bank, impact assessment is intended to determine more broadly whether the program had the desired effects (positive and negative) on individuals, households, and institutions and whether those effects are attributable to the program intervention (Baker, 2000). In the National Agricultural Research and Education System (NARES), the impact assessment is used to assess the socio-economic effects of an intervention; problems associated with technologies and user systems; and setting research and development priorities. Impact assessment of agricultural research or technology intervention is a continuous process (Manyong et al., 2001).

The impact assessment protocols are influenced by the nature of agricultural technology being studied. The strengths and limitations of each technology must be kept in mind when setting the indicators of impact. Various types of agricultural technologies as identified by CGIAR (2011) are described in Box 7.

Box 7: Types of agricultural technologies

1. Yield-increasing and cost-saving technologies

The yield-increasing technologies are the material (e.g. plat variety, fertiliser and pesticide) or process (e.g. cultivation practices) which maximises the output per unit area of the land. Cost-saving technologies include materials (e.g. low input requirement variety) and processes (e.g. zero tillage) to produce comparable output per unit area of land with minimal inputs or management.

2. Risk-mitigating technologies

The risk-mitigating technologies may not maximise output per unit area under favourable conditions, but they reduce the risks under unfavourable disastrous conditions. Pest or disease resistant varieties and livestock vaccines are examples of these technologies.

3. Quality-improving technologies

The quality improving technologies produce high quality outputs without any significant increase in the output per unit area of land. The orange-fleshed sweet potatoes (vitamin A rich) and golden rice are examples of these technologies. These technologies are consumer-oriented which benefit the consumers directly.

4. Technologies that alter environmental externalities

These technologies can reduce the negative effects on natural resources. Few examples are bio control of pests and diseases and spot application of fertilisers.
Source: de Janvry et al. (2011)

Types of impact assessments

Broadly, the impact assessment methods can be classified into quantitative, qualitative and mixed-methods. The quantitative methods are focusing on generating quantitative data on the impact indicators, while qualitative methods are concerned with impacts within local socio-cultural and institutional context. Mixed-methods combine both qualitative and quantitative approaches to provide a comprehensive view of the impacts within the socio-cultural milieu.

Quantitative approach

The quantitative impact assessment follows micro-economic approaches to assess the effect of interventions on target group. They are of two types, i.e. ex post and ex ante. An ex-ante evaluation attempts to measure the intended impacts of future programs and policies, while ex post approaches measure actual impacts accrued by the beneficiaries due to programme intervention.

The main challenge of a quantitative impact assessment is to determine the effect of intervention on the beneficiaries if the programme had not existed (Khandker et al., 2010). Counterfactual is an estimate of what the outcome would have been for a program participant in the absence of the program. It is estimated in two ways (i) “Before-after” designs to assess the impact on a same group prior to and after the intervention, and (ii) Forming two identical groups and offering treatment to one group, while keeping the other as a control. The quantitative approaches for impact assessment are discussed in Box 8.

Box 8: Quantitative Approaches to Impact Assessment

Experimental approaches

Randomized evaluations

In the randomized evaluations, the programme benefits are extended to a randomly selected treatment group (beneficiaries), while keeping an identical group as control. The progress of the treatment and control groups on selected impact indicators is tracked over time (Khandker et al., 2010). Randomised evaluations are used when (i) When the eligible population is large enough to deliver the programme (ii) When a program needs to be gradually phased in until it covers the entire eligible population. The major advantage of this approach is its ability to avoid bias in selecting the respondents.

Quasi-Experimental approaches

Propensity score matching

This method is a quasi-experimental approach where the control population (non-beneficiaries) are selected by "matching" them with the actual beneficiaries on few observable characteristics (personal and socio-economic attributes).The matching was based on the "propensity score" which is the predicted probability of participation given observed characteristics. The matched control groups can be selected either before project implementation (prospective studies) or afterwards (retrospective studies).
Various approaches for matching the beneficiaries and non-beneficiaries include nearest-neighbour (NN) matching, caliper and radius matching, stratification and interval matching, and kernel matching and local linear matching (LLM) (Khandker et al., 2010).

Non-experimental approaches

Double difference or difference-in-differences methods

The Double difference or difference-in-differences methods compare a treatment and a comparison group before (first difference) and after the intervention (second difference). This method can be applied in both experimental and quasi-experimental designs and requires baseline and follow-up data from the same treatment and control group.

In this method, a baseline survey is conducted prior to the intervention to assess the outcome indicators with both beneficiaries (treatment) and non-beneficiaries (control or comparison), which are compared to estimate the differences (Khandker et al., 2010). After the intervention, the survey is repeated to assess the differences in treatment and control groups. The mean difference between the "after" and "before" values of the outcome indicators for each of the treatment and comparison groups is calculated followed by the difference between these two mean differences. The second difference i.e. difference in the difference, is the estimate of the impact of the program.

Instrumental variable (IV) methods

The instrumental variable method is a statistical estimation method to be used with non-experimental design of impact analysis. In this method, the unobservable biases in sample selection are minimised by including a new variable in the analysis. The new variable is called as "instrumental variable" since it increases the probability a person to be selected as beneficiary in the study, but has demonstrated to have no influence on the outcome of the intervention. For example, "geographical variation" may be included as an instrumental variable when assessing the impact of poverty alleviation programmes.

Regression discontinuity design

The regression discontinuity design (RDD) is a quasi-experimental pretest - posttest design that elicits the causal effects of interventions by assigning a cut-off or threshold above or below which an intervention is assigned. By comparing observations lying closely on either side of the threshold, the average treatment effect is estimated. This method is used in the conditions in which randomization was unfeasible. There are two types of RDD such as (i) Sharp method which assigns a discrete cut-off point for both beneficiaries and non-beneficiaries and compares means of treatment effects to assess the impact, and (ii) Fuzzy method was used in instances where few eligible people are excluded from the intervention or became ineligible due to other reasons. The fuzzy version is the widely used method.

Distributional impacts

In this approach, the impact is measured to understand how programs have affected households of individuals across the distribution of outcomes. For example, the impact of poverty alleviation programme is measured as its effect on poorer households as compared with wealthier households.

Qualitative and mixed methods

The qualitative methods of assessing impacts are mostly concerned with assessing the quantitative impacts with respect to the socio-cultural milieu of the respondents. Most of the extension research employs qualitative approach to assess the "perceptual impacts" using participatory methods like Participatory Rural Appraisal, Focus groups, case studies, participant observation etc. This approach plays an important role in impact evaluation by providing information useful to understand the processes behind observed results and assess changes in people's perceptions of their well-being. Furthermore qualitative methods can be used to improve the quality of survey-based quantitative evaluations by helping generate evaluation hypothesis and strengthening the design of survey questionnaires and expanding or clarifying quantitative evaluation findings (Khandker et al., 2010).

A recent approach "Participatory Action Learning Approach" which involves stakeholders in all stages of the evaluation or assessment, such as determining the objectives of the study, identifying and selecting indicators to be used, and participating in data collection and analysis etc, provides valuable data on local outcome indicators and the mechanism to measure impacts from a user perspective (Spath, 2004). A mixed-methods approach for assessing impact of agricultural technologies is displayed in Box. 9.

Box 9: A mixed-methods approach for impact assessment

Based on the technology development process, a mixed methods approach for impact assessment of agricultural technology interventions viz. impact for priority setting (i.e., ex ante impact), on-farm technology evaluation, adoption, and ex .post impact were identified by CGIAR .

1. Ex ante impact assessment

This assessment is undertaken before the programme is initiated for setting priorities based on the potential impacts of alternative research plans on aggregate net benefits or on poverty alleviation. Ex ante impact studies are conducted to estimate the expected returns from current alternative research plans. Assessment of future impact includes measures of productivity impacts, distribution of economic benefits, and effects on environmental quality (Alene et al., 2006).

2. On-farm technology evaluation

The technology development begins after identifying research priorities. This involves on-station development of new varieties, crop or animal management practices or pest/disease management strategies. The best performing technologies are then transferred to farmers' field for on-farm testing. During on-farm technology evaluation, technology performance parameters like their profitability, acceptability to both farmers and consumers, adaptability to varying environmental and socio-economic conditions are recorded.

3. Adoption

Adoption studies are carried out to monitor the extent and pathways of adoption and the impact of proven technologies on farm-level productivity during the technology promotion stage. These studies measure the extent of use of the technology, the performance of the technology (productivity changes, advantages, and disadvantages), changes in farm management induced by the new technology, and characteristics of the diffusion process.

4. Ex postfacto impact assessment

Expost facto impact assessment is conducted after a technology has been widely adopted by farmers in the target areas. Ex post impact assessment develops the confidence of scientists, research managers, and stakeholders and makes the case for enhanced research support. Increase in productivity, cost-minimisation, enhanced marketability, increase in livelihood income etc are few impact indicators collected in this assessment.
Source: (Alene et al., 2006).

An innovative impact assessment approach developed by Ms. Susanne Neubert of German Development Institute, Germany, MAPP (Method for Impact Assessment of Poverty Alleviation Projects, 1998) combines a quantitative approach with participatory assessment to derive tangible results to address the needs of managers and policy makers. In this method, the impact is assessed through a series of workshops with stakeholder representatives. It has wide applications to analyse complex development goals like poverty reduction, democratization, good governance, economic and sustainable development. A detailed description of various impact assessment methods used in socio-economic research can be found at http://are.berkeley.edu/~sadoulet/papers/deJanvryetal2011.pdf

5.2.2. Forecasting and estimating technology demand

Prediction and forecasting

Predicting the future of a technology using the forecasting procedures helps in (1) assessing the demand of the technology at specific time period, (2) understanding the impact created or expected by the stakeholders and (3) identifying the need for developing and refining technology. The prediction and forecasting methods are integral part of market-led extension and have great potential in stabilizing market price. In general, a prediction is deriving an outcome based on deductive logic or beliefs while forecast is a means to validating a prediction based on an analysis of varying factors and patterns. Though the prediction and forecasting are largely quantitative, conducted mostly by economists, they are equally important for extension science as well.

There are many overlapping forms of forecasting technology developments and their impacts, including technology intelligence, forecasting, road mapping, assessment, and foresight. Several technology forecasting methods have been developed over the years and it is essential for any forecaster to match the method with the purpose with logic and commonsense to derive accurate estimates. The forecaster has to judiciously select a technique or a combination of techniques depending upon the methodology and end objective in view.

Judgmental forecasting

The judgmental forecasting methods including Delphi and scenario analysis can be effectively used in extension research. These forecasting methods are used in ambiguous situations where the information on past performance of a technology or a service is not available. For example, if a food technologist wishes to assess the market demand for a novel food like gluten-free pasta, where the data on the market demand of pasta is either not available or not accessible, the extension professional can help to estimate the approximate demand by using the judgmental methods. These methods rely on expert opinion that uses incorporate intuitive judgment and opinions to derive subjective probability estimates.

Delphi method

Delphi is a popular judgmental method, developed by RAND Corporation in Santa Monica, USA during 1950s. The Delphi uses a convergent approach to develop expert estimate on a particular aspect (e.g. demand of a technology, price, cost of a project, etc) using a two or three stages assessment, where experts' opinions are collected and information is combined, and then returned to the experts for re-evaluation A classic example of Delphi study is the USDA forecasts for soybean and corn prices (Isengildina et al., 2004). Delphi method was also used for strategic planning (Rikkonen et al., 2006), identify locations for Agricultural Service Center (Zangeneha et al., 2015) and need assessment for crisis communication (McGuire et al., 2012).

Recently, the computer based real-time or almost real-time Delphi is gaining popularity owing to its cost and time saving processes. The dissensus-based Delphi, an exploratory variant of the classical Delphi, focuses on divergent approach where a variety of opinions or estimates are derived through expert consultation on a particular issue for on a bipolar distribution (e.g. high to low, good to bad) (Steinert, 2009). This method was developed by Turoff in 1970 which is widely used in policy analysis. Two examples of dissensus Delphi are argument Delphi (Kuusi, 1999) and disaggregative Policy Delphi (Tapio, 2003).

Scenario analysis

Scenario analysis is a process of analysing possible future events by considering alternative possible outcomes. It is useful to generate a combination of an optimistic, a pessimistic, and a most likely scenario of any commodity or aspect. This is an important tool in the world of finance and economics, and is used extensively to make projections for the future. "Scenario planning" was developed in the 1950s (Kahn and Wiener 1967) and it has been used in the area of sustainable development (Rotmans et al. 2000). The scenario analysis is used successfully to assess the impact of water and agriculture policy scenarios on irrigated farming systems in Italy (Bartolini et al., 2007) and participatory water management planning in France (Graveline et al., 2014). Scenarios are arrived at by a team composed of key decision makers, experts, and stakeholder representatives during two or three one-day workshops held over a period of weeks or months.

5.2.3. Measurement of attitudes, beliefs and opinions

Measurement of stakeholder's attitudes, beliefs and opinions on a technology, approach, system and development intervention is an important area of extension research. Understanding the stakeholder attitudes and beliefs will help in assessing the adoption potential of a technology, extent of user participation and utility of a development intervention, enhancing the effectiveness of organisational processes etc. The terms "attitudes", "beliefs" and "opinions" are often used interchangeably in the extension research. However, it is essential to understand the differences between these concepts to choose the right research approach for their measurement (Box 10).

Box 10: Attitude, Beliefs and Opinions

An attitude is defined as a predisposition to respond in a favourable or unfavourable manner with respect to a given attitude object i.e. a person or thing (Oskamp and Schultz, 2005), while beliefs are the statements indicating a person's subjective probability that an object has a particular characteristic (Fishbein and Ajzen, 1975). A chief difference between attitudes and beliefs is that beliefs are cognitive-thoughts and ideas and attitudes are affective feelings and emotions. For example, "this pesticide is very effective against borer pests" is a belief statement while "I like this pesticide as it can control borer pests in my crop" indicates the attitude of the farmer. However, the evaluative beliefs that state a value judgment about an object (e.g. this pesticide is very good), are essentially attitudes. Opinions involve a person's judgments about the likelihood of events or relationships regarding some object, and they also may involve evaluations of an event or object on specific dimensions (Oskamp and Schultz, 2005). For instance, "Recycling of farm waste saves natural resources" is an opinion, whereas "It's a good thing to recycle farm waste" indicates an attitude.

In general, the attitudes, beliefs and opinions are studied in five different ways in social science research. They include (a) Description; (b) Measurement; (c) Polls; (d) Theories and (e) Experiments (Oskamp and Schultz, 2005). Describing attitudes/ beliefs/opinions is a traditional and less sophisticated method which focuses on providing verbal or written description of an observed behaviour inferred from uncontrolled observations or interactions. Describing farmers' attitudes towards contract farming by informally interacting with a group of farmers is an example of this approach. Measurement involves a rigorous scientific approach where the attitudes, beliefs and opinions are measured implicitly or explicitly through systematic observation, quantification and scaling.

Most attitudinal research in extension employs the measurement approach for measuring or understanding attitudes, beliefs and opinions. Classical test theory and scaling methods like Thurstone's Method of Equal-Appearing Intervals (Thurstone, 1928) and Likert's Summated Ratings (Likert, 1932) are popular measurement scales used in extension research. Polls are generally concerned with the shared attitudes, beliefs and opinions on important social issues held by very large groups of people (Oskamp and Schultz, 2005).The polling approach is relatively new for extension research, but has tremendous potential in understanding stakeholders' opinions on broad issues like climate resilient agriculture, use of Genetically Modified Organisms (GMOs) etc.

Theorists are concerned with explaining the formation and modification of attitudes, beliefs and opinions using a measurement or experimental approach. Diffusion of innovations theory developed by Rogers (2003) attempts to explain the spread of innovations in a social system over time. In the experimental research, few predictor variables are manipulated at different levels to understand their effect on the attitude, belief or opinion in a systematic way. Studies on the effect of food labelling on the consumer acceptability of food (Bower et al., 2003; Borgmeier and Westenhoefer, 2009) are examples of this experimental approach. More details on measurement of attitudes, beliefs and opinions are discussed in Annexure 1.

5.2.4. Measuring perceptions

Understanding users' perception of a technology/ method/initiative is necessary for facilitating adoption. Perception is the subjective process of acquiring, interpreting, and organizing sensory information (Nelson, 2008). Perceptions indicate the users view of a technology/method/initiative, which is formed based on his previous experiences. Perception can be studied using a variety of methods including self-report survey, arguments, introspection, psychophysical and neuroscience methods (Stufflebeam, 2006).

Survey method

In extension research, perceptions are measured using survey method. In this procedure, the respondents were directly asked to provide information on how they perceive such matters as the effectiveness of extension programmes, marketing system, improved technologies etc. Survey questions that assess perception are aimed at identifying the processes that (a) underlie how individuals acquire, interpret, organize, and, generally make sense of (i.e. form beliefs about) the environment in which they live; and (b) help measure the extent to which such perceptions affect individual behaviours and attitudes as a function of an individual's past experiences, biological makeup, expectations, goals, and/or culture. In this method, perception can be accessed through open-ended and close-ended questions. In extension research, close

ended questions with Summated-rating or other rating scales are widely used.

Arguments

Arguments or debates are qualitative methods of measuring perception. An argument is what we offer through language as a means of proving, explaining, persuading, convincing, or showing that the truth of something follows from the truth of something else. Every argument consists of two parts i.e. claim - a statement asserting a case and the other is the evidence -- the statements presented to show that the claim is true (Stufflebeam, 2006).Research studies employed debates as a method of assessing student's perception about how technology-enabled classrooms develop critical skills (Scott, 2008) and oral communication skills (Zare and Othman, 2015).

Introspection

The method of introspection asks respondents to "look into themselves" and report their conscious thoughts, reasoning, or sensations. Here, respondents may be asked how their perceptions compare with the perceptions of other people in their own judgement. However, the researcher doesn't reveal other respondents perceptions to the subject and refrain from judging their perception as right or wrong. The guided introspection and researcher introspection are widely used methods to elicit consumer perception about a product or service (Wallendorf and Brucks, 1993).

Psychophysical methods

Psychophysical methods are popular research tools in the experimental psychology whereby a researcher forms a hypothesis, tests the hypothesis by requiring that a subject perform a relevant task, observes the subject's behaviour, then evaluates the hypothesis in relation to the positive or negative data collected (Stufflebeam, 2006). These experiments that are designed to "evoke reports" are used to study perceptual phenomena such as "pop-out" effects, visual illusions, object recognition, matching and discrimination abilities and motion detection. The sensory evaluation experiments like Quantitative Descriptive Analysis and intensity testing are popular psychophysical methods used to assess the intensity of various sensory attributes of foods.

Neuro-scientific methods

The neuro-scientific methods are directly examining the human brain to understand the processes of perception. These methods fall into two classes such as invasive and non-invasive (Stufflebeam, 2006). The invasive methods are research techniques that require the introduction of an "instrument" into a subject's brain. They include surgery and lesion studies that are widely used for stimulation studies, electroencephalogram, evoked response potentials, and single cell recordings. Non-invasive methods are research techniques that do not require the introduction of an instrument into a subject's brain. Of the several neuro-imaging methods used to study perception, some are used to identify brain structures: conventional radiographs (X-rays), computerized tomography (CT), and magnetic resonance imaging (MRI). Others are used to identify functional areas of the brain: functional autoradiography, positron emission tomography (PET), and functional magnetic resonance imaging (fMRI) (Stufflebeam, 2006).

Repertory Grid Method

The repertory grid technique is a method for representing and exploring a person's understanding of things (Holman, 2004). It is a useful method for assessing persons' perceptions and beliefs of topics to which they have previously given little thought, or find difficulty expressing. It measures how

people construct "meanings" by interacting with the world around them. Repertory grids were developed in the 1950s by the American social psychologist George Kelly. The repertory grid is a structured interviewing process, which begins with identification of elements i.e. subjects of evaluation of the study topic. For example, a researcher wishes to identify farmers' perceptions about an improved variety. In this case, the elements constitute various varieties of the crop or animal. These elements are printed in separate cards and given to respondents as random "triads". The respondents were asked to identify broad criteria (constructs) on which they rank the elements.

After constructs are identified, the triads are ranked for each construct based on their preference. In this process, the respondents are also asked to explain the reasons for their choice. After completing ranking of all "triads", the data is coded and subject to analysis. The repertory grid methods seek to explore the mental representations implied by a construct, rather than attempting to gain an objective measure of reality. This knowledge is particularly useful in studies seeking to explore the rationale behind individual judgements. This method was used to elicit older people's perceptions towards conventional and functional yoghurts (Messina et al., 2008).

Means-ends chain analysis

The means-ends chain analysis, developed by Gutman (1982), is a popular qualitative research method of measuring the perceptions, which is used widely in marketing research. The means-end theory indicates the way consumers relate to products can be represented by a hierarchical model of three interconnected levels: product attributes, consequences of use and personal values. This analysis has been employed to identify the use and non-use values that underlie farmers' decision making with respect to animal welfare in Sweden (Hansson and Lagerkvist, 2015).

5.2.5. Information and communication technology research

The growth of information and communication technology (ICT) comprised of media, computing and telecommunication technologies during the last decade have been phenomenal which led to significant changes in everyday life. The ICTs are highly interactive media, which can be used to deliver information and training individually for large number of people and also enable them to use it at their convenience. These developments created new opportunities for the extension workers to perform the information dissemination, capacity building and technology application more effectively.

In general, the ICTs are helping the extension system by (i) mobilising stakeholder involvement in planning and implementing targeted intervention programmes, (ii) improving stakeholders' access to extension advisory services, (iii) facilitating technology development and application for livelihood improvement and (iv) strengthening the marketing capacities of stakeholders for sustained development. These tasks are performed through specific ICT functions of (i) Information exchange (storage and distribution of data for creating awareness and enriching knowledge of stakeholders; feedback on technologies and development systems), (ii) Networking (To improve stakeholder participation in the technology decision process; facilitating collective processes), (iii) Building capacities of the stakeholders (For technology application, entrepreneurship, group processes, and livelihood improvement) and (iv)Providing access (Information, technology, credit, inputs, market and other location-specific information as well as quality advisory services) and (v) Decision support (Forecasting climate parameters,

pest/disease outbreak, market intelligence, optimising land and input usage)

The research on ICT application in extension is still at infancy stage in India. Our analysis of the research papers indicated that Indian ICT research focused on ICT infrastructure at stakeholder systems, coverage of ICT-enabled education and extension services, usage of ICT technologies in agricultural education and extension, constraints associated with effective ICT use, ICT readiness, effectiveness of ICT applications and documentation of success stories. Many of the recent papers in this theme lack empirical evidence and the investigations only deal with the periphery of the problem. There is a need to work on emerging areas of ICT research to catch up with the developments at the international level. Some of the areas for research on ICTs are discussed in Box 11.

Box 11: Research on use of ICTs in extension

Quality of service provided by web portals

The Web portals provides the users with online information and information-related services like search engines, web communities, commerce offerings, market intelligence, personal productivity applications, and also communication with the site owner and peer users. Interacting through web portal is different from traditional interaction, which involve interaction (1) between customers and the portal employees via either Internet-based communication tools (e.g., email, chat room, etc.) or traditional channels (e.g., mail, fax, etc.); (2) between customers and the portal; and (3) among peer users of similar goods and services via email, chat rooms, etc (Yang et al., 2005). Though the first type of interaction is traditional, other two indicates the quality of web design. Several studies conducted to assess the website quality in e-commerce (Liu and Amett, 2000) and its impact on customer loyalty (Jeon, 2009) and online purchase behaviour (Zhou et al., 2009). Several multi-item measures involving website usability, usefulness of content, adequacy of information, accessibility, and interaction were developed and standardised for measuring web portal service quality. Since the website quality is the primary factor which determines user satisfaction and actions, the extension research can explore this research area to maximise the effectiveness of the extension services.

Usability testing of websites

Usability refers to the speed and ease with which users are able to carry out their tasks via a given digital media like websites (Alcántara-Pilar, and del Barrio-García, 2014).).. A website with good usability is well organized, shows and explains the products and services clearly and concisely, makes the registration process as simple as possible, downloads quickly, easy to use, and fosters positive experiences for the user (Alcántara-Pilar et al., 2015). The usability of the website is determined by the users “personal motivation”. These motivations may be utilitarian (extrinsic) or hedonic (intrinsic) (Childers et al., 2001). In digital environments, the utilitarian factors are related to comfort, ease of access to products and services, time-saving, and cost, while the hedonic factors are related to positive emotions like surprise, excitement and uniqueness, social benefits, and involvement with a product or service category. Both factors together determine the usability of the digital media (Alcántara-Pilar et al., 2015). From a design perspective, the utilitarian factors correspond to web design attributes such as functionality, perceived usefulness, and ease of use, while the hedonic factors are related to information content, its presentation, and the flow state (feeling of wholeness people experience when completely absorbed in a task) achieved by the user while browsing the portal.

In a recent study Alcántara-Pilar et al., (2015) employed 2x2 experimental design to demonstrate the importance of utilitarian and hedonic factors on the perceived usability of websites. Various studies conducted using self-report, mental measurement scales indicated that ease of navigation (Nantel and Senecal, 2007), download speed (Venkatesh and Agarwal, 2006) and interactivity (Agarwal and Venkatesh, 2002), responsiveness (user feedback) and information content (Palmer, 2002) as major factors influencing usability of a website. Few studies (Tan and Wei, 2006; Aranyi et al., 2012) employed "Think Aloud Protocol"to examine the cognitive processes during the web browsing behaviour of the users to enhance the usability of the websites.

Think-aloud protocol is a qualitative usability testing method used in psychology and other social sciences. It is primarily a verbalisation of the cognitive processes while the users are engaged in performing a task. The think-aloud method was introduced in the Information System (IS) usability field by Clayton Lewis in 1982 (Lewis, 1982) and has been regarded as the "single most valuable usability engineering method" in IS research.

Procedure

1. Recruit representative users and ask them to perform a specific task. They are also asked to "think aloud" i.e. recognise and speak out their thoughts, feelings and emotions as they experience while performing the task intermittently.
2. Observe the users and record their "think aloud" verbalisations without interacting with them.

Types

- Think aloud protocol is available in two forms: concurrent think-aloud protocols (CTA protocols) and retrospective think-aloud protocols (RTA protocols).
- The CTA protocols are popular among psychology and information system researchers, where the potential users perform a particular task and constantly speak out their experiences.
- The RTA protocols are a variant of the CTA protocols, involving participants who silently work with a particular test object and then share their thoughts afterwards, often on the basis of a video recording of their performance
- In another variant of "open-ended" protocol, no task is specified, and the user is free to choose the task. This method allows the researcher to concentrate on naturally occurring problems

User acceptance of ICT service or system

User acceptance of an ICT service or system refers to the prospective users' liking, intention to use and actual use of the service or system. A significant number of past research indicates that use of any specific ICT is determined by various perceptual factors like perceived usefulness and perceived ease of use that influence the users' behavioural intentions to use the system. Various theories or models like the Theory of Reasoned Action (TRA), the Theory of Planned Behaviour (TPB) and the Technology Acceptance Model (TAM) are the most commonly applied ways of analysing the behaviour and perceptions of ICT users (Turel et al., 2007). The user acceptance studies were conducted on a variety of ICT services and systems like expert advisory system (Duan et al., 1995), wireless short messaging services (Turel et al., 2007), instant messaging (Lu et al., 2009) and Skypeout communications (Laio, and Tsou, 2009).

Instructional design

Rapid advancements in computing and Internet technologies has made e-Learning become an important learning system. One of the key characteristics of e-Learning is its capability to integrate different media, such as text, picture, audio, animation and video to create a multimedia instructional material, which motivates the learner and enhance learning effectiveness, Despite its high potential, research has shown that the design of multimedia is costly (Neumann, 1998) and it does not produce consistent effects on promoting learning performance.

Instructional design plays a crucial role in determining the effectiveness of multimedia applications developed specifically for technology transfer. Though few Indian studies have examined the effectiveness of multimedia based extension applications like Interactive Multimedia Compact Disc (Anandaraja et al., 2006), CD-ROM (Rajula Shanthy, and Thiagarajan, 2011) and e-agriculture prototype (Saravanan, 2012), the role of instructional design was not examined critically. Since these ICT applications are targeted to improve the users' knowledge, skill and positively enhance their intention to use the technology/ aspect, instructional design plays a crucial role in determining the effectiveness of these applications.

The human-computer interaction research has applied several theories like media richness theory (Trevinoet al., 1987), cognitive load theory (Sweller, 1994) and Social response theory (Nass et al., 1996) to increase the instructional effectiveness of multimedia. The media richness theory states that communication efficiency between people is affected by the fitness of the media and the characteristics of the communication task. Sun and Cheng (2007) applied "media richness theory" for multimedia design and demonstrated that only the course units with high uncertainty and equivocality in content need high richness media representation.

The cognitive load theory indicates that human mind has limited short term memory for cognitive processing. During the learning process, the humans allocate most of their cognitive resources to this activity, and in many cases it is the instructional format which causes an overload. Research indicated that cognitive load can be reduced through worked examples training (Sweller et al., 1998) and by adding visual cues to the pictures (Tabbers et al., 2004)

Social response theory states that people tend to view computers as a social actor, and their level of interacting with computers vary according to type of social cues, such as language, emotion, and voice (Moon, 1998). Using animated characters in multimedia modules can help to improve learning effectiveness as they project human characteristics by expressing movements, gestures, facial expressions, voice, and dialogue (Gulz, 2004). Research has shown that animated characters that expressed a sense of caring helped to reduce negative emotions of the learners (Chou et al., 2003; Chen, 2007).

Furthermore, some research showed that information overload, cognitive overload, and learning disorientation affected the quality of learning (Bartscha, and Cobern, 2003). Few studies employed experimental approaches to demonstrate the effectiveness of multidimensional concept maps in reducing learners' learning disorientation (Huang et al., (2012) and enhancing learning through maximising learning achievement, learning satisfaction, and learning retention (Chiou et al., 2015).

5.2.6. Research synthesis

Extension is a field-oriented discipline and a sizable proportion of agricultural GDP is spent in the public sector extension services. The policy makers and extension mangers rely on generalisations derived from empirical data to decide on critical aspects of extension service provision. As the extension research is focusing on relatively small sample studies, it offers little help for the policy makers to know the impact or identifying priorities for devising new programmes. Research synthesis is an emerging research tradition, which can aggregate the results of various researchers conducted in extension over the years to get insights into the dynamics of extension phenomenon. The research synthesis is a process through which two or more research studies are assessed with the objective of summarizing the evidence relating to a particular question (Chiapelli, 2014). The primary aim of research synthesis is to identify the patterns in the results of the published empirical research, which will help in generalising and theorizing these works.

Research synthesis is an urgent need for social sciences like extension because of the following reasons:

- The volume of extension research is often piling up and fast growing. It is evident from our analysis that each extension journal in India publishes over 60 papers in a year.
- The potential users' access to individual reports or published research is haphazard and biased. The large volume of information will confuse the readers who often look to the specifics.
- The quality of published reports, level of evidence, and strength of recommendations are diverse and complicated for a reader to get a comprehensive view.
- The sample size of individual studies is often too small to permit reliable statistical inferences and generalisations.

Systematic reviews

A systematic review is a popular way of conducting research synthesis by integrating the evidence about an effect of a variable or intervention involving the summary of findings from a defined set of relevant and usable primary sources such as published papers (Marks and Skyes, 2003). Statistical methods may or may not be used to analyse and summarise the results of the included studies. The systematic reviews are the foundations for conducting research synthesis studies. More details on conducting a systematic review are presented in Box 12.

Box 12: Steps in conducting a systematic review

The systematic review is a structured research process which follows a systematic and logical process of conducting research. The stages in systematic reviews are described below:

1. Formulation of research problem, objectives and hypotheses

The research synthesis problem is selected from the topic in which a great deal of primary research was conducted and published data or papers available. The research problem should clearly indicate the topic and state its importance in the present context.

The researchers need to answer three questions about their research problems or hypotheses to decide on an appropriate research designs.

a) Should the results of the research be expressed in numbers or narrative?

b) What is the purpose of hypothesis – description, association or explanation?

c) Does the problem or hypothesis seek to understand how a process unfolds within an individual unit over time, or what is associated with or explains variation between units or groups of units?

The research synthesis studies employ a variety of techniques to aggregate descriptive data into quantitative terms, summarise results from studies conducted with a variety of research designs to generalise on association or causality among variables, and to estimate progressive effects or time-specific interactions among variables of interest.

2. Defining eligibility criteria for studies to be included and identifying them

The type of studies to be included in the analysis is determined based on the time interval, nature of research problem, specific topic, nature of relationships to be studied, and statistical estimates reported. The specific databases to be searched may also be specified and searched to collect eligible studies.

3. Assembling the dataset

Once the researchers have gathered the relevant literature, they must extract from each document those pieces of information that will help answer the questions that impel research in the field. The descriptive data, association and causality estimates are assembled into a master table which can be interpreted easily and also amenable for estimating synthesis coefficients

4. Analysing this dataset using statistical synthesis

Various analytical techniques for estimating effect sizes, fixed and random effects models, sensitivity analysis etc are performed to derive new insights into the compiled data.

Pantoja (2011) described three types of research synthesis methods based on their primary objective, and the type of studies and data primarily used by the specific synthesis method. According to him, the quantitative approaches are the methods that use numerical data or transform evidence into numbers to enable different types of statistical or logical analyses. The 'qualitative approaches' use text base data or transform other evidence into this form in order to generate conceptual and theoretical interpretations or explanations of a body of evidence. Finally in the mixed approaches are the methods that combine the findings of multiple studies of both qualitative and quantitative methods. More details on use of quantitative, qualitative and mixed methods are presented in Annexure 2.

6. Strategies for improving extension research in India

Extension is a unique discipline among social sciences as it has evolved from "field practices" that are implemented to improve the quality of life of rural communities. Thus, it is expected that research "outputs" of extension should contribute to improving the efficiency of an existing practice. However, the extension research has long distanced itself from contributing to improving the field practice. The chief reasons for this lacunae is the absence of theoretical research that develop knowledge and skills to guide the extension practice, inability to derive significant outputs from empirical research using appropriate "state-of-the-art methods", varying perceptions about extension research among research and extension managers and traditional and outdated extension curriculum which fails to integrate new perspectives based on emerging needs. In this context, extension research has to reinvent itself by integrating the following strategies to meet the demands of the complex situations in both at organisational and field levels.

Developing theories to address the emerging needs and sustain professional development

Theories are the life-line for any discipline, which aims to achieve high professional standards by contributing significantly for betterment of society. While several other disciplines consider theories as the pillars on which their subject matter is built upon, there is a widespread opinion among extension scientists and professionals that extension research should be "applied" in nature and therefore its focus should not be on developing theories and models that are purely academic. However, theories guide the growth of any discipline and the empirical research helps to improve generalizations of theories and enhance 'replicability' of the practices. Therefore, it is crucial for extension science to establish its own theories to sustain in the long-term. It is essential to practice the extension science is an applied, problem-oriented field, and 'scientific knowledge' (which includes theory) within extension should exhibit both 'scientific rigor' and the 'applied perspective' of the extension work.

Enriching methodological rigor of the extension research

Following good practices of conducting social research will help to derive accurate results. Competency, creativity and commonsense are few essential qualities to improve the methodological rigor of extension research. Though the text books provide detailed guidelines for carrying out research in an unbiased way, it is the duty of the researcher to manage the data generation situations creatively and skilfully to collect objective, unbiased and accurate data. There is a need to develop capacities of the young researchers and students of extension discipline on conducting quality research in unstructured settings. Though there are many national and state level Institutions for agricultural extension, they are mandated to improve field extension rather than extension research. The ICAR Sponsored Summer/Winter Schools and short courses are attractive options for the researchers to gather practical and useful knowledge in improving the methodological rigor. But the number of such courses is very limited. Moreover, there is dearth of programmes for developing competencies of the students in extension research. There is a need to organise research workshops and trainings for the students at cheaper rates to enable maximum participation. Integrating "right" research methods from various disciplines to address the field

problems while advancing knowledge, is the key for maximising the impact of extension discipline in the future. A list of advanced extension research methodology books and software is given in Annexure 3.

Developing mastery over multivariate analyses

The goal of scientific research is to identify the hidden patterns in the observed data to make generalisations on the phenomenon under study. The knowledge and use of statistics helps in this. Quantification of relationships among a social phenomenon provides several leads for further research, besides explaining the research questions under the study. In simple words, the mastery of statistics does not only improve the quality of the output, but also helps in conducting a sound empirical research and enhancing the probability of getting the output published in peer-reviewed high impact journals. There is a widespread perception among extension scientists that quantitative studies using statistics are theoretical in nature and that they do not lead to any meaningful interpretation. Using statistics is often perceived as a "suffix" phenomenon i.e. performing the statistical analysis after collecting the data. However, statistics provides us with the knowledge and tools for assessing complex natural phenomenon in a systematic and objective way. However, the extension curriculum is yet to integrate quantitative methods especially econometrics, multivariate statistics, experimental design and statistics, and psychometrics which are essential for equipping students with data analytical skills.

Review the role of professional societies in improving quality of extension research

The professional societies in extension education play a crucial role in fostering professional development in extension by creating opportunities for scientific interaction, facilitating quality empirical research through publishing, and networking of the researchers, academicians and extensionists for functional exchange of information, skill upgradation and technical cooperation. In India, most extension societies are fragmented on regional lines and focuses on a specific group of extension professionals. There is a need to consolidate these fragmented societies to provide a national outlook for the discipline of extension. It is a cumbersome process to be carried out based on consensus, and perhaps a national level agency such as ICAR or the Directorate of Extension, Ministry of Agriculture and Farmers' Welfare, (Government of India) should play a lead role in this task. Besides, there is a pressing need to improve the quality of research journals to compete with global standards. The focus should be on the quality of research publications rather than the quantity of published papers. Rigorous reviewing procedures, restricting the quantity of papers, and fostering a global outlook in the quality of publishing are essential to improve the extension research outputs in the country.

7. Conclusion

Extension research in India is currently not providing either fresh insights for extension policy or any guidance on the practice of extension. The review of articles published in two of the most important extension journals clearly revealed the current shortcomings in extension research. To improve the situation, alternative theories, models and methods are suggested in the research domains of adoption and impact studies, technology forecasting, attitude and belief measurement, perception and use of ICTs. The paper also suggests several measures to improve the methodological rigor in research, develop mastery over research and multivariate analyses, revamp curriculum to address emerging needs and energise professional societies to bring about professionalism in extension research and develop competent work force to deal with the new challenges facing extension in India. We sincerely hope some of these suggestions would be taken up by the students and teachers in extension and also the professional societies that exist in the name of strengthening extension in India.

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Annexure

Annexure 1: Measurement of Attitudes, Beliefs and Opinions

In general, the attitudes, beliefs and opinions are measured through explicit and implicit measures. The explicit or direct measures focus on the conscious attitudes of a person who can identify and express his/her feelings and evaluation of an object while the implicit or indirect approaches deal with evaluations that are triggered automatically when exposed to a stimuli without a person's awareness or ability to control them (Dovidio et al., 2002). Explicit measures of attitudes rely on self-report, where respondents report their own attitudes and behaviour through a telephone call, questionnaire or interview. Most explicit measures employ ordinal level of measurement for measuring the attitudes, beliefs and opinions.

A. Explicit or direct measures

The explicit or direct measures are traditionally based on the File drawer model (Wilson and Hodges, 1992). This model assumes that the attitudes exist within a person as stable metal files containing his/her evaluation of an object or person, and stored in a file drawer (memory). When people are asked how they feel about something, they retrieve it accurately from the memory without any modification (Wilson and Hodges, 1992). This stable and pre-existing attitude approach was later replaced with a comprehensive cognitive-contextual approach (Tourangeau and Rasinski, 1988) where the respondents first interpret the attitude question, and cobble together relevant beliefs and feelings to arrive at an appropriate judgment and response. Common explicit measures used in social science research include attitude scales, graphical scales, observations and unobtrusive measures.

Attitude scales

Attitude scales are constructed by combining several items on a specific aspect to form a scale, then to compute a single score for each respondent for the selected group of items (Oskamp and Schultz, 2005).The era of quantitative attitude measurement began with the development of Bogradus Social Distance Scale (Bogardus, 1925) in the 1920s. Since then, the attitude scaling has gained momentum and several scales are developed using classical test theory and recent Item Response Theory (IRT) approaches. The four popular and widely used scaling methods are Thurstone's method of equal-appearing intervals (Thurstone, 1928), Likert's method of summated ratings (Likert, 1932), Guttman's cumulative scaling (Guttman, 1944), and Osgood's Semantic Differential methods (Osgoodet al., 1957).

Other explicit measures like graphic or pictorial rating scales allow a respondent to rate an object by choosing any point on a graphical continuum. It is an extension of conventional response types simplified with graphics. Graphic scales are suitable for children and low literate groups. The Visual Analogue Scale (Hayes and Patterson, 1921) is a popular extension of rating scales, which presents a line (usually 10 cm in length) representing semantic labels on either side of the line and the respondents mark a point on the line that best reflects their degree of attitude or experience of a physiological reactions like hunger, pain etc. Feeling Thermometers are graphical scales used in public opinion research (where respondents indicate their attitude on a scale of degrees ranging from 0° (Very cold) to 100° (Very warm), with 50° representing no feelings. Feeling thermometers are often used to understand gender roles and opinions on environmental issues (Price and Bohon, 2012).

As these scale construction approaches are well known and widely used in extension research, only few good practices or recent advances in attitude scale construction are discussed

Good practices in attitude scale construction

The attitudes scales are constructed following a three stage approach: (i) Specifying goals of the measures and formulate theoretical assumptions that guide its construction (ii) Generating a pool of potential items for measuring a specific construct, and (iii) Evaluating items for their relevance and potential and selection (Wegener and Fabrigar, 2004). The following are few guidelines for improving the practice of attitude scale construction at different stages.

(i) Specifying goals of the measures and formulate theoretical assumptions

At the beginning of the scale constructing process, it is essential to specify the domain, population and context the attitude scale intends to measure. Precisely, the researcher has to indicate if he/she wishes to develop general measures of attitude that can be used across various attitude objects (e.g. developing a scale to measure the entrepreneurial orientation of all categories of the farmers) or design measures for a single attitude object or a specific class of attitude objects? (e.g. scale to measure attitudes of pig owners towards Tail Biting and Tail Docking) (Wegener and Fabrigar, 2004). Specifying domains is a critical aspect in extension as majority of extension research reported in the extension journals are conducted in academic settings under time and resource constraints. Since generalizability of research across domains is the key factor for the progress of any professional discipline, it is essential to develop measures that can be used for various attitude objects across domains.

Since the measurement is interdependent on specific theories, there is a need to formulate theoretical assumptions while constructing scales (Wegener and Fabrigar, 2004). For example, self-report measures of attitude and beliefs are based on the assumption that people possess different levels of these attributes and are competent enough to report them corresponding to their actual levels. If a researcher foresees that these assumptions will be violated, then he/she may choose an alternate method of measuring the attitudes. For example, measuring school children's attitude towards computer based exams using a traditional Likert scale may result in inaccurate results as the children may not comprehend the response pattern and also face difficulties in quantifying their attitudes for the response type specified.

(ii) Generating a pool of potential items for measuring a specific construct

Using single-item measures are often discouraged due to issues related to reliability and validity (DeVellis, 2003). However, there are instances where single item measures are used to measure attitude or opinion like in exploratory studies or under resource and time constrained situations. Recent research indicates that well-defined single items measures can produce valid results when used in studies conducted with small samples (less than 50) and with weaker effect sizes (Stebbins, 2001; Diamantopouloset al., 2012).

In attitude scales, the respondents usually rate items on a unipolar or bipolar scale containing 5, 7 or 10 points. In general, a rating scale with many scale points can easily capture differences in the construct measured (Wegener and Fabrigar, 2004). However, recent studies (Krosnick and Fabrigar, 1997; Dawes, 2008) found that 5- or 7-point scales are likely to produce reliable scores than a 10-point scale.

The order of response options can influence the likelihood of selecting those options (Krosnick and Fabrigar, 1997) leading to primacy effect or serial position effect i.e. selecting earlier options than later options, and recency effect (remembering best the items that are placed at the end of the list) of choosing later options. Other biases include central tendency bias (avoiding extreme categories), acquiescence bias or "yea-saying" (agreement with the statements as presented), social desirability bias (agree with socially acceptable items) (Zickar and Gibby, 2006),"halo" and "horn" effects (over-generalized view of the rated person based on his/her performance on a single dimension) (Murphy et al., 1993). Presenting items in a forced-choice from or in blocks will help to eliminate these biases (Oskamp and Schultz, 2005).

(iii) Evaluating items for their relevance and potential and selection

Item evaluation is a critical component of attitude scale construction which employs several methods like judges' rating, item-descriptive statistics, item to total correlations and factor analysis.

The judges' rating is a popular method used in extension, where the experts rate the items on either "favourable – unfavourable" or "most important – least important" scales to identify relevant ones for inclusion in the final scale. It is also used as a measure of face validity or content validity. The index of item-objective congruence measure (Rovinelli and Hambleton, 1977) is an alternative to judge's rating for selecting attitude items. In this method, the content experts assess individual item by the extent to which it clearly measures the construct. If they perceive that an item clearly measures a construct, they assign a score of +1, while the items that are not clearly measuring are assigned or the degree to which it measures the content area is unclear, are assigned scores of -1 and 0 respectively. After the experts completed the evaluation, the ratings were combined to provide indices of item-objective congruence values for each item on each objective.

Item descriptive statistics also reveal problematic items which pose threats to reliability and validity. Discarding items having means score near end points of the scale and smaller variance are suggested since they are unlikely to differentiate the respondents (Wegener and Fabrigar, 2004). Item to total correlation is computed to assess the ability of an item to have unique nature besides contributing to the latent variable. It also indicates the discrimination power of the item to differentiate high and low scoring respondents (Nunnally and Bernstein, 1994).

Exploratory factor analysis (EFA) is widely used method to identify the latent constructs (factors) and to assess the contribution of each item to the identified factor. It helps to identify if the scale is one-dimensional or multi-dimensional based on the items selected to represent the construct(s). Using the factor loadings, magnitude of factor-item associations is computed and the poorly loaded items are eliminated. The extension researchers often use the Principal Component Analysis (PCA) for selection of items for an attitude scale. EFA computes shared variance among the variables by separating common variance from unique variance, while PCA is estimates only total variance (Parket al., 2002). Since attitude scales are constructed using items which have both unique and common characteristics, EFA is the most appropriate technique for measurement of attitudes. While using EFA, employing Maximum Likelihood factor extraction along with Promax rotation is ideal for social science research. Varimax, quartimax, andequamax are commonly available orthogonal methods of rotation while direct oblimin, quartimin, and promax are oblique rotations.

Orthogonal rotations produce factors that are uncorrelated while the oblique methods allow the factors to correlate. Since the social science variables are often related and exhibit some correlation, the oblique methods are preferred (Costello and Osborne, 2005).

In the recent years, Confirmatory Factor Analysis (CFA) is increasingly used for item analysis for attitude scale construction. The factor structure identified in EFA is tested through CFA by specifying exact relations between items and factors. The CFA also helps to estimate construct validity, convergent and discriminant validity and composite reliability, which are either cumbersome or impossible to estimate through conventional methods. A recent work by Sivakumar et al., (2014) demonstrates the utility of CFA in developing a scale to measure the computer use behaviour of extension personnel. Statistical software like SAS (PROC CALIS procedure), AMOS, LISREL are widely used for Confirmatory Factor Analysis.

Using EFA and CFA for attitude scale construction eliminate the need for conducting pre-testing to estimate reliability and validity. As discussed above, various measures of reliabilities (Composite reliability) validity (Convergent and discriminant validity) can be estimated using the CFA which eliminates the need to run the analysis for calculating these coefficients.

One of the emerging approaches for item analysis is the Item Response Theory (IRT), which examine relationship between the respondents' place on a latent construct and the probability of choosing a particular response (Wegener and Fabrigar, 2004). Whereas classical test theory focuses on the scale as a whole, item response theory shifts its focus to the individual items. An individual's ability and probability of selecting a response is estimated through following methods (Psychometrictest.org.uk, 2015):

- Rasch Model - The one parameter logistic model (1PL) uses item difficulty as a only parameter for calculating a person's ability.

- The two parameter logistic model (2PL) uses both item difficulty and item discrimination as parameters.

- The three parameter logistic model (3PL) uses item difficulty, item discrimination and the extent which candidates can guess the correct answer, as parameters.

The IRT eliminates various drawbacks of the classical test theory like additive response (adding all responses of a scale together for computing a score) and ordinal bias (treating ordinal variables as interval).The IRT approach treats ordinal variables as ordinal and the IRT approach estimate boundaries between the response categories rather than assuming that they are equidistant (Oskamp and Schultz, 2005).

Evaluating quality of attitude measures – Reliability and validity

Reliability

Reliability refers to the consistency of measurement. From a measurement perspective, reliability is the proportion of variance that can be attributed to true scores rather than random error (Wegener and Fabrigar, 2004). The reliability is assessed through internal consistency using split-half method, alternate-form agreement, and the alpha coefficient of internal homogeneity of items (Cronbach, 1984), stability (test-retest correlations) and equivalence reliability (Wegener and Fabrigar, 2004).

The popular index of internal consistency reliability is Cronbach Alpha (Cronbach,

1984), which is primarily a split half method repeated several times. Though Alpha is a widely used index of internal consistency, it is influenced by the numbers and inter-relationships among items (John and Benet-Martinez, 2000). The Alpha value increases with addition of every new item to the scale. Since Alpha doesn't indicate unidimentionality of the scale, Exploratory Factor Analysis or Confirmatory Factor Analyses are necessary.(Wegener and Fabrigar, 2004). It is evident from our initial analysis that most extension research papers didn't report any indices of reliability and validity indicating poor ways of constructing attitude scales.

"Test-retest" reliability is assessed by computing Pearson correlation between two different administrations of a same measure. Though this approach is popular among attitude researchers, its efficacy is contingent upon the constructs theoretical stability over time (Wegener and Fabrigar, 2004). For example, the extension concepts like empowerment, food, nutritional and livelihood security are dynamic concepts which changes with context, location and time. Though extension researchers attempt to develop composite scales by integrating meanings across contexts and time, this approach will lead to potential danger of piling up irrelevant scales that are incompatible with social systems.

Validity

Validity means accuracy or correctness of measurement. Various forms of validity include (i) content validity - items fully represent the construct; (ii) face validity – items appear to measure the construct of interest; and (iii) criterion validity -ability of the measure to predict or correlate with related constructs (Wegener and Fabrigar, 2004). Two major forms of validity include (a) Associative – items associated with constructs or outcomes that are predicted by the specific theory and (b) dissociate forms which distinguishes a construct from others.

The associative forms of validity are assessed by their correlation with alternate measures of the same construct (Convergent validity), concurrent correlations with related constructs (Convergent validity) and correlations with antecedents and consequences of the construct (predictive validity) (Wegener and Fabrigar, 2004). In dissociate forms, a concept is not associated with unrelated constructs, it is termed as divergent validity. Recent advances in Exploratory and Confirmatory Factor Analyses can help to estimate these validities from the existing model data.

B. Implicit or indirect measures

Since the early 1990s, a sizable amount of research has begun to examine implicit attitudes—automatic evaluations that occur without conscious reflection and are not necessarily available for introspection or control (Fazio, 1990; Banaji and Bhaskar, 2000; Ottaway et al., 2001). Methodologies used to measure implicit attitudes: reaction time, priming, and the Implicit Association Test. Despite their objectivity and popularity, the extension research system has not utilised implicit measures of measuring attitudes, beliefs and opinions.

(i) Reactions to partially structured stimuli – Projective techniques

In projective tasks, respondents are presented with an ambiguous image and asked to elaborate on what they see, and the task is presented as a measure of imagination or social sensitivity rather than of their attitude. Because the scoring of the resulting responses is often subjective without numerical values, there are serious issues with their validity and reliability.

(ii) Physiological reactions

A second type of indirect measure that

is useful for measuring attitudes utilizes physiological reactions. This approach is based on the principle that people have different physiological responses to stimuli that they like (or agree with) than to stimuli that they don't like (or don't agree with). In these tasks, respondents are exposed to a stimulus about which they may have an attitude, and measures are obtained of arousal (heart rate, blood pressure), tiny muscle movements in the face electromyography (EMG) (McHugoet al., 1991) or electrical activity in the brain (ERP) (Ma et al., 2015). Much of the early research utilizing physiological measures found that stronger attitudes were positively correlated with physiological measures of arousal, but that these physiological measures were unable to determine the positive or negative direction of a person's attitude. However, more recent studies using EMG measures of facial movements and ERPs in a series of exposures to different objects have been able to discern both direction and strength of an attitude.

(iii) Priming

Assess existing attitudes by presenting participants with a stimulus (pictures or words) and assessing the degree to which the stimulus activates positive or negative reactions. This procedure is known as affective priming. In the priming studies, stimuli (most often words or pictures) are presented to the participants who are asked to complete a simple task after that. One classical study examined women's attitudes towards the gender-stereotyped domains of arts (positively stereotyped) and mathematics (negatively stereotyped) using affective priming (Steele and Ambady, 2006).

(iv) Implicit Association Test (IAT)

A widely used measure, which is based on associative network principles, is the IAT. It requires respondents to make many quick associations between evaluative dimensions (e.g., good-bad) and attitude categories (e.g., George W. Bush-Al Gore). The difference in average reaction time for incompatible versus compatible pairings is used to indicate the direction and strength of the attitude. The Environmental Attitudes Inventory which measures the attitude towards natural environment was developed through IAT (Milfont and Duckitt. 2010).

Annexure 2: Methods of Research Synthesis

A. Quantitative approaches

Meta-analysis

Meta-analysis is a statistical synthesis of the data from primary studies, where the weights assigned to each study are based on mathematical criteria that are specified in advance. The meta-analysis use data from several different studies and produces a single estimate of the effect usually a treatment or specific variable. It is a most popular synthesis method in the systematic reviews. Meta-analysis is used when (i) more than one study has estimated the effect of an extension intervention or of a factor, (ii) when there are no differences in participants, interventions and settings which are likely to affect outcome substantially, (iii) when the outcome in the different studies has been measured in similar ways, and (iv) when the necessary data are available.

The meta-analysis produces three estimates such as (i) a pooled estimate and confidence interval for the treatment effect (e.g. effectiveness of multimedia instruction) after combining all the studies, (ii) indicates whether the treatment or other factor effect is statistically significant or not , and (iii) a test for heterogeneity of the effect on outcome between the included studies. The meta-analytical study (Hakikit, 2014) begins with the (i) defining the objectives, (ii) systematic searching and identifying eligible studies, (iii) assessing the quality of studies for eligibility using explicit and objective criteria for inclusion or rejection, (iv) extracting data from selected studies and estimating the effect sizes using mean difference, risk ratio, odd ratio, correlation, standardized regression coefficients etc, (v) selecting an effect model (either fixed or random effect model) for analysis, and (vi) presenting results with forest plots, heterogeneity estimates and meta-regression results. A meta-analytic study on returns to research investment of IFPRI (Alston et al., 2000) is a classical example of research synthesis in social sciences.

Range of effect sizes approach

This approach is also called as “medians of medians approach” which uses the median of effects reported by studies and provides a way of quantifying the effects of interventions without making numerous assumptions (Pantoja, 2011). It is a two-stage process that begins with the identification of the median effect across each study’s eligible outcomes. Once all the median effects of eligible studies are identified, the inter-quartile range across all included studies is calculated.

Vote counting

In the vote counting methods, eligible studies are classified into three categories based on the relationship of the specific variables of interest such as (i) the relationship is statistically significantly positive, (ii) the relationship is statistically significantly negative and (iii) no discernible relationship. The selected studies were classified among these three categories and the class with highest frequency of studies is declared winner. This method is not popular among researchers as it fails to estimate the effect size of an intervention and also ignores the precision of the estimate from the primary comparison (giving equal weight to comparisons with 100 or 1000 participants) (Pantoja, 2011). The vote counting procedure for research synthesis was successfully applied to estimate the effects of farming systems and fertilisers on pests and natural enemies (Garratt et al., 2011).

Narrative summary

A narrative summary involves the selection, chronicling, and ordering of evidence of relationships of a phenomenon to produce detailed and comprehensive view of it (Dixon-Woods et al., 2005). Narrative summaries are often used in systematic reviews, when meta-analysis is not found appropriate. The narrative summaries range from simple recounting (as used in many systematic reviews) to a more interpretive and reflexive approach involving higher levels of abstraction (Narrative synthesis).

B. Qualitative approaches

Meta-ethnography

Meta-ethnography is a method for synthesizing multiple qualitative research reports that works with metaphors or concepts as the unit for synthesis (Pantoja, 2011). Three different methods of synthesis are used in meta-ethnography (Barnett-Page and Thomas, 2009).

- Reciprocal translational analysis - In this approach, the concepts are translated from individual studies into one another to produce overarching concepts or metaphors.
- Refutational synthesis – This approach involves exploring and explaining contradictions between individual studies.
- Lines-of-argument synthesis – This approach involves building a larger picture from studies from its parts.

The meta-ethnography is a valuable method for policy-makers as it can explain them a comprehensive view of the problem derived from seemingly divergent quantitative and qualitative study findings

Thematic analysis

Thematic analysis involves identifying prominent or recurrent themes in the literature and summarising the findings of the different studies under thematic headings. Summary tables, providing descriptions of the key points, can then be produced (Mays et al., 2001). This analysis combines and adapts approaches from both meta-ethnography and grounded theory. Harden et al., (1999) followed thematic analysis approach to synthesize the experiences of health promotion to assess their effectiveness.

Narrative synthesis

In narrative synthesis, the researcher synthesizes the evidence relevant to a wide range of questions that relies primarily on the use of words and text to summarise and explain findings of multiple studies in the form of a story. The narrative analysis is primarily a text based approach, which may also involve statistical manipulation. Mayrhofer et al., (2014) employed narrative analysis for identification of accident scenarios and causes of agricultural occupational accidents in Australia.

Meta-narrative review

The Meta-narrative review is a relatively new method of systematic review, designed for topics which have been differently conceptualised and studied by different groups of researchers (Greenhalgh and Wong, 2013). For example, impact assessment is a diverse concept which ranges from increase in output per unit area to beneficiary empowerment. In this approach, the eligible studies are critically analysed and summarised in an over-arching narrative, by highlighting what the different research teams might learn from one another's approaches. Poole et al., (2013) used meta-narrative approach to present a critique of commercialising smallholder farming for agriculture in Sub-Saharan Africa.

Qualitative comparative analysis

A research analysis technique is a qualitative method for analysing complex causal connections using Boolean logic to explain pathways to a particular outcome (Ragin, 1987). In this method, the data sets are analysed by listing and counting all the combinations of observed variables, and then applying the rules of logical inference to determine which descriptive inferences or implications the data supports.

C. Mixed-methods approaches

Realist synthesis

A Realist Synthesis is the synthesis of evidence that seeks to identify underlying causal mechanisms and explore how they work under what conditions, answering the question "What works for whom under what circumstances?" rather than "What works?". Realist synthesis is a theory-driven approach aims to explain the mechanisms of success or failure of a development intervention. Cole et al., (2012) employed realistic synthesis approach for assessing an index based microfinance system to help small farmers to mitigate weather-related risks.

EPPI-Centre approach

This synthesis begins with stating a broad review question from which separate questions are developed. The sub-questions may focus on effectiveness, appropriateness, barriers and enablers to implementation, and the perspectives of the group targeted by the intervention. After deriving answer for each sub-question, are then combined in a 'meta-synthesis' form.

Annexure 3.Extension Research Methods Resources

Few books and software for conducting advanced extension research are listed below:

Title	*Authors*	*Publishers*
Foundations of Behavioral Research	F N Kerlinger and HB Lee	Harcourt College Publishers; 2009
Psychometric Theory (Third edition)	Jum Nunnally and Ira Bernstein	Tata McGraw-Hill Education; 2010.
Introduction to Psychometric Theory	Tenko Raykov and George A. Marcoulides	Routledge; 2010
Attitude Measurements in Science Education: Classic and Contemporary Approaches	Myint Swe Khine	Information Age Publishing, Charlotte, USA; 2011
Internet Research Methods (Second Edition)	Claire Hewson, Carl Vogel and Dianna Laurent	SAGE Publications Ltd; 2015
The SAGE Handbook of Action Research (Third Edition)	Hilary Bradbury	SAGE Publications Ltd; 2015
Doing Social Network Research: Network-based Research Design for Social Scientists	Garry Robins	SAGE Publications Ltd; 2015
Analyzing Social Networks	Stephen P Borgatti, Martin G Everett, Jeffrey C Johnson	SAGE Publications Ltd; 2013.
Visual Methods in Social Research (Second Edition)	Marcus Banks and David Zeitlyn	SAGE Publications Ltd; 2015
Discourse and Narrative Methods: Theoretical Departures, Analytical Strategies and Situated Writings	Mona Livholts and Maria Tamboukou	SAGE Publications Ltd; 2015.
A Concise Introduction to Mixed Methods Research	John W. Creswell	SAGE Publications Ltd; 2015.
Experimental Design and Analysis for Psychology	Herve Abdi, Betty Edelman, Dominique Valentin and W. Jay Dowling	Oxford University Press; 2009.
Qualitative Text Analysis: A Guide to Methods, Practice and Using Software	Udo Kuckartz	SAGE Publications Ltd; 2014.
Digital Tools for Qualitative Research	Trena Paulus, Jessica Lester and Paul Dempster	SAGE Publications Ltd; 2014.
The SAGE Handbook of Qualitative Data Analysis	Uwe Flick	SAGE Publications Ltd; 2013.
Qualitative Data Analysis with NVivo (Second Edition)	Patricia Bazeley and Kristi Jackson	SAGE Publications Ltd; 2013.

Analyzing Quantitative Data: Variable-based and Case-based Approaches to Non-experimental Datasets	Raymond A Kent	SAGE Publications Ltd; 2015.
Basic Econometrics (Fifth Edition)	D Gujarati and D Porter	McGraw-Hill Education; 2008.
Multivariate Data Analysis (Seventh edition)	Joseph F. Hair Jr, William C. Black, Barry J. Babin, Rolph E. Anderson	Pearson New International Edition, Prentice Hall; 2009.
Discovering Statistics using IBM SPSS Statistics (Fourth Edition)	Andy Field	SAGE Publications Ltd; 2013.
IBM SPSS for Intermediate Statistics: Use and Interpretation (Fourth Edition)	Nancy L. Leech, George A. Morgan and Karen C. Barrett	Routledge; 2011.
Principles and Practice of Structural Equation Modeling, (Third Edition)	Rex B Kline	The Guilford Press; 2010.
Practical Nonparametric Statistics (Third Edition)	W J Conover	Wiley; 1999.

Software

General statistical analysis - IBM® SPSS® Statistics (Ver. 23), SAS (Ver 9.4), STATA (Ver 14), MINITAB (Ver 17), R-3.2.2 (Open source)

Structural Equation Modeling–IBM SPSS AMOS (Ver. 22), LISREL (Ver. 9.1)

Item Response Theory- IRTPRO 2.1, BILOG-MG, MULTILOG, PARSCALE

Qualitative data analysis– Nvivo, ATLAS.ti, CAT (Open source)

Several free software for statistical analysis are listed inhttp://statpages.org/javasta2.html.