

**Towards Enabling Externalization of Tacit  
Knowledge Using Mobile Phone: The Case of  
Farmers Research Group in Ethiopia**

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## Abstract

### Towards Enabling Externalization of Tacit Knowledge Using Mobile Phone: The Case of Farmers Research Group in Ethiopia

The purpose of this study was to explore mechanisms of tacit knowledge externalization and factors impacting the process, to propose a conceptual framework and system architecture that support the development of mobile-based tacit knowledge externalization platform. A multi-methodological approach to IS research combining exploratory qualitative case study method and system development approach was followed to conduct the study. Data was collected through an in-depth semi-structured interviews and focus group discussion with 22 respondents, i.e., 14 multi-disciplinary agricultural researchers and extension agents and 8 farmers. Data was analyzed through thematic coding and thematic analysis which resulted in identifying unique patterns.

The finding of this study revealed that the dominant forms of tacit knowledge articulated include skill, experiences, expertise and rules-of-thumb from low degree of tacitness/abstraction; and judgments, insights, practical intelligence and indigenous knowledge from medium degree of tacitness/abstraction. The data didn't support taxonomies of tacit knowledge with high degree of abstraction. The study also revealed that metaphor, storytelling, dialogue, apprenticeship or mentoring, experimentation and evaluation, observation, learning by doing, lessons learnt, modeling technique, asking question, localization and on-farm demonstration were major mechanisms used for externalizing the stated taxonomies of tacit knowledge. As opposed to one-to-one relationship proposed by prior studies, our study revealed that one mechanism can be used to externalize tacit knowledge with different degrees of tacitness. The study further revealed that externalization process is influenced by level of cognitive competence, social capital, communication skill/method/media, group heterogeneity, motivational factors, degree of complexity, distance compounded with poor physical infrastructure and resource constraint. Finally, the conceptual artifacts derived in theory building were used as a basis for proposing a three tire system architecture for mobile based tacit knowledge externalization platform called *mPlatform*.

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LIST OF FIGURES.....	viii
LIST OF TABLES.....	ix
<b>CHAPTER ONE:1INTRODUCTION .....</b>	<b>1</b>
1.1. Background .....	1
1.1.1. Taxonomies of Knowledge .....	2
1.1.2. Tacit Knowledge and Its Taxonomies .....	2
1.1.3. Tacit Knowledge Externalization .....	6
1.1.4. The Role of ICT in Tacit Knowledge Externalization .....	10
1.2. Motivation of the Study .....	13
1.3. Statement of the Problem .....	19
1.4. Objective of the Study .....	25
1.5. Theoretical Framework .....	25
1.6. Research Methodology.....	30
1.6.1. Research Design .....	30
1.6.2. Selection of Research Case and Research Sites .....	32
1.6.3. Data Collection .....	33
1.6.4. Data Analysis .....	35
1.6.5. Design Science Research Principle.....	35
1.7. Significance of the Study .....	36
1.8. Scope of the Study .....	38
1.9. Organization of the Thesis .....	39
<b>CHAPTER TWO: LITERATURE REVIEW.....</b>	<b>41</b>
2.1. Knowledge .....	42
2.1.1. Definition of Knowledge .....	42
2.1.2. Taxonomies of Knowledge .....	43
2.2. Tacit Knowledge .....	44
2.2.1. Definition of Tacit Knowledge .....	45
2.2.2. Taxonomies of Tacit Knowledge .....	47
2.2.3. Roles of Tacit Knowledge .....	51
2.3. Tacit Knowledge Externalization: Definition, Controversies, Mechanisms and Factors ...	54
2.3.1. Tacit Knowledge Externalization – Definition .....	54
2.3.2. Controversies in Tacit Knowledge Externalization .....	55
2.3.3. Mechanisms of Tacit Knowledge Externalization .....	67
2.3.4. The Role of Collaboration and Social Interaction .....	78
2.3.5. Factors Affecting Tacit Knowledge Externalization Process .....	79
2.4. ICT and Tacit Knowledge Externalization .....	90
2.4.1. Introduction .....	90
2.4.2. The Role of ICT in Tacit Knowledge Explication and Sharing .....	92
2.4.3. The Potential of Mobile Phone .....	96
2.5. Review of Related Works .....	98
2.6. Summary .....	109

<b>CHAPTER THREE: METHODOLOGY .....</b>	<b>116</b>
3.1. Why Qualitative Study .....	116
3.2. Research Design .....	117
3.3. Selection of Research Sites and Respondents .....	123
3.4. Description of Research Context .....	127
3.5. Data Collection .....	131
3.6. Data Analysis .....	134
3.6.1. Preliminary Steps in Coding Process .....	135
3.6.2. Thematic Coding and Thematic Analysis .....	136
3.7. Design Science Research Principles .....	141
3.8. Validity .....	146
<b>CHAPTER FOUR: DATA PRESENTATION AND ANALYSIS .....</b>	<b>150</b>
4.1. Taxonomies of Tacit Knowledge .....	150
4.1.1. Low Degree of Tacitness .....	152
4.1.2. Medium Degree of Tacitness .....	154
4.2. Mechanisms of Externalizing and Sharing Tacit Knowledge .....	160
4.3. Factors that Impact Externalization and Sharing of Tacit Knowledge .....	174
4.3.1. Creating Interactive Platform .....	175
4.3.2. Disparity in Cognitive Competence or Knowledge Capability .....	179
4.3.3. Social Capital Factors .....	182
4.3.4. Communication Skill, Method and Media .....	191
4.3.5. Group Heterogeneity .....	194
4.3.6. Motivational Factors .....	197
4.3.7. Degree of Complexity in Knowledge Being Articulated and Shared .....	199
4.3.8. Model Farmers as Knowledge Intermediaries .....	202
4.3.9. Resource and Infrastructure Problem .....	203
4.4. Summary .....	205
<b>CHAPTER FIVE: FINDINGS AND DISCUSSIONS .....</b>	<b>208</b>
5.1. Taxonomies of Tacit Knowledge .....	209
5.1.1. Low Degree of Tacitness .....	210
5.1.2. Medium Degree of Tacitness .....	211
5.2. Mechanisms of Externalizing Tacit Knowledge .....	214
5.3. Factors that impact Externalization and Sharing of TK .....	227
5.3.1. Creating Interactive Platform .....	227
5.3.2. Disparity in Cognitive Competence or Knowledge Capability .....	229
5.3.3. Social Capital Factors .....	232
5.3.4. Communication Skill, Method and Media .....	239
5.3.5. Group Heterogeneity .....	241
5.3.6. Motivational Factors .....	242
5.3.7. Degree of Complexity .....	244
5.3.8. Resource and Infrastructure Problem .....	245
5.4. Framework for Tacit Knowledge Externalization .....	247

<b>CHAPTER SIX: SYSTEM ARCHITECTURE FOR MOBILE - MEDIATED TACIT KNOWLEDGE EXTERNALIZATION .....</b>	<b>249</b>
6.1. Rationale for Proposing M-Application .....	249
6.2. Current Uses of Mobile Phone in Participatory Research .....	251
6.3. Current Challenges in Capturing of Externalized Tacit Knowledge .....	253
6.4. Requirements for ICT Support .....	254
6.5. Design of System Architecture .....	257
6.5.1. Interaction Scenario and Existing Problems .....	258
6.5.2. System Requirement for mPlatform .....	264
6.5.3. Systems Architecture for mPlatform .....	269
6.5.4. Implementation strategy .....	277
6.6. Validation of Theoretical Framework and Architecture .....	279
<b>CHAPTER SEVEN: CONCLUSION .....</b>	<b>284</b>
7.1. Summary of Findings .....	284
7.2. Contribution of the Study .....	297
7.2.1. Contribution to Theory .....	297
7.2.2. Contribution to Practice .....	300
7.3. Recommendation .....	303
7.4. Limitation of the Study .....	307
7.5. Future Research .....	308
REFERENCES .....	310
APPENDIX – I: KEY INTERVIEW QUESTIONS FOR RESEARCHERS AND EXTENSION WORKERS ....	326
APPENDIX – II: KEY QUESTIONS FOR FOCUS GROUP DISCUSSION WITH FARMERS .....	328
APPENDIX – III: KEY INTERVIEW QUESTIONS FOR HEADS OF OFFICES .....	329
APPENDIX – IV: DOCUMENTS REVIEWED .....	330
APPENDIX – V: RESPONDENTS’ PROFILE .....	331
APPENDIX – VI: MAJOR THEORETICAL CONCEPTS OR ANALYTICAL UNITS.....	332
APPENDIX – VII: LETTER OF VERIFICATION FOR TRANSLATED and TRANSCRIBED INTERVIEW TRANSCRIPT .....	333

## LIST OF FIGURES

Figure 1.1: Proposed Research Framework for Tacit Knowledge Externalization .....	29
Figure 2.1: Characterizations of Tacit Knowledge Made by Polanyi and Knowledge Management Authors.....	59
Figure 3.1: A Process for Systems Development Research Adopted from Nunamaker, et al. (1991).....	144
Figure 5.1: Analytical Framework for Chapter 5.....	209
Figure 5.2: Farmers' Resource Mapping Activity (Bedru, et al., 2009).....	224
Figure 5.3: Tacit Knowledge Externalization Framework for Participatory Agricultural Innovation System.....	247
Figure 6.1: mPlatform Architecture for Tacit Knowledge Externalization.....	271
Figure 6.2: A hybrid of Centralized and Distributed Network Architecture for mPlatform.....	277

## LIST OF TABLES

Table 1.1: Relationship between Degree of Tacitness, Mechanisms of Tacit Knowledge Externalization and Level of Media Richness.....	28
Table 2.1: The Difference between Explicit and Tacit Knowledge.....	44
Table 2.2: Summary of Tacit Knowledge Externalization Mechanisms.....	111
Table 2.3: Summary of Determinant Factors.....	113
Table 3.1: Summary of Methods to Conduct Rigorous Qualitative Analysis.....	138
Table 4.1: Summary of Empirically Supported Mechanisms of Tacit Knowledge Externalization.....	174
Table 4.2: Summary of Empirically Supported Determinant Factors.....	204
Table 5.1: Mapping Externalization Mechanism to Tacit Knowledge with Different Degrees of Tacitness.....	227
Table 5.2: Mapping the impact of factors to different externalization mechanisms.....	246
Table 6.1: Purpose of Use of Mobile Phone in FRG Related Projects.....	251
Table 6.2: Summary of excerpts on requirements for ICT and Infrastructure.....	256
Table 6.3: Interaction Scenarios and Associated Problems in Participatory Agricultural Research System.....	259
Table 6.4: Functional Requirements of mPlatform .....	265

# CHAPTER ONE

## INTRODUCTION

### 1.1. Background

In today's economy, knowledge is the most valuable resource to develop new technology and new products, to increase efficiency of processes and quality of products, to sustain competitive advantage and to increase individual's domain expertise and their work performances (Chou and Chang, 2008; Jun and Weiguo, 2008). Knowledge as a critical resource serves not only the high tech industries and the service sector but it is also a critical input for enhancing sustainable agricultural development and food security (Mangstl, 2008). It is considered as a source of wealth creation and exploitation (Merx-Chermin and Nijhof, 2005) and a powerful driving force for sustainable economic and social development (Wang, 2012).

Knowledge is defined as a mix of framed experience, important values, contextual information, and expert insight (Davenport and Prusak, 1998); as information combined with experience, context, interpretation and reflection (Alavi and Leinder, 2001) and as a justified true belief (Nonaka 1994). Knowledge is embedded in human actions and interactions (Jakubik, 2008). It is demonstrated in terms of performing skillful action and enabling humans to define, prepare, shape, and learn to solve a task or problem (Nonaka and von Krogh, 2009).

### **1.1.1. Taxonomies of Knowledge**

The most popularized taxonomy of knowledge is explicit and tacit. Explicit knowledge is defined as formal and systematic knowledge that can be easily articulated in the form of text, diagrams, and product specifications and presented in the form of reports, documents, and manuals (Sunassee and Sewrya, 2002; Chou and Chang, 2008; Smuts, et al., 2009). Technology related knowledge like that of agricultural researchers is characterized by Puri (2007) as explicit, considered universally applicable, rational, analytical, objective, codifiable, and hence transferable. Such knowledge arises from researchers' educational background and their institutional practices (Puri, 2007). Therefore, new technologies including new varieties, implements, methods, etc., generated by agricultural researchers, are classified under explicit knowledge. Knowledge is also possessed in the mind of individuals which is related to facts, procedures, concepts, interpretations, ideas, observations, and judgments (Alavi and Leidner, 2001) which are either tacit knowledge or rooted in tacit knowledge (Alwis and Hartmann, 2008).

### **1.1.2. Tacit Knowledge and Its Taxonomies**

Tacit knowledge, which is the subject of the study, is a form of knowledge that is embedded in the human mind, non-codified, difficult to articulate, subconsciously understood and applied, developed from direct experience and action and usually shared through highly interactive conversation, storytelling and shared experience (Al-Qdah and Salim, 2013, Nonaka, 1994; Nonaka and Takeuchi, 1995; Nonaka and Konno 1998). It takes the form of experience, know-how, skills, expertise, best practices, values, ideas, feelings, emotions, insights, judgments, beliefs and cognition (Zhang, et al., 2012;

Wang, 2012; Wu, et al., 2010; Puusa and Eerikäinen, 2008; Alwis and Hartmann, 2008; Zhu, et al., 2007; McAdam, et al., 2007; Ambrosini and Veronique, 2001; Nonaka, 1994; Nonaka and Takeuchi, 1995; Nonaka and Konno 1998). It is developed from direct experience and action; and usually shared through highly interactive conversation, storytelling and shared experiences. It constitutes technical dimensions – know-how, crafts, skills that apply to specific contexts; and cognitive dimensions – mental models or schemata, paradigms, beliefs and viewpoints that provide perspectives that help individuals to perceive and define their world (Nonaka, 1994).

Indigenous knowledge is a form of tacit knowledge acquired by local communities through the accumulation of experiences, informal experiments, and intimate understanding of the environment in a given culture (Puri, 2007). It may be informally expressed in local customs, experience, technology, and wisdom (Ibid.). The understanding these communities have of their land—its layout, topography, cropping patterns, location of water bodies, the local drainage pattern and much more—is referred to as indigenous knowledge (ibid.). It is context-specific and embedded in the everyday practices of the members of a community.

The working definition of tacit knowledge for the study is therefore:

*It is a form of knowledge which is –rooted in individuals’ and collective practices, experiences, technical know-how, skills, and embodied expertise; developed from direct experience and action; local or context-specific; shared through highly interactive conversations, reflections, narratives, metaphors, shared experiences, observations, imitation, etc.*

Tacit knowledge is categorized into different classifications based on degree of tacitness or the extent to which tacit knowledge can be articulated. Certain kinds of tacit knowledge are entirely unconscious and inaccessible for introspection, while others are conscious and are accessible, if triggered properly (Chennamaneni and Teng, 2011). Therefore, the degree of tacitness determines whether a specific knowledge type is accessible or not. McAdam, et al. (2007) classified tacit knowledge into three – high, medium and low degree of tacitness. Under high degree of tacitness *intuition, gut-feelings or hunches, beliefs, mental-models, taste and artistic-vision* are included. Medium degree of tacitness includes *insights, talent, judgment, rules-of-thumb, practical intelligence*. Low degree of tacitness includes *know-how, skills, experiences, expertise, best practices, improvisation, instinctive reaction and ability*. Castillo (2002) also classified tacit knowledge into non-epistle, sagacious and semantic knowledge. It is believed that such categorizations are quite important for understanding tacit knowledge and exploring mechanisms for its articulation (Haldin-Herrgard, 2003; McAdam, et al., 2007). It offers new possibilities to study tacit knowing (McAdam, et al., 2007) and informs the design of a system to support articulation and flows of the various types of tacit knowledge (Alavi and Leidner, 2001).

Knowledge resource has been metaphorically expressed as an iceberg where explicit knowledge is considered as the visible top of the iceberg while tacit knowledge is the invisible and significant part of it which is found beneath the surface (Mahroeian and Foroza, 2012). It is therefore, claimed that the great majority of knowledge capital is tacit.

Innovation is the process of generating new ideas and putting those ideas into practice (Büchel, et al., 2013). A great deal of knowledge that is important to innovation or improvement of a given process or product is tacit knowledge (Ibid.). Tacit knowledge plays a dominant role in agricultural research, extension, and advisory services which are the most knowledge-intensive elements of agricultural innovation systems (Goyal, 2011). It provides dynamic responses to context-specific problems (Vat, 2004); ensures competitiveness and innovativeness (Chun, et al., 2010; Xu and Chen, 2010; Zhu, et al., 2007; Greenman, 2006); serves as a critical vehicle to successfully transfer best practices within communities (Greenman, 2006) and has more value to innovation than explicit knowledge (Swan et al., 2000). Innovativeness in agriculture is highly dependent on the extent of using collective tacit knowledge of agricultural researchers, farmers, extension workers, processors, buyers, input providers, local leaders, government officers, local development programs and NGOs, educational institutions, etc. (Tenywa, et al., 2011).

Therefore, it is argued that one of the most important objectives of any knowledge management initiative should be fostering articulation, capturing and sharing of tacit knowledge (Wipawayangkool, 2011). Although codifying tacit knowledge is difficult, it is worth doing because of its substantial value (Nonaka and Takeuchi 1995; Davenport and Prusak, 1998). Priority should be given towards making tacit knowledge widely available to foster innovation (Swan et al., 2000) through externalizing and transforming it into explicit knowledge.

Tacit knowledge constitutes significant proportion of the whole knowledge capital since all knowledge is either tacit or is encompassed by tacit knowledge and its contribution in

innovating a given product or technology is significant (Alwis and Hartmann, 2008; McAdam, et al., 2007). It is also the basis to efficiently implement the existing codified knowledge and creating new codified knowledge (McAdam, et al., 2007). Tacit knowledge serves as a true source of innovation (Xu and Chen, 2010); provides dynamic responses to context-specific problems (Vat, 2004); provides mechanisms for transferring best practices (Greenman, 2006) and serves as a basis for developing, interpreting and applying explicit knowledge (Vat, 2004; Alavi and Leidner, 2001).

### **1.1.3. Tacit Knowledge Externalization**

There are two different schools of thought regarding externalization and codification of tacit knowledge. Some researchers consider that tacit knowledge is ineffable and cannot be turned into explicit knowledge (e.g. Polanyi, 1966; Tsoukas, 2003; Gourlay, 2006) while others believe that tacit knowledge can be translated, must be made explicit for sharing and therefore, is transferable (e.g. Nonaka, 1994; Nonaka and Takeuchi 1995, Nonaka and Konno 1998, Brown and Duguid 2000, Davenport and Prosa 2000, Ambrosini and Bowman 2001, Garavelli et al. 2002, D'Eredita and Barreto 2006; Wu, Kao, and Shih, 2010). Although tacit knowledge is hard to formalize and communicate, it is possible to make parts of tacit knowledge conscious in the sense that some parts of tacit knowledge become “focal points” of (conscious) attention (Tuomi, 1999).

Externalization is therefore, a process of conversion of tacit knowledge into explicit, codified and standardized knowledge which is an extremely important phase for knowledge creation, diffusion and utilization (Nonaka,1994; Tsoukas, 2009; Sigala and Chalkit, 2007). Dynamic capabilities are required for converting tacit knowledge into appropriate processes, products and systems (Gubbins, et al., 2012). Such capabilities are

developed through applying different tacit knowledge conversion mechanisms including metaphor, analogy, dialogue, storytelling/ narratives (myths and stories), mentoring or apprenticing, “reflection in action”, cognitive mapping, and prototyping (Nonaka, 1994; Schön, 1983; Ambrosini and Veronique, 2001; Swap, et al., 2001; Taylor, 2007; Chen, 2008; Senaratne and Sexton, 2008; Yajun, et al., 2008).

Externalization also occurs through a series of social interactions, personal reflection and insight, and through different forms of experiential learning (Robert, Dennis and Ahuja, 2008). Tacit knowledge is dynamic since it is created within social interaction between individuals, groups and organizations (Nonaka and Takeuchi, 1995; Balestrin, Vargas and Fayard, 2008). Social interaction helps to extract and develop ideas which are formed in the minds of individuals (Nonaka, 1994). New concepts are created, crystallized and clarified when people engage in the course of continual interaction (Ibid.) and negotiate specific meanings and understandings (Nahapiet and Ghoshal, 1998). Personal subjective knowledge can be socially justified and brought together with other’s knowledge so that knowledge keeps expanding (Massey and Montoya-Weiss 2006). The shared language, symbolic communication and shared meaning developed in social interaction enhance the articulation and use of tacit knowledge (von Krogh, 2009). Innovative vocabulary is required for correctly representing the new knowledge created and to make it easily understandable by the community (Jakubik, 2008).

According to Nonaka and Takeuchi (1995) the key to knowledge creation lies in the conversion of tacit knowledge into explicit forms. With the process of externalization tacit knowledge is constructed, articulated, redefined, and integrated with the intent of creating new knowledge (Ling et al., 2012; Tsoukas, 2009). New meanings and insights

are generated through new associations, connections, and hunches of tacit knowledge (Newell et al., 2004). Articulation enables participants to clarify their ideas and to develop new and more adequate concepts or models about the technology they are trying to develop (Lawson and Lorenz, 1998).

A shared space or 'ba' is necessary in order to externalize and share tacit knowledge – feelings, emotions, experiences and mental models (Nonaka, 1994). These include a physical space (such as meeting room), the virtual space (such as the e-mail or a virtual community) and the mental space (such as shared ideas and mental models) or any combination of these (Nonaka and Konno, 1998; Nonaka et al., 2006; Balestrin, et al., 2008). It is a space where knowledge is embedded and meanings are harbored, serving as a foundation for knowledge creation (Hussi, 2004). Nonaka et al. (2002) identified four types of ba, corresponding to the four knowledge conversion modes (Socialization, Externalization, Combination and Internalization – SECI model): *originating ba* (for socialization), *dialoguing ba* (for externalization) *systematizing ba* (for combination), *exercising ba* (for internalization). The shared space accelerates the explication of tacit knowledge which is shared by members (Nonaka, 1994).

Various factors affect the process of tacit knowledge externalization and sharing. Some of them include lack of shared language and systems of meaning that can be understood by all actors (Swan, et al., 2000), reluctance of people to share their knowledge (Wipawayangkool, 2011), being unable to properly conceptualize or articulate tacit knowledge (Bossen and Dalsgaard, 2005), and variation in the cognitive competence of actors (Xu and Chen, 2010). Institutional arrangements including the establishment of trust, provision of incentive and sharing mechanisms; building of a physical or a virtual

platform, creating conducive environment for learning by doing, enhancing the cognitive competence or knowledge capability of participants and improvement of the knowledge entity's absorptive capacity are identified as factors that improve the process of articulation and sharing of tacit knowledge (Venkitachalam and Busch, 2012; Xu and Chen, 2010; Erden, von Krogh and Nonaka, 2008; Yi, 2006; Choudrie and Selamat, 2004; Nonaka, 1994). Shared experience, language, access to high quality tacit knowledge and the improvement of similarity in tacit knowledge increases the degree of trust among collaborating actors and such an increase in trust enhance the social process of tacit knowledge conversion (Xu and Chen, 2010). It is also argued that contextually embedded knowledge can be understood and shared between different groups through enhanced processes of communication and negotiation (Puri, 2007).

Proper elicitation, capturing, storing, transfer and integration of tacit knowledge are extremely important for the success of agricultural innovation and the development of effective technological packages (Lema and Schut, 2013). Effective exchange and integration of knowledge across members of the community requires the establishment of communication mechanisms (Puri, 2007). Considering tacit knowledge as a social construct and as a product of social interactions emphasizes the need for appropriate IS design that can integrate knowledge articulated by different members of communities (ibid.). Therefore, there is a need to build an appropriate ICT based communication system and enhance the close interaction among key stakeholders in agriculture (Victor, et al., 2013).

#### **1.1.4. The Role of ICT in Tacit Knowledge Externalization**

##### ***The Role of ICT in General***

ICT can play an important role in transmitting tacit knowledge from one actor to another in different ways including writing, visual representations, video and sound (Bossen and Dalsgaard, 2005). The technology can support capturing of knowledge through converting it from being unpredictable and tacit to predictable and explicit (Smuts et al., 2009). Therefore, for tacit knowledge externalization and sharing both the interactive and integrative technologies are required to provide shared space and to capture and disseminate knowledge through network respectively (Janicot and Mignon, 2012). Virtual shared space can be created for emerging relationships between and among various stakeholders and facilitate the externalization of their tacit knowledge using technologies including Internet, Intranet, Extranet, e-mail, teleconferencing and video conferencing tools, and web 2.0 technologies (Al-Qdah and Salim, 2013). Technologies that support real time online interaction like groupware and Web 2.0 technologies are most appropriate to exchange high degree tacit knowledge with fast and focused feedback (Wu, Kao, and Shih, 2010). Articulation and sharing of medium degree tacit knowledge can be supported by collaboration systems such as online chat, concept mapping systems, telephone and other groupware technologies. Communication media such as e-mail, voice-mail and some applications of groupware can efficiently and accurately convey low degree tacit knowledge (Chennamaneni and Teng, 2011). The technologies can facilitate virtual joint work, permit exchange of high degree of tacit skills efficiently with fast and focused feedback and enhance collective knowledge creation (Chennamaneni and Teng, 2011; Natalya, 2010; Smuts, et al., 2009; Costa et al., 2008, Bossen and Dalsgaard,

2005). Therefore, the creation of virtual shared spaces together with the coding and sharing of tacit knowledge are the key potential areas for technological intervention pertaining to tacit knowledge management (Alavi and Leidner, 2001).

E-agriculture is considered as a major priority for economically underdeveloped nations to enhance sustainable agriculture and food security through improved processes of knowledge access and exchange using ICT. E-agriculture is taken as one of the action lines identified in the declaration and plan of action of the World Summit on the Information Society (WSIS) (Mangstl, 2008). The national policy and planning documents of most Economic Commission of Africa's (ECA) countries have articulated the need and the advantages of effective coordination, networking and collaboration in agricultural sector development with major emphasis on management and utilization of agricultural knowledge. ICT can set the foundation for knowledge creation by promoting knowledge communication and sharing (Wu, 2008) and by providing collaborative mechanisms.

The participatory agricultural research process opened opportunities for stakeholder collaboration and exchange of tacit knowledge using ICT including multimedia tools and web platforms (Goyal, 2011). Such tools enabled capturing and sharing of local and indigenous knowledge which are mostly transmitted orally (Ibid.). ICT can empower rural people by capturing and sharing undocumented, local and tacit forms of knowledge. Relevant experiences, lessons learned and best practices can be added to web based social networks as a story and information on related stories, images, videos, audios or any other electronic document (Costa et al., 2008). Topics representing community issues can be posted on a social networking system, dialogues among different actors can be

facilitated and the results of the dialogues can be stored and classified using special keywords (tags) and made accessible for members of the community (ibid.). Rating tools can be applied to rate each piece of knowledge (stories, topics, documents, objects, etc.) so that the most relevant piece of knowledge can be selected and shared (Ibid.).

In the context of participatory innovation platform farmers are key actors since the type of innovation that ultimately makes the difference is what farmers decide to do (Water-Bayer, 2006). They actively engage in experimentation and sharing of their experiences, know-how and practices. Such tacit knowledge which is expressed in words of rural communities can be harvested using a mix of traditional and modern media: text, drawings, photography, video and audio recordings (Peter, 2010). In this regard, participatory research approach in agricultural innovation systems can open opportunities for deploying ICT that serve as a virtual shared space ('Ba') for farmers and other stakeholders to articulate and share their tacit knowledge. The focus of IT support in such collaborative environment is on interaction and collaboration which facilitates externalization of tacit knowledge, its storage and management (Wu, Kao, and Shih, 2010).

### ***The Potential of Mobile Phone***

When it comes to rural areas in low income counties where there is poor electricity and network infrastructure, mobile phone is the most appropriate technology to create virtual shared spaces for researchers, farmers and extension agents to articulate and share their tacit knowledge (Goyal, 2011). With mobile phone, it is possible to expand communication, cooperation and ultimately innovation among the growing array of

actors in agriculture (Ibid.). The focus has shifted to the low-cost ICT like mobile phone because of its high penetration rate, its portability, its growing computational power and its network effects allowing two way communications at a distance without limits of time and space (Mittal and Tripathi, 2009; Goyal, 2011). In addition, mobile phones are multifunctional devices – having the capacity for voice transmission, text messaging, capturing and sending still and moving images using camera, mobile internet, mapping functionality using GPS sensors, etc. Technologies that do not depend on literacy (digital photography and video clips) are extremely effective for sharing tacit knowledge within and between farmers. Features of touch-tone navigation system with local language prompts and photos or moving images are effective ways of reaching poorly educated (semi-literate) farmers (Goyal, 2011). Mobile phones are being implemented in different agricultural areas including consultation and remote diagnosis and provision of information pertaining to managing natural resources, market price, government and legal requirements (Furuholt and Matotay, 2011).

Some of the design considerations in the development of knowledge management system include simplicity of the technology, ease of use, the alignment of the technology to user's needs, the pertinence of the knowledge and the standardization of the knowledge structure or ontology (Cassivi et al., 2009).

## **1.2. Motivation of the Study**

Some of the challenges that low income countries, including Ethiopia, face in the area of agricultural knowledge creation and innovation include: high dependence on knowledge produced by universities and research institutes; ignoring indigenous and tacit knowledge possessed by multiple agricultural stakeholders including farmers (Ngulube, 2002); weak

linkages among agricultural stakeholders; a top-down and a technological driven agricultural knowledge transfer; and lack of support for the use of the potentials of local knowledge (Hartwich et al., 2007). Sectoral, multidisciplinary, interdisciplinary and trans-disciplinary integration of efforts towards knowledge creation is also limited (Tenywa, et al., 2011). These problems are caused by the traditional or conventional top-down research-extension-farmer link approach where agricultural research generates technology which extension experts transfer to farmers. This approach resulted in the generation of agricultural knowledge and technology with limited relevance and application (Hartwich et al., 2007).

But new ways of managing agricultural knowledge have emerged across developing countries, focusing on new dynamics such as participation, collaboration and joint learning between farmers and other agents contributing to the development and diffusion of knowledge (Hartwich, 2007). Such collaborative group environment serves as a social context where individuals cooperate, share, and integrate their ideas on a particular task (Javadi and Gebauer, 2009). Through collaboration it is possible to complement and develop ideas or perspectives of individuals which is central to handle complex problem solving (Wat, 2004). The social learning process which arises from such collaborative effort can facilitate the generation of new knowledge by embedding experiential as well as local and contextual knowledge into scientific one (Bouwen and Taillieu, 2004).

Because of the stated advantages of collaboration, countries tend to shift from the traditional linear model to agricultural innovation system (AIS) that involves interaction and cooperation among multiple stakeholders in the generation, diffusion, adaptation and use of new knowledge (Hall et al., 2004 a and b; Anandajayasekeram and Berehanu,

2009; Hartwich et al., 2007; Tenywa, et al., 2011). Diverse individual and institutional stakeholders bond together based on shared issues, challenges or opportunities, intending to combine their tacit and indigenous knowledge, skills and decision making with the aim of solving problems. Participatory research therefore, allows combining of fresh ideas, insights, knowledge and experiences of different people and enhances innovation (von Krogh et al. 2000; Victor, et al., 2013). The integration of this tacit knowledge provides an ideal set of solutions for agricultural problems and improves the quality, effectiveness and sustainability of development actions.

Ethiopian Agriculture is the leading sector in the economy in terms of its contribution to national gross domestic product (GDP), employment and foreign exchange earning – each accounting for 45%, 85% and 86% respectively (Ethiopian Government Portal, 2015). It is contributing to the overall economic growth and development by supplying food for domestic consumption, raw materials for the domestic manufacturing industries and primary export commodities for foreign exchange earnings. Despite such predominance of the sector in the economy, it is characterized by subsistence mixed farming on small plots of land, low productivity of land and labor, natural resource degradation, low use of improved technologies and limited access to markets. In addition, recurrent droughts, variable rainfall, limited access to modern inputs and infrastructure such as improved seeds, fertilizer and irrigation are also factors contributing to the slow growth of the sector. Because of these problems the sector failed to attain food security and unable to produce sufficient wealth that can serve as a basis for the development of other sectors of the economy. Therefore, enhancing smallholder productivity through sustainable agricultural innovation is central to the Ethiopia's development discourse.

Just like other low income countries, agricultural innovation in Ethiopia has depended on the conventional approach (linear model) of generating and diffusing agricultural knowledge and technology. Ethiopian Institute of Agricultural Research (EIAR), Research Centers in different regions and public universities have been the major actors engaged in developing, testing and diffusing agricultural technologies to farmers through extension workers. As it is stated above this conventional approach ignored the indigenous and tacit knowledge possessed by key stakeholders including farmers. In this approach farmers are considered as the end users of technology developed at research centers. It ignores possible experimentation by individual farmers, informal networking among farm communities, private sector participation, collaboration among extension workers and collaboration between researchers and farmers (Goyal, 2011). This traditional approach encourages research and extension to act independently of one another and of farmers, to the extent that each group becomes relatively isolated (Ibid.). It also limited the local capacities of agricultural innovation and resulted in poor adoption of agricultural technologies. In general, this traditional approach ended up with a limited impact by generating inappropriate knowledge and technology.

To curb the stated limitations, a participatory technology development approach has been advocated as the only research and development process applicable to resource poor, marginal and complex farming system (Habte, et al., 2009). It is believed that such participatory research approach enhances functional and institutional linkages and strengthens technology development, verification, transfer and adoption. It also contributes to the integration of felt needs, innovative ideas, and indigenous knowledge

of farmers and to the development of situation specific technologies (Deressa and Kelemework, 2004).

With due consideration of the benefits of this participatory research approach, a project on Farmer Research Group (FRG) was launched in 2004 by the concerted efforts of Ethiopian Agriculture Research Institute (EARI), Oromia Agriculture Research Institute (OARI) and Japan International Cooperation Agency (JICA) (Habte, et al., 2009). FRG project involved researchers, farmers and extension workers as primary actors who have been directly involved in the participatory research process and worked as a team at functional level. In addition, both policy makers as well as research and development institutions at higher level and research centers, district agricultural offices, NGOs, private companies have also been involved in participatory innovation. These groups jointly identify desired outcomes, diagnose problems, pilot approaches, evaluate their impact, and propose improvements and get back to the cycle (Homann-Kee, et al., 2013). Farmers as technology developers in their own right are considered as key stakeholders being involved from the beginning to the last stages in the research process (Emana, 2009). FRGs are among the ideal multi-stakeholder platforms that bring various partners together in order to provide practical and output oriented solutions to multifaceted problems emerging from farmers' level reality (Habte, et al., 2009). The key collaborative activities include observation, discussion, analysis, collective decision making, presentation and taking appropriate actions on on-farm activities. This could be done through organizing workshops, seminars, training, field days and other suitable fora (Anchala, et al., 2004). The collaboration enabled farmers, researchers, extension workers and other stakeholders to exert their effort towards the generation, development,

verification, packaging, transfer and utilization of agricultural technologies. It also improved the capacity of farmers to innovate, experiment and cope with changes (Habte, et al., 2009). The project has brought remarkable result in boosting agricultural production of major crops (Emana, 2009).

As the great deal of knowledge that is important to the development of new technology is tacit (Büchel, et al., 2013), the platform contributed to the generation of significant amount of tacit knowledge in the form of new ideas and insights, expertise, rich experiences, best practices, skills, attitudes, indigenous knowledge, etc. But the exchange of tacit knowledge is done without either storing it in explicit form or transferring it to other farmers or researchers outside the specific group. This created a huge gap in the level of knowledge gained within members of FRG (among trial and non-trial farmers in the same FRG) (Mume, et. al., 2009). Other farmers who are not members of FRG in the same or different locality do not have access to tacit knowledge generated by researchers, farmers and extension workers involved in particular FRG projects. This is mainly because of lack of practice in capturing and sharing tacit knowledge which is generated in the process of participatory innovation. The smooth flow of tacit knowledge is also affected by the highly scattered nature of the projects, distance and time factors that limited the frequency of contact among researchers, extension workers and farmers. Limited field visits, short duration of training, short practical sessions and reluctance of trial farmers to share their practical knowledge with other farmers also affected the potential of the platform in terms of articulating and sharing of tacit knowledge to a wider farming community (Mume, et. al., 2009).

Therefore, FRG has a great potential for the enhancement of rural innovation and boosting agricultural productivity through pulling and integrating wealth of tacit knowledge from multiple stakeholders. Despite this promising potential there are still challenges in terms of effectively eliciting, sharing and integrating tacit knowledge into agricultural innovation system. Therefore, one of the critical issues to be addressed is exploring the possibility of developing and implementing ICT based solution that can facilitate communication among actors involved in participatory research process and support them in articulation of their embedded tacit knowledge.

### **1.3. Statement of the Problem**

There are debates over whether or not tacit knowledge can be made explicit. Polanyi (1967) and his followers argue that tacit knowledge cannot be converted into explicit. One of their justifications is that tacit knowledge is an integral part of all knowing and it cannot be a separate category of knowledge. They believe that the possessor of it is not conscious of the knowledge he/she possesses and thus, the person cannot articulate it. On the contrary, Nonaka and his followers argue that one of the central dynamics of knowledge creation is the transformation of knowledge from tacit to explicit (Schön, 1983; Nonaka, 1994; Nonaka and Takeuchi, 1995; Ambrosini and Veronique, 2001; Swap, et al., 2001; Sigala and Chalkit, 2007; Taylor, 2007; McAdam, et al., 2007; Balestrin, Vargas and Fayard, 2008; Chen, 2008; Senaratne and Sexton, 2008; Yajun, et al., 2008; Tsoukas, 2009; Gubbins, et al., 2012). Although tacit knowledge is hard to formalize and communicate, it is not impossible (Nonaka et al. 2000; Teece 1998). Some parts of tacit knowledge become “focal points” of (conscious) attention (Tuomi, 1999). This consciousness allows articulation and, thus, externalization of tacit knowledge. Its

existence can be known by looking at the outcome of its application (Polanyi, 1967) and it is demonstrated and reflected in its utilization (Sigala and Chalkit, 2007). Tacit knowledge can be displayed or manifested in what we do and it is externalized when our actions or communications are recursively emphasized (Tsoukas, 2003). Tacit knowledge becomes increasingly explicit in the process of uttering, formulating a sentence and capturing it in writing (Nonaka et al, 1996).

As McAdam, et al. (2007) argued we also believe that tacit knowledge must be made explicit for sharing. Our study therefore, adopts the perspective of dichotomizing knowledge into tacit and explicit and Nonaka's concept of externalization because of its dominance in the knowledge management literature and its implication to practice. Sigala and Chalkit (2007) claimed that "tacit knowledge has to be the focus of study in knowledge management field not only because of its greater strategic importance, but also because it runs a greater risk to become disregarded, as it is intangible and so, invisible". Although there are controversies in the areas of externalization, one area that needs further investigation and deeper understanding is the process of externalization of tacit knowledge and the potential factors influencing this process (Sigala and Chalkit, 2007; Mahroeian and Forozia, 2012). Tacit knowledge externalization and diffusion and the potential of various mechanisms for externalizing different forms of tacit knowledge is still unexplored and not fully understood (Mahroeian and Forozia, 2012; Chennamaneni and Teng, 2011). The extant literature on how tacit knowledge is articulated and transferred is fragmented and weak lacking a profound discussion in the area (Chennamaneni and Teng, 2011). Therefore, tacit knowledge has become an area of research focus with an emphasis to better understand the role and level of usage of tacit

knowledge (Goffin and Koners, 2011); deeper understanding of its externalization mechanisms (McAdam, et al., 2007) and its wider availability to foster innovation (Hartwich et al., 2007). It is claimed that what is less encountered and more desirable in the scholarship discourse is examining how to make better use of tacit knowledge (Venkitachalam and Busch, 2012).

In addition, the agricultural sector has rarely been the topic of inquiry in research related to tacit knowledge elicitation and most previous studies focus on high tech industries and business organizations (Galindo, 2007). Currently, there is a growing trend of participatory agricultural research which mainly involves researchers, farmers and extension agents as primary stakeholders. Intensive joint activities related to experimental practices are identified as key processes that are associated with articulation and sharing of tacit knowledge (Vaccaro, et al., 2008). In such collaborative environment tacit knowledge is said to have a critical role in innovation processes (Hennala, et al., 2011). However, to the knowledge of the researchers, no empirical research has been conducted, more specifically, by focusing on externalization, sharing and integration of tacit knowledge of farmers and other stakeholders in the efforts of collaborative agricultural innovation in low income countries. We believe that the issues become more complex and unique when articulation and sharing of tacit knowledge by rural communities is considered. Given such participatory agricultural innovation platform like FRG, further studies are required to better understand the mechanisms of tacit knowledge externalization and sharing in order to enhance the dynamic capabilities of converting stakeholders' tacit knowledge into appropriate processes, products, structures and

systems (Goffin and Koners, 2011; Gubbins, et al., 2012; Swan et al., 2000; Hartwich et al., 2007).

From ICT/IS perspective, how various forms of tacit knowledge embedded in lived experiences, agronomic practices, know-how, skills, indigenous knowledge, etc. can be integrated through appropriate IS design and implementation remains an ongoing challenge for IS researchers (Puri, 2007). Past studies pertaining to managing tacit knowledge emphasized the behavioral and managerial perspectives and limited studies have been conducted from the perspective of ICT (Al-Qdah and Salim, 2013). In addition, how to make full use of the technology to establish an effective local community support system in the areas of tacit knowledge elicitation and sharing has not been fully studied (Venkitachalam and Busch, 2012; Yu, Liu, and Xia, 2011; Goh, 2005). Therefore, further studies are recommended on how to develop a media-enriched system to support externalization of tacit knowledge by local communities (He and Li, 2010).

It is identified by previous studies that collaborative technologies including Internet, Intranet, Extranet, e-mail, video-conferencing and teleconferencing tools, Web 2.0 technologies such as weblogs, wikis, social tags, and social networking sites assist externalization and transfer of tacit knowledge (Smuts, et al., 2009; Costa et al., 2008; Natalya, 2010). But these technologies are beyond the reach of the rural community because of poor ICT infrastructure in rural areas of low income countries. Mobile technology is being used for rural communities in the areas of rural banking, marketing, advisory services or mediated agricultural extension, remote diagnosis, data collection, e-learning and sharing of information specific to price, technologies, climate change, disaster management and natural resource management in countries like India, Kenya,

Tanzania, Uganda and Chile (Hudson, 2006; Furuholt and Matotay, 2011). Beyond informational and advisory services, the current applications are not capable of providing features to support participatory agricultural research which involves the most intensive forms of tacit knowledge sharing and integration (Goyal, 2011). These applications don't support articulation, exchange, capturing and integration of tacit knowledge which are generated in the process of collaborative experiment and evaluation of technologies.

One of the efficient and productive uses of mobile phone is facilitating the exchange of tacit knowledge for the purpose of improving crop yield and livestock production (Martin and Abbott, 2011), attaining food security and respond to challenges of environmental change successfully. With its pervasive nature and with its capability of reaching millions of rural people, mobile phones are the major driver of change in linking farmers, researchers and extension workers and facilitating sharing of their tacit knowledge (Peter, 2010). From the perspective of mobile technology its usage at the interface between farmers, extension and research is one area to be explored in the context of experimentation and innovation (Ibid.). In order to develop appropriate communication system using this technology, we need to explore and understand the nature of interaction between and among key stakeholders (Spielman, et al., 2010) and identify the different tacit knowledge sharing formats (Peter, 2010). In addition, the process of tacit knowledge externalization must be modeled in order to propose the design of new or improved ICT support system (Wu, et al., 2010). There should be innovative ways of conceptualizing, designing, developing, evaluating and applying such systems for the rural domain (Franklyn and Tukur, 2012).

This study aimed at exploring mechanisms of tacit knowledge externalization and factors that affect the process and explored how this process can be supported by mobile phone.

The study addressed the following research questions:

- 1) What type of tacit knowledge is shared in participatory agricultural research?
- 2) a) What mechanisms are used by actors including farmers to externalize and share their tacit knowledge?  
b) What determinant factors affect tacit knowledge externalization?
- 3) How can externalization of tacit knowledge be best supported by mobile phone?

A framework was developed to show the dominant forms of tacit knowledge being shared in participatory agricultural research process, the corresponding externalization mechanisms and determinant factors that impact externalization process. All the identified mechanisms and factors and the way they behave in the externalization process were used as design concepts for generating system architecture that represent the mapping of externalization mechanisms into features of mobile phone based communication system. The theoretical work was integrated with the design of the architecture and the output of the former was an input for the latter. The integration process was guided by Nunamaker et al.'s (1991) Multi-methodological Approach. Both the framework and the system architecture have practical implications in terms of providing guidance for the development of the mobile phone based communication system as well as to create better policy and infrastructural framework to support the implementation and use of the new communication system.

## 1.4. Objective of the Study

### *General Objective*

The general objective of this study is proposing theoretical framework and system architecture representing tacit knowledge externalization through exploring mechanisms and determinant factors.

### *Specific Objectives*

The specific objectives of the study are to:

- Identify taxonomies of tacit knowledge being shared among innovation group
- Explore the mechanisms used to externalize the different taxonomies of tacit knowledge
- Identify factors that impact tacit knowledge externalization
- Develop a conceptual framework of mechanisms and factors determining externalization of tacit knowledge
- Propose mobile phone based system architecture for developing a communication system that can support externalization of tacit knowledge
- Validate the proposed conceptual framework and system architecture

## 1.5. Theoretical Framework

SECI Model (Nonaka and Takeuchi,1995), Media Richness Theory (Daft and Lengel, 1986), the concept of epitomes of tacit knowledge and degree of tacitness (McAdam, et al., 2007) and a framework for mapping the degree of tacitness to mechanisms of externalization and communication media (Chennamaneni and Teng, 2011) are the

theoretical lenses used to guide the study aimed at proposing system architecture for mobile phone based tacit knowledge externalization.

Nonaka (1994)'s organizational knowledge creation theory is the most widely adopted theory in the proper representation of the knowledge creation process. The theory posits that organizational knowledge is created through interactions between tacit and explicit knowledge in a spiral process of socialization, externalization, combination, and internalization (SECI). In socialization tacit knowledge is shared directly between individuals in joint activities through observation, imitation and practice. In the process of externalization knowledge is converted from tacit to explicit often in a team environment through techniques such as metaphors, analogies and models. Combination represents a form of knowledge conversion from explicit to explicit, where different bodies of explicit knowledge are combined and documented through meetings, conversations and networks. The new explicit knowledge is created by reconfiguring, re-categorizing and re-conceptualizing the existing explicit knowledge (Chun et al., 2010). In the internalization process knowledge is converted from explicit to tacit knowledge through re-experiencing others' experiences that is available in explicit forms. Externalization, the conversion of tacit knowledge into explicit knowledge, has been taken from the SECI model as a major construct in our study. The corresponding mechanisms of tacit knowledge externalization are also taken from the model.

Considering the importance of identifying different types of tacit knowledge for understanding it and for exploring the possibilities of its articulation, McAdam, et al. (2007) identified the most frequently used epitomes/subtypes of tacit knowledge from literature and categorized them into three degrees of tacitness. Under a high degree of

tacitness – *intuition, hunches/gut-feelings, beliefs and mental models*; under a medium degree of tacitness – *insights, talent, judgment, rules-of-thumb and practical intelligence*; and under a low degree of tacitness – *best-practices, knowhow, skills, improvisation, instinctive reaction and ability* are classified. The classification is made based on the extent of abstraction. Those under a high degree of tacitness cannot be conveyed to others unless they are involved in the specific situation and can therefore be considered intangible. Those under a medium degree of tacitness lead to more concrete results expressed in behavior or in the work outcomes and appear in more tangible forms. Those under a low degree of tacitness are highly visible.

Chennamaneni and Teng (2011) developed a framework for mapping knowledge transfer mechanisms to degree of tacitness and degree of tacitness to communication media. For knowledge with a high degree of tacitness the authors identified observation, mentoring and apprenticeship as appropriate mechanisms of externalization and face-to-face communication as appropriate media. For knowledge with medium levels of tacitness the authors identified metaphor, analogies, storytelling, concept mapping, prototyping, and brainstorming as appropriate mechanisms of externalization and video conferencing, web 2.0 technologies, synchronous groupware, video conferencing, groupware, and concept mapping as appropriate communication mediums. For knowledge with low degrees of tacitness expert systems, structured expert interviews, best practices, and lessons learned are identified as appropriate mechanisms and asynchronous groupware, written mail, voice-mail, and e-mail are recommended as relevant mediums.

Our goal is to develop architecture for a mobile phone based system of communication that enhances agricultural innovation through supporting elicitation, capturing and integrating tacit knowledge of multiple actors including farmers. We apply media richness theory to guide the design of the architecture for mobile phone based communication system. The theory identifies four intrinsic characteristics of communication media to determine its richness (Daft and Lengel, 1986). The first is conveyance of multiple cues (facial expressions, body language, general appearance, an emotional voice tone, attitude or formality, etc). The second is ability to provide immediate feedback (which can be either concurrent or sequential). The third is allowing language variety (for example, text, graphics, tables, etc.). The fourth is the capability of the media to have a personal focus (the possibility of personalizing messages based on the receiver and the context in which the communication takes place).

The conceptualizations of constructs relevant to the study and their relationships are summarized in the following three by three matrix.

Table 1.1. Relationship between Degree of Tacitness, Mechanisms of Tacit Knowledge Externalization and Level of Media Richness

<b>Degree of Tacitness</b>	<b>Mechanisms of Tacit Knowledge Externalization</b>	<b>Level of Media Richness</b>
<b>High</b> intuition, hunches or gut-feelings, beliefs and mental models	observation, mentoring and apprenticeship	<b>High</b> face-to-face communication
<b>Medium</b> insights, talent, judgment, rules-of-thumb and practical intelligence	metaphor, analogies, storytelling, concept mapping, prototyping, and brainstorming	<b>Medium</b> video conferencing, web 2.0 technologies, synchronous groupware, video conferencing, and groupware
<b>Low</b> best-practices, know-how, skills, improvisation, instinctive reaction and ability	expert systems, structured expert interviews, best practices, and lessons learned	<b>Low</b> asynchronous groupware, written mail, voice-mail, and e-mail

Source: Modified Version of the framework developed by Chennamaneni and Teng (2011)

As the above theories demonstrate degree of tacitness inform the kind of mechanisms of externalization to be applied and the corresponding level of media richness required to effectively articulate and share the individual’s embedded tacit knowledge. Literature also indicates that there are various factors which affect the process of externalization including trust, language, absorptive capacity, etc. We extended these relationships to explore how the stated constructs inform the design of mobile phone application in the areas of tacit knowledge externalization. With this background we propose the following research framework in order to guide our research which will finally end up with proposing M-architecture.

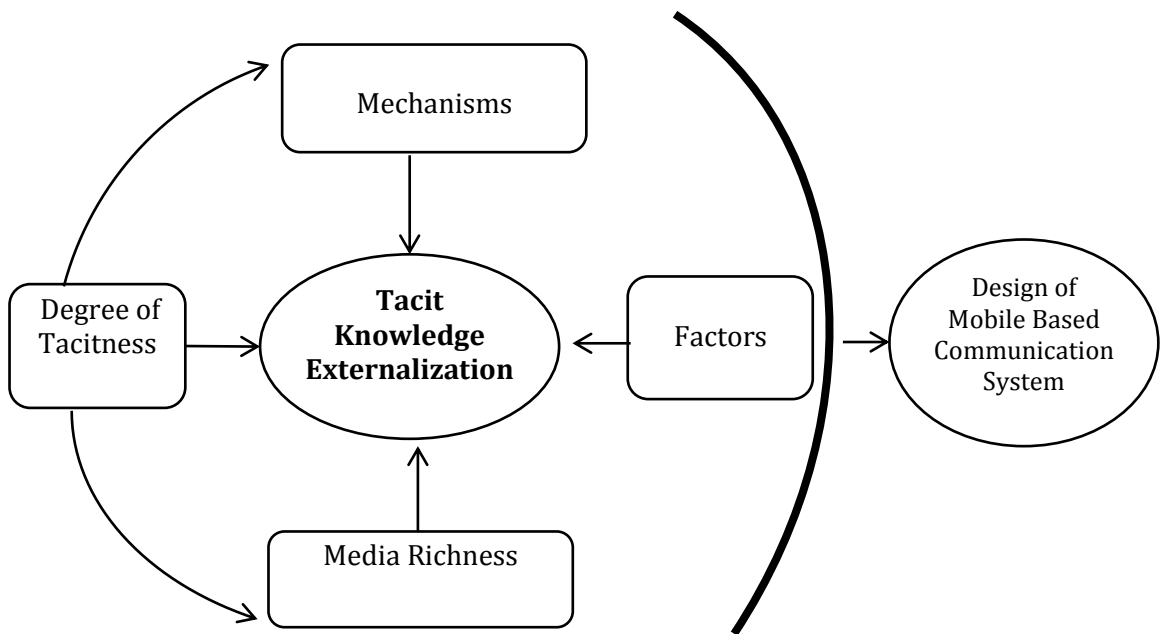


Fig. 1.1: Proposed Research Framework

Figure 1.1 describes the relationship of degree of tacitness, mechanisms of tacit knowledge externalization, determinant factors and media richness in the process of

externalization of tacit knowledge. It also indicates that the overall interrelationships inform the design of mobile phone based communication system that can facilitate tacit knowledge externalization.

Based on the above research framework we conducted the study and identified dominant patterns of externalization process and factors impacting the process. This contributed to the development of the conceptual framework. We also extracted the design features from the dominant patterns of externalization process and the mechanisms used in order to develop architecture for mobile phone based tacit knowledge externalization system.

## **1.6. Research Methodology**

### **1.6.1. Research Design**

This study is a process oriented research approach exploring the mechanisms used to externalize and share different types of tacit knowledge and factors that impact this process. It also addresses how these mechanisms and factors inform the design and development of mobile phone based system of communication to facilitate externalization of tacit knowledge. Due to the complexity of the concepts involved, we applied qualitative case study method that can generate rich and contextual data. Case study research is now accepted as a valid research strategy within the Information System research community (Lawrence, 2010). It is appropriate for the study of IS development, implementation and use since it provides rich and contextual data as well as detailed situated knowledge (Eisenhardt, 1989; Mayers, 1997; Lawrence, 2010). To address the research problem a positivist case study research philosophy was followed using Yin's (2009) proposed principles. Such principles include the four conditions related to

research design quality (construct validity, internal validity, external validity, and reliability). The other principles are techniques of pattern matching that involves qualitative but logical deduction, wherein an empirically based pattern is compared against a predicted pattern derived from rival theoretical perspectives. Qualitative study explores social phenomena which are socially constructed, complex, and constantly changing and uses human perceptions, understandings, and beliefs to explore the behaviours (Tavakol and Zeinaloo, 2004).

Therefore, we chose qualitative case study to explore the complex social interaction among multiple actors with varying cognitive level and language diversity. In addition, developing theory in the areas of tacit knowledge externalization and the potential of mobile technology in supporting the process of externalization in the rural context are not explored. Our study was a single case (the case of Farmers Research Group or FRG). But this single case covered highly diversified FRG projects. Projects vary in their levels of complexity and intensity of engagement which had implications to the process of tacit knowledge articulation. Such diversity increased the possibility of deriving different perspectives pertaining to the process of tacit knowledge externalization and the potentials of different mechanisms. Divergent views were generated from multiple actors involved in participatory agricultural innovation through qualitative interviews, focus group discussion and document analysis (Crump and Logan, 2008). We gained a full picture of what is happening in the participatory agricultural research process in terms of externalizing tacit knowledge. The unit of analysis is individual (researcher, extension agent and farmer) within each FRG to explore how these actors externalized and shared

their tacit knowledge. Focusing on individual member of the research group enabled us to generalize to the individual's ability in externalizing tacit knowledge using different mechanisms.

According to Kuechler, et al. (2009), theories generated from qualitative research either develop 'explanation' about reality, or an attempt to build 'prescription' about issues. In our case the qualitative research generated a theory that explained the reality about mechanisms and factors pertaining to tacit knowledge externalization in participatory agricultural research context. The theory also provided prescription to the design of mobile based communication system. In addition, design science principles were followed to conceptualize, design and validate mobile based system architecture that can support the existing mechanisms of tacit knowledge articulation. Panel of experts was used as a method of validating the conceptual model and system architecture.

### **1.6.2. Selection of Research Case and Research Sites**

The principle of theoretical sampling was followed to select a case which is exemplar and more suitable for revelation of key theoretical dimensions and analytical generalization (Yin, 1994). We selected participatory agricultural research platform as a research context and, Farmers Research Group (FRG) projects as research case. FRG approach is a research approach by which multi-disciplinary research team, extension workers and groups of farmers jointly conduct a research on selected topics on farmers' needs and on farmers' field. Farmers and extension workers are involved from the planning to the final stage of implementation and dissemination of the final output. Other stakeholders are also involved when needed. FRG projects were selected as a unique exemplar of the process of tacit knowledge externalization because they represent an area which involves

intensive joint experiment as well as articulation and sharing of significant amount of tacit knowledge among groups of farmers, researchers and development agents (DAs). They combine their tacit knowledge including fresh ideas, insights, expertise, experiences, best practices and skills to enhance innovation and solve persistent agricultural problems. The case is also unique since it involves illiterate and semi-literate farmers in the articulation and sharing of tacit knowledge. We believed that selecting FRG as a case for this study can provide a rich environment for investigating tacit knowledge externalization and sharing.

### **1.6.3. Data Collection**

The study targeted FRG Projects led by different agricultural research institutes and universities and thus, a number of FRG projects run by these research institutes and universities have been considered as a case or as a subject of the study. Snowballing technique was used to select relevant Agricultural Research Centers and Universities that implemented different FRG projects. We first contacted the Chief Advisor of FRG II/EIAR-JICA Cooperation Office and based on his recommendation we picked three Agricultural Research Centers and two Universities that have effectively implemented the projects and have rich experiences to share. From the selected research centers Melkasa Agricultural Research Center (MARC) and Adami Tulu Agricultural Research Center (ATARC) are the only two leading research centers in terms of implementing FRG projects between 2004 and 2009. The third one is Assosa Agricultural Research Center which was included in the study due to its exemplar best practices and experiences in FRG projects. The two Universities which were recommended as the best examples in FRG project implantation were Welayita Sodo University and Mekele University. The

case study protocol was adapted from past research which satisfied acceptable reliability and validity level.

Regarding the selection of participants we used purposive, non-random sampling technique mainly, snowballing in order to pick appropriate respondents for the in-depth interview and focus group discussion. Key respondents who had dominant role, status and experience in FRG projects were included in the study since they assist researchers to deeply understand the phenomenon. Regarding the number of respondents, Marshall, et al. (2013) recommended that single case studies should contain 15 to 20 interviews. The authors also emphasized that having too much samples and data can be counterproductive and hinder deeper and richer analysis of the data which are the central purposes of qualitative research. . Guest, et al. (2006) also confirmed that most of the data saturation had occurred by 12 interviews.

We decided on the maximum number of respondents based on the above stated guideline and the criteria of theoretical saturation, i.e, stopped to add samples when additional interviews failed to produce substantial new insight (Eisenhardt, 1989; Marshall, et al., 2013). Therefore, qualitative data was collected from 22 respondents – 14 multi-disciplinary agricultural researchers and extension agents and 8 farmers. From the 14 researchers 4 of them were PhD holders and 10 of them were M.Sc. holders. All the 3 extension agents were Diploma holders. Three of the farmers were 7<sup>th</sup>, 8<sup>th</sup>, and 9<sup>th</sup> grade complete and 5 of the farmers were illiterate. Respondents were picked from the selected Agricultural Research Centers, Universities and FRG members. Farmers were involved in

two focus group discussions. Each interview took a minimum of one hour and a maximum of three hours duration. Interviews and focus group discussions were digitally recorded and transcribed verbatim for analysis. The data gathered through interview was supported by document review.

#### **1.6.4. Data Analysis**

Data analysis involved thematic analysis and thematic coding using NVivo qualitative data analysis software. It was used to analyze qualitative data collected through interview, focus group discussion and document analysis. Unique patterns pertaining to different forms of tacit knowledge, mechanisms of its externalization and factors impacting the externalization process were extracted from the data. We followed an inductive analysis approach which mainly focused on building categories, themes and patterns from the data in order to come up with concepts and relationships (Kuechler, et al., 2009). Themes were identified by linking codes to the constructs, the objectives and the research questions and by using the hierarchical coding structure provided in NVivo. The themes were repeatedly revised in order to come up with refined data and description of the stakeholders' practice of articulating their tacit knowledge.

#### **1.6.5. Design Science Research Principle**

One of the research questions of the study is exploring the possibility of supporting the process of externalization of tacit knowledge through mobile technology. We followed multi-methodological approach to IS research which is recommended by Nunamaker, et al. (1991) and we applied their framework to integrate the results of the qualitative research with the design of the system architecture. Our qualitative exploratory research

aimed at developing and justifying theories which explain mechanisms and factors pertaining to tacit knowledge externalization. The theory helped us to identify and understand problems as well as to gain insights and increase familiarity with the problem area (Nunamaker, et al., 1991). The results of the qualitative research (theory) served as a basis for developing system requirement specification and architecture (artifacts) for mobile mediated tacit knowledge externalization.

### **1.7. Significance of the Study**

From the theoretical perspective, the study will address some issues of theoretical debates between two different schools of thought regarding externalization by supporting with empirical data the argument that tacit knowledge must be made explicit for sharing. The conceptual model consisting typologies of tacit knowledge, mechanisms and factors pertaining to social process of tacit knowledge externalization and use is also another theoretical contribution.

The role of ICT in managing tacit knowledge is still arguable in previous and current researches (Al-Qdah and Salim, 2013). In this regard, based on the understanding of the nature of tacit knowledge being externalized and shared and the mechanisms used for doing so, our research has demonstrated that it is possible to design an appropriate ICT artifact that can facilitate the process of externalization and sharing. The system can support eliciting farmers' and other stakeholders' tacit knowledge and integrate it with technical knowledge.

A mobile based virtual platform that can be developed based on the proposed architecture may initiate interaction and collective action among research institutes, farmers,

extension agents and the Ministry of Agriculture with the aim of capturing and integrating a huge but scattered body of tacit knowledge into rural innovation.

The design and development of the mobile application enable scientists and the government to monitor farming activities and local problems remotely and to leverage the concerted efforts and knowledge of multiple key stakeholders including farmers to solve regional and national challenges.

With the mobile application it is possible to conduct more rigorous and frequent monitoring and evaluation of outcomes of experiments conducted through participatory research. It is also possible to capture and reuse unique and highly contextual tacit knowledge of different actors generated during the monitoring and evaluation process.

This research also opens an opportunity for agricultural research institutes and the government to think towards the direction of building participatory e-research, aligning ICT investments to research and innovation processes and create access to untapped tacit/indigenous knowledge of multiple actors involved in the innovation process. The system to be developed may also assist farmers to document and preserve their own local or indigenous knowledge so that it can be shared with other communities.

The research output can be also used as a guideline to invest in technological infrastructure and cellular networks to facilitate participatory agricultural experiments and innovations. It can also serve as an input to develop the optimal ICT investment portfolio for a mobile based network of national research institutes, researchers, farmers and other pertinent stakeholders.

The study can also guide policy makers to see the value of mobile phone in serving agricultural development and to create a favorable environment for the provision of sufficient access to devices and networks to rural community and making the technology affordable and have useful applications and content.

### **1.8. Scope of the Study**

Our study focuses only on tacit knowledge and Nonaka's externalization mode of knowledge creation. This is because a great deal of knowledge that is important to the innovation or improvement of a given process or product is tacit knowledge (Büchel, et al., 2013). Externalization is also an extremely important phase for knowledge creation, diffusion and utilization (Nonaka,1994; Tsoukas, 2009; Sigala and Chalkit, 2007). It has practical implications since once tacit knowledge is well articulated it is easy to integrate and incorporate it into a new product or a process. Therefore, the study doesn't deal with explicit knowledge as well as socialization, combination and internalization constructs of Nonaka's model.

The scope of research is limited to participatory agricultural research approach, FRG projects, since the researchers believed that selecting FRG as a case for this study can provide a rich context for investigating tacit knowledge externalization. Therefore, other forms of agricultural research are not part of this study.

The study focused on three leading Agricultural Research Centers and two Universities which had significant experience in FRG project implementation. Melkasa Agricultural Research Center (MARC) and Adami Tulu Agricultural Research Center (ATARC) were the only research centers in the country which had been conducting farmer participatory

research using FRG approach between 2004 and 2009. During this period the two centers established 80 farmer research groups with more than 1,400 members including 800 female farmers. More than 50 researchers from nearly 20 disciplines formed a number of multidisciplinary teams and conducted 41 research topics in partnership with extension workers and farmers as well as many other public and private sectors. Therefore, the two research centers were selected because they are pioneers and have rich experience in implementing FRG approach. Assosa Agricultural Research Center is one of the research centers which has active FRG projects and included in the study due to its exemplar best practices and experiences in these active projects. The two Universities, Welayita Sodo University and Mekele University, were also recommended as the best examples in FRG project implantation.

Because of the limitation of time and resource the study was limited to the development of the Mobile Communication System Architecture and will not go into the development of a prototype which requires an iterative process of testing and modifying.

### **1.9. Organization of the Thesis**

This thesis is organized into seven chapters. The first chapter presented the overview of the study by providing background of the study, motivation, statement of the problem, objectives, theoretical framework, methodology, significance and the scope of the study. The second chapter focused on review of current literature on different concepts including tacit knowledge, tacit knowledge externalization and its mechanisms, factors affecting the process of tacit knowledge externalization, the role of ICT in tacit knowledge externalization and presentation of literature gap. The third chapter covered the methodology applied to address the research questions including rationale for

qualitative study, research design, selection of research sites and respondents, description of research context, data collection, data analysis, design science research principles and validity. The fourth chapter of this study presented and analyzed the qualitative data. Data was presented and analyzed on participatory research approach, epitomes of tacit knowledge, mechanisms of tacit knowledge externalization, factors influencing tacit knowledge externalization and current uses of mobile phone, challenges and requirements. The fifth chapter analyzed the findings of the study as compared to the current literature and finally proposed tacit knowledge externalization framework as an output of the qualitative research. The sixth chapter built system architecture for mobile-mediated tacit knowledge externalization based on design constructs extracted from qualitative research. The seventh and final chapter concluded the study by summarizing the major findings pertaining to the research questions and by presenting both theoretical and practical implications of the study.

## **CHAPTER TWO**

### **LITERATURE REVIEW**

This chapter provides a review of theoretical and empirical research in the areas of tacit knowledge, its externalization process and possible technological support mechanisms in the context of collaborative innovation system. The chapter constitutes six main streams of literature which are important to frame the focus of this study. The first section deals with what knowledge in general is and the epistemology of knowledge. The second section provides a broad discussion of tacit knowledge which is the subject of the study. It includes definition and taxonomies of tacit knowledge. The third section reviews ways of creating group tacit knowledge by integrating individuals' tacit knowledge through social interaction and how it contributes to the enhancement of collaborative innovation. The fourth section focuses on tacit knowledge externalization which reviews major controversies between different schools of thought regarding externalization and codification of tacit knowledge, various mechanisms of tacit knowledge externalization, the concept of shared space ('ba'), and factors affecting the process of externalization process. The fifth section covers review of literature on the role of ICT on tacit knowledge externalization. The last section presents the literature gap in the study area.

## **2.1. Knowledge**

### **2.1.1. Definition of Knowledge**

Various authors defined knowledge from different perspective. Knowledge is defined as a mix of experience, important values, contextual information and expert insight (Davenport and Prusak, 1998); as information combined with experience, context, interpretation and reflection (Alavi and Leinder, 2001; Yi, 2006); as justified true belief that increases an entity's capacity for effective action (Nonaka 1994, Nonaka et al. 2006; Nonaka and von Krogh, 2009); as a product of different human processes involving social, situational, cultural and institutional factors (Martins, 2011). Knowledge is also described as a state of knowing, with knowing being a condition of understanding gained through experience or study; the sum or range of what has been perceived, discovered, or learned (Alavi and Leidner, 2001). Knowledge is also defined in terms of its hierarchy.

The hierarchy of knowledge demonstrates that data is raw numbers and facts, information is processed data, and knowledge is authenticated information (Alavi and Leidner, 2001). Tuomi (1999) reversed the hierarchy from data to knowledge and argued that knowledge must exist before information can be formulated and before data can be measured to form information. The reversed knowledge hierarchy is represented in such a way that knowledge exists which, when articulated, verbalized, and structured, becomes information which, when assigned a fixed representation and standard interpretation, becomes data. According to this argument information is converted into knowledge once it is processed in the mind of individuals and knowledge becomes information once it is articulated and presented in the form of text, graphics, words, or other symbolic forms.

Knowledge originates at individual, group and organizational levels and is interpreted and used by these three levels (Martins, 2011). Knowledge is demonstrated when people perform skillful action and when they are capable of solving problem through defining, preparing, shaping and learning (Nonaka and von Krogh, 2009).

Knowledge has become the basis for nations' wealth creation and exploitation, for socio-economic progress and sustainable economic and social development (Wang, 2012). It is a key resource for the development of new and quality products and maintaining competitive advantage through fueling innovation (Jun and Weiguo, 2008; Al-Qdah and Salim, 2013).

In an environment where agricultural innovation involve integrated efforts of multiple stakeholders, knowledge creation and dissemination creates positive externalities directly related to prosperity and development of the rural community (Galindo, 2007).

### **2.1.2. Taxonomies of Knowledge**

Knowledge is classified into tacit and explicit which is adopted from Polanyi (1958) and popularized by Nonaka and Takeuchi (1995) in their theory of organizational knowledge creation (Virtanen, 2011). This classification was accepted by many researchers and it became the basis for epistemology of the knowledge management theory (Al-Qdah and Salim, 2013). Explicit knowledge is defined as knowledge that has been articulated in the form of text, diagrams, product specifications, etc. which can exist in reports, documents, and manuals and can easily be gathered and stored as a knowledge base (Smuts, et al., 2009). Knowledge that can be uttered, formulated in sentences, and captured in drawings

is explicit (Janhonena and Johanson, 2011). Yi (2006) differentiated tacit and explicit knowledge by identifying three major areas:

Table 2.1: The Difference between Explicit and Tacit Knowledge

Area	Explicit Knowledge	Tacit Knowledge
Codifiability and mechanisms for transferring	<ul style="list-style-type: none"> <li>• Can be codified, understood, and shared without a “knowing subject.”</li> <li>• Ease of communication and transfer is its fundamental property</li> </ul>	<ul style="list-style-type: none"> <li>• Intuitive and unarticulated.</li> <li>• It can’t be communicated, used, or understood without the “knowing subject”</li> <li>• Knowledge of this type is action-oriented.</li> <li>• It needs close interaction and build up of shared understanding and trust.</li> </ul>
Method for acquisition and accumulation	<ul style="list-style-type: none"> <li>• Can be generated through logical deduction and acquired by formal study</li> </ul>	<ul style="list-style-type: none"> <li>• Acquired through practical experience in the relevant context, i.e., “learning by doing.”</li> </ul>
The potential for aggregation and modes of appropriation	<ul style="list-style-type: none"> <li>• Can be aggregated at a single location, stored in objective forms, and appropriated without the participation of the knowing subject.</li> </ul>	<ul style="list-style-type: none"> <li>• Personal and contextual</li> <li>• It is distributive and cannot be easily aggregated</li> <li>• The realization of the full potential requires close involvement and cooperation of the knowing subject.</li> </ul>

Source: Yi (2006)

## 2.2. Tacit Knowledge

This section is dedicated to an in-depth discussion of tacit knowledge because it is the subject of this research. Examining tacit knowledge has become timely and both theoretically and practically relevant since it constitutes significant proportion of the whole body of knowledge capital and there is a strong increase in knowledge-intensive activities (He and Li, 2010; Puusa and Eerikäinen, 2008). Tacit knowledge has to be the focus of study in knowledge management field not only because of its greater strategic importance, but also because it runs a greater risk to become disregarded, as it is intangible and so, invisible (Sigala and Chalkit, 2007). The concept of tacit knowledge is

primarily useful in the context where verbal interaction and communication dominate (Styhre, 2009). Our study focuses on participatory agricultural innovation that involves multiple actors including farmers and it is dominated by highly interactive conversation.

### **2.2.1. Definition of Tacit Knowledge**

Tacit knowledge is a form of knowledge which is embedded in the human mind, unarticulated and tied to the senses, tactile experiences, know-how, skills, insights, intuitions, perceptions, ideas, values, feelings, emotions, beliefs, mental models, or implicit rules of thumb (Nonaka, 1994; Nonaka and Takeuchi 1995; Ambrosini and Veronique, 2001; Virtainlahti, 2006; McAdam, et al., 2007; Zhu, et al., 2007; Yajun, et al., 2008; Nonaka and von Krogh, 2009; Wu, et al., 2010; Zhang, et al., 2012; Wang, 2012).

Tacit knowledge is also defined as knowledge that is local/contextual and embedded in individuals' know-how and collective practices (Oğuz and Şengün, 2011). Alwis and Hartmann (2008) associated tacit knowledge to individual's education, natural talent, experience and judgment. Eden and Spender (1998 as cited by Venkitachalam and Busch, 2012) have also suggested that tacit knowledge consists of a set of ingredients in an individual's head which are a range of experiences, education, technical know-how and cultural values. Tacit knowledge is hidden in the human mind, to the extent that even the knowledge holder may not be aware of its existence (Ambrosini and Bowman, 2001). Tacit knowledge is acquired through inner individual processes such as experience, reflection, internalization and individual talent (Gubbins, et al., 2012) and through sharing experiences, observation and imitation (Alwis and Hartmann, 2008).

Tacit knowledge is subconsciously understood and applied; both known and unknown to the holder; hard to formalize and communicate fully; developed from direct experience and action; and usually shared through highly interactive conversation, storytelling and shared experiences (Nonaka, 1994; Nonaka and Konno, 1998; Sunassee and Sewrya, 2002; Yajun, et al., 2008; Chun, et al., 2010; Wu, et al., 2010).

Tacit knowledge constitutes technical dimension that covers concrete know-how, crafts, and skills that apply to specific contexts and cognitive dimension or mental models that include schemata, paradigms, beliefs and viewpoints that provide perspectives that help individuals to perceive and define their world (Nonaka, 1994). Cognitive dimension of tacit knowledge is difficult to articulate but it shapes the way an individual perceives the world. Understanding the way a person thinks about the world helps to understand that person's actions. Therefore, cognitive dimension allows us to specify the process of externalization as a means to the flow of knowledge between communities (Nonaka and Konno, 1998). The concept of "implicit" knowledge is offered as an alternative to tacit knowledge (Grant, 2007). Implicit knowledge might be described as tacit knowledge that could be made explicit but need not be, in a community that shares a common view of the necessary tacit knowledge (Ibid.).

The working definition of tacit knowledge for the study is therefore:

*It is a form of knowledge which is –rooted in individuals' actions and collective practices, experiences, technical know-how, skills, and embodied expertise; local or context-specific; shared through highly interactive conversations, reflections, narratives, metaphors, shared experiences, observations, imitation, etc.*

### **2.2.2. Taxonomies of Tacit Knowledge**

Identifying taxonomies of tacit knowledge are quite important for understanding of tacit knowledge and exploring the possibilities of and methods for articulating tacit knowledge into explicit knowledge (McAdam, et al., 2007). It offers new possibilities to study tacit knowing (McAdam, et al., 2007) and informs the design of a system to support articulation and flows of the various types of tacit knowledge (Alavi and Leidner, 2001).

Most of the theories focus on the degree of tacitness or the extent to which tacit knowledge can be articulated as a basis for developing various classifications. Tacitness can be represented as abstraction and the level of abstraction varies from completely abstract to quite concrete. Certain kinds of tacit knowledge are entirely unconscious and inaccessible for introspection, while others are conscious and are accessible, if triggered properly (Chennamaneni and Teng, 2011). The degree of tacitness determines whether a specific knowledge type is accessible or not. The closer the knowledge is to the extremely tacit, the more difficult it is to access (Ibid.).

Ambrosini and Veronique (2001) identified three forms of tacit knowledge. The first is tacit knowledge that is totally unavailable or unconscious and not accessible to the knower because it is too deeply ingrained. The second type is tacit knowledge that is unarticulated but that could be articulated readily if organizational members were simply asked the question: how do you do that? The third type is tacit knowledge that can be expressed through other means (e.g. metaphors and storytelling) than formal words.

McAdam, et al. (2007) identified three classifications of tacit knowledge based on degree of tacitness. The first category constitutes tacit knowledge under high degree of tacitness

which includes *intuition, gut-feelings or hunches, beliefs, mental-models, taste and artistic-vision*. Such category of tacit knowledge cannot be tapped into by others than those involved in the specific situation and can therefore, be considered intangible. These epitomes of tacit knowledge include only the individual as an actor and cannot be felt by more than one individual since it is impossible to transfer the same feeling to another actor. The second category constitutes tacit knowledge under medium degree of tacitness which includes *insights, talent, judgment, rules-of-thumb, practical intelligence*. These epitomes of tacit knowledge are called imperfectly articulable knowledge (Ambrosini and Veronique, 2001). They can lead to concrete results, expressed in behavior or in the work outcomes and can appear in more tangible forms. The third category constitutes tacit knowledge under low degree of tacitness that include *know-how, skills, experiences, expertise, best practices, improvisation, instinctive reaction and ability*. These epitomes of tacit knowledge are related to practical work and they are highly visible for the individuals, groups and organizations and can be easily articulated. When tacit knowledge is more easily observed, taught, codified and disaggregated from its context, such kind of knowledge has a relatively low proportion of tacitness and is based on principles, rules, heuristics, and stable relationships (McIver, et al., 2012). Epitomes of tacit knowledge categorized in the medium and low degree of tacitness like mental models, attitudes, know-how, judgment, skills and improvisations include not only individuals as actors but also teams and groups of actors. In teams it is possible to find shared mental models and a collective know-how developed by former and present members (McAdam, et al., 2007). The skills or know-how can be discussed, observed,

and learned and it is learned by observation, imitative application, participating in routines, and personal experience (McIver, et al., 2012).

There are also similar classifications developed by researchers based on the extent to which tacit knowledge can be articulated (Castillo, 2002). One category is a *non-epistle* tacit knowledge that is the result of implicit learning and which is completely inarticulable. This kind of knowledge is extremely difficult, if not impossible for individuals to access and explicitly transfer (Ambrosini and Bowman, 2001; Castillo, 2002; Leonard and Sensiper, 1998). The second category of tacit knowledge is *sagacious* knowledge, a form of knowing that emanates in an acute and keen practical sense and which is imperfectly articulated tacit skills (Castillo, 2002) and which is categorized by Nonaka (1994) as cognitive form of tacit knowledge. According to Nonaka (1994) this knowledge can be articulated through metaphor and analogy. The third category of tacit knowledge is *semantic knowledge* which is once explicit knowledge but made tacit through Nonaka's (1994) internalization process and this can be recaptured relatively easily by asking the right question and through conversations between experts (Ambrosini and Bowman, 2001; Castillo, 2002; Nonaka, 1994).

The classification of tacit knowledge based on degree of tacitness has implication on methods used for its articulation and sharing. It is generally argued that knowledge sharing at tacit level is bound to the senses, personal experience and bodily movement and requires close physical proximity with the work being done, through observation and narration (Von Krogh, et al., 2000). Tacit knowledge which are classified under high degree of tacitness can be best transferred in an informal atmosphere and face-to-face interaction. Mentoring and apprenticeship are also appropriate techniques for these types

of tacit knowledge (Chennamaneni and Teng, 2011). In the case of medium level of tacitness which are inexpressible through words is better articulated by metaphors, storytelling, concept mapping, etc. (Chennamaneni and Teng, 2011). Epitomes of tacit knowledge with low degree of tacitness can be learnt by trial and error, short period of apprenticeship, posing the right questions using structured expert interviews, protocol analysis, and triggering the right dialogue (Chennamaneni and Teng, 2011).

Indigenous knowledge is also another form of tacit knowledge. It is a shared tacit knowledge that a local community has evolved over time, through trial and error (Puri, 2007), in a particular environment. Sletli and Singhal (2016, p 814) stated that “indigenous knowledge is usually tacit, i.e. not explicitly codified and systematized, and it belongs to a particular community and is embedded in local practices, relationships, and rituals.” It is field tested for its suitability to local needs, conditions and ethos (Mundy and Compton 1995). It may be informally expressed in local customs, experience, technology, and wisdom. The understanding these communities have of their land—its layout, topography, cropping patterns, location of water bodies, the local drainage pattern and much more—is referred to as indigenous knowledge (Puri, 2007). It is context-specific and embedded in the everyday practices of the members of a community (Ibid.).

It is argued that most parts of tacit knowledge is potentially articulable if appropriate knowledge management mechanisms are employed (Ambrosini et. al., 2001; Nonaka, 1994). Effective externalization and sharing of tacit knowledge results in successful generation of new ideas, products or processes and enables solving of problems in a flexible manner (Alwis and Hartmann, 2008). In addition to the degree of tacitness, the

possibility of externalizing and sharing of tacit knowledge is determined by whether we are dealing with tacit knowledge at the individual or group level.

### **2.2.3. Roles of Tacit Knowledge**

More focus is given to tacit knowledge since it constitutes a significant proportion of knowledge in the sphere of knowledge management. Mahroeian and Forozia (2012) metaphorically expressed knowledge resources as an iceberg and considered tacit knowledge as the invisible and significant part of the iceberg. A great majority of the whole knowledge capital is hidden in people's experiences and skills which are tacit forms of knowledge (Puusa and Eerikäinen, 2008). Ninety (90) percent of the knowledge in any organization is embedded and synthesized in tacit form (Wah, 1999b in McAdam, et al., 2007). All knowledge is either tacit knowledge or is rooted in tacit knowledge meaning that the explicit knowledge depends on or is encompassed by tacit knowledge (Alwis and Hartmann, 2008). A great deal of knowledge that is important to the operation or improvement of a given process or product technology is tacit (Ibid.). Tacit knowledge is important to efficiently implement existing codified knowledge and even create new codified knowledge (McAdam, et al., 2007).

Knowledge creation is often seen as the "front-end" of product development where tacit knowledge plays a significant role in achieving innovation success (Erden, von Krogh and Nonaka, 2008). Therefore, the importance of tacit knowledge is associated with innovation and new product development (McAdam, et al., 2007). Innovation is the process of generating new ideas and putting those ideas into practice (Büchel, et al., 2013). At the early phases of innovation process tacit knowledge, its articulation and transfer contributes to idea discovery and generation (Alwis and Hartmann, 2008). In the

later phases of the innovation process tacit knowledge contributes a great deal to the speeding-up of the innovation process and thus results in successful generation of new ideas, products or processes or to solve problems in a flexible manner (Ibid.). Therefore, tacit knowledge serves as a true source of innovation (Xu and Chen, 2010); provides dynamic responses to context-specific problems (Vat, 2004); provides mechanisms for transferring best practices (Greenman, 2006) and serves as a basis for developing, interpreting and applying explicit knowledge (Vat, 2004; Alavi and Leidner, 2001). It is tacit rather than explicit knowledge which has more value to innovation processes (Swan et al., 2000).

New knowledge begins with the individual's tacit knowledge (Nonaka, et al., 2000). For example, a brilliant agricultural researcher may come up with new technology (tool or improved variety), techniques or methods based on his/her insight or tacit knowledge. The agricultural scientist can also use his/her tacit knowledge to apply techniques embedded in codified knowledge which is published in scientific journals. Tacit knowledge can therefore, support the contextual adaptation of explicit knowledge (e.g., research findings) so that they become relevant and applicable to local populations and conditions. The unstructured and intangible tacit knowledge is the higher levels of knowledge and one has to master this knowledge in order to implement the structured and explicit knowledge (McAdam, et al., 2007). Tacit knowledge forms the background necessary for assigning the structure to develop and interpret explicit knowledge (Ibid.). Explicit knowledge is for everyone to find and use but tacit knowledge separates the masters from the common (Mahroeian and Foroza, 2012). Core competency in any field is more than explicit knowledge of "know-what"; It requires the more tacit "know-how"

to put ``know-what'' into practice (Brown and Duguid, 1998). In this regard we need to consider the role of tacit knowledge in intervention design, implementation protocols and/or in understanding the underlying mechanisms related to knowledge creation, dissemination and utilization. If an environment is more innovation oriented, tacit knowledge becomes increasingly important to the generation of new knowledge and to meet emerging environmental trends and challenges (Bennet and Bennet, 2008; Wang, 2012). Tacit knowledge which can only be acquired through practice and experience enables individuals to formulate scientific problems and develop strategies aimed at their solution.

In most cases, innovation is not the product of a single person but a collective work of a group of people or a team which signify the importance of group tacit knowledge (Ibid.). The kind of knowledge exchanged in a collective environment is more of tacit and the more tacit forms of knowledge are said to have a crucial role in innovation processes (Hennala, et al., 2011). There is a growing understanding that "getting evidence into practice" is a complex process that involves different disciplinary approaches, beliefs, values and worldviews (Kothari, et al., 2011). Therefore, tacit knowledge is seen as a critical element to the success of groups. Recent scholarly works have focused on how institutions can create conditions that enable knowledge creation on the basis of availing and amplifying tacit knowledge (Nonaka et al., 2006, Mahroeian and Forozia, 2012).

In general, individual or organizational success depends on appropriate internalization and application of tacit knowledge (Haron and Noordin, 2010). Tacit knowledge can contribute to innovation if it is converted into explicit knowledge in the form of a concept for a product or a service and justified by a social action (Krogh, 1998).

## **2.3. Tacit Knowledge Externalization: Definition, Controversies, Mechanisms and Factors**

### **2.3.1. Tacit Knowledge Externalization - Definition**

Externalization is a process of conversion of tacit knowledge into explicit, codified and standardized knowledge that can be understood by others (Nonaka and Takeuchi, 1995; Nonaka and Konno, 1998; Yajun, et al., 2008; Chen, 2008). Externalization is a method that expresses knowledge in the form of codes which could hold natural languages or a combination of media, and its end result is a knowledge object (Wu, et al., 2010).

Tacit knowledge is the invisible part and it is essential to identify, convert, capture and use it (Sigala and Chalkit, 2007). The process of converting tacit knowledge into codified knowledge is vital in economic terms since national economies are more than ever dependent on their capacities to produce and use such knowledge (Rix and Lie`vre, 2008). Externalization holds the key to knowledge creation, because it extracts new, explicit concepts from tacit knowledge (Chatti, et al., 2007). The articulated concepts are then converted into appropriate structures, processes, products and systems that can solve problems in a flexible manner (Alwis and Hartmann, 2008; Gubbins, et al., 2012). In the process of knowledge conversion through externalization practitioners may discover new ways of defining problems and searching for solutions (Nonaka and Konno, 1998). Therefore, tacit knowledge has no value unless it is codified and generalized through the identification of best practices (Oğuz and Şengün, 2011).

Although tacitness and complexity makes tacit knowledge transfer very difficult, it can be extracted in the process of direct transfer among individuals (WanJun, et al., 2010) and shared among people through non-verbal practices and experiences. Interest in tacit

knowledge externalization has heavily increased mainly because it is closely related to knowledge diffusion and utilization which in turn critically determines the process of innovation (Sigala and Chalkit, 2007). The engine of knowledge creation is “articulation”—a continuous process of making knowledge explicit and relevant to the task at hand (Tsoukas, 2009).

There are people focused strategies that enable the articulation and sharing of tacit knowledge (Gubbins, et al., 2012). In people focused strategy conversion and sharing of tacit knowledge by individuals through social interaction is emphasized. Individuals are considered as fundamental repositories of tacit knowledge and active agents in its use. Therefore, their ability and willingness to engage in tacit knowledge articulation and transfer are major determinants. In this process tacit knowledge is transformed from the individual to group and from tacit to explicit (Nonaka et al., 2000).

There are variations in opinions regarding different aspects of tacit knowledge including the level at which it is manifested, how it is acquired, what its function is, and whether or not it can be made explicit in organizations (McAdam, et al., 2007).

### **2.3.2. Controversies in Tacit Knowledge Externalization**

Different meanings were given to tacit knowledge by different researchers causing confusion and debate over what tacit knowledge is and whether it can be captured or not (Taylor, 2007). There are two different schools of thought regarding externalization and codification of tacit knowledge. Some researchers consider that tacit knowledge is ineffable and cannot be turned into explicit knowledge (e.g. Polanyi, 1966; Tsoukas, 2003; Gourlay, 2006) while others believe that tacit knowledge can be translated, must be

made explicit for sharing and therefore, is transferable (e.g. Nonaka, 1994; Nonaka and Takeuchi 1995, Nonaka and Konno 1998, Brown and Duguid 2000, Davenport and Prosak 2000, Ambrosini and Bowman 2001, Garavelli et al. 2002, D'Eredita and Barreto 2006; Wu, et al., 2010). Nonaka and Konno (1998) assert that converting tacit knowledge into explicit knowledge using a process of externalization should take place before sharing. However, Polanyi (1966) suggest that to be able to share tacit knowledge the possessor of it must first become conscious of the knowledge he/she possesses and then find a way to express the knowledge.

### ***Arguments against Tacit Knowledge Conversion***

Polanyi (1966) is the first author who originated the study of tacit knowledge and represented tacit knowledge by a phrase “we can know more than we can tell”. This means that what is expressed in words and numbers is only a small part of the actual knowledge that an individual has. Although individuals perform the task successfully, they cannot articulate the decision rules for their actions. Polanyi and his followers believe that tacit knowledge is deeply ingrained in the human mind and is very difficult for the individual to articulate. In addition, they believe that tacit knowledge is not separable from explicit knowledge. Tacit knowledge is considered as an integral part of all knowing. They claim that tacit and explicit knowledge are mutually constituted, or they are two dimensions of the same knowledge and should not be viewed as two separate types of knowledge. Tsoukas (2003) consider tacit and explicit knowledge as complements. Tacit knowledge is inseparable and trying to do so is impractical.

According to Polanyi (1966) the existence of tacit knowledge is known by looking at the outcomes of its application which implies that some tacit knowledge is governing a certain activity but the person cannot articulate it. Tacit knowledge is deeply rooted in action and context and it cannot be codified or communicated in a “language”; it is acquired without awareness, but through shared experiences, observation and imitation (Alwis and Hartmann, 2008, Matthew and Sernberg, 2009). Tacit knowledge is instinctively understood as the knowledge that people have in their heads, rather than knowledge that is written down and recorded (He and Li, 2010).

Tacit knowledge is more individualistic in nature and is consequently complicated to extract from the heads of individuals (Mahroeian and Foroza, 2012). Individual processes like experience, reflection, internalization or individual talents are ways of acquiring tacit knowledge (Ibid.).

According to Polanyi’s Theory of Tacit Knowledge there are two kinds of awareness which are part of the structure of consciousness: *focal awareness* which is referred as conscious attention and *subsidiary awareness* which is referred as below-view (not directly attended by the person). The focal awareness is the knowledge about the phenomenon in focus, e.g. driving a nail. The subsidiary awareness is the activities that are *NOT in focus* when using personal skills or knowledge or the “knowing how” to do things, e.g. holding the hammer, swinging the hammer, holding the nail without hitting your fingers or hand, etc. According to his theory tacit knowing is the process by which elements in a person’s focal awareness are integrated with elements in their subsidiary awareness.

Based on Polanyi's and KM author's ideas of tacit knowledge Virtanen (2011, p. 7-8) distinguished three different levels of content of mind from the perspective of its accessibility. Level 1 content refers to conscious linguistic representations or representations that are easily made linguistic (e.g. declarative knowledge, propositional thoughts, texts etc.). For Polanyi, focal awareness means explicit knowledge where focal attention is directed, whether it is a perceived object or a mental representation. Level 2 content refers to conscious representations that are difficult to articulate because of, for example, lack of words (e.g. an unusual colour), modality of the representation (e.g. a vision or a multimodal experience) or not-yet analysed nature of representation (an incomplete idea or assumption not yet submitted to verification). In other words, compared to the representations of level 1, the representations of this level are more phenomenological in nature. Level 3 represents unreachable content impossible of becoming a conscious representation. The 3<sup>rd</sup> level is referred by Polanyi as subsidiary awareness which is difficult to trace and there is loss of meaning of tacit knowledge if it is tried to attend focally.

Based on his distinction Virtanen (2011, p. 8) argued that "the characterizations of tacit knowledge made by Polanyi and many KM authors applying his theory for externalization are not talking about the same mental phenomena when referring to tacit knowledge. To Polanyi tacit knowledge is a phenomenon of the level 3, whereas tacit knowledge in the KM literature refers to both level 2 and 3. However, the focus is on the level 2 since externalization of tacit knowledge is generally considered to be one of the main functions of organizations" (Virtanen, 2011, p. 8)

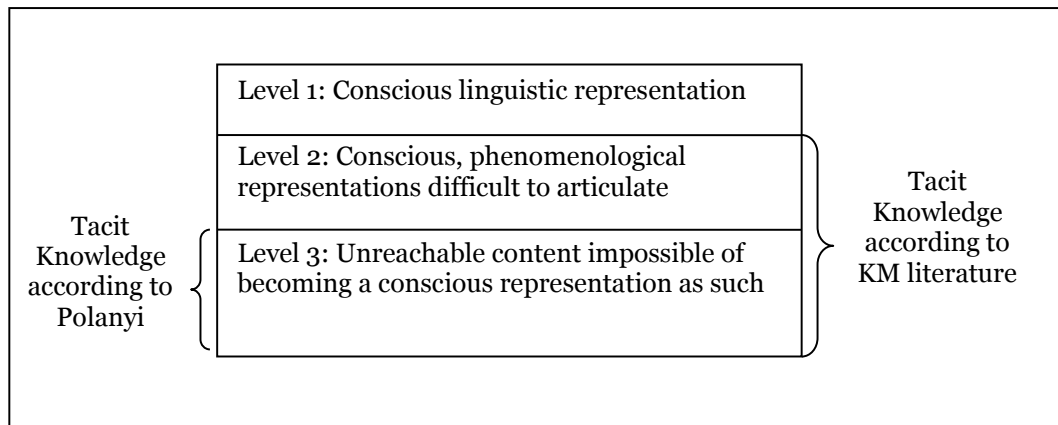


Fig. 2.1: Characterizations of Tacit Knowledge Made by Polanyi and KM Authors

The authors criticized that using concept of tacit knowledge without referring to a specific level leads to significant confusion. Level 2 and 3 covers so many mental phenomena that the concept has become meaningless buzzword that can refer to almost anything. This has led great confusion of the meaning of the concept. In this case the knower is unaware of the tacit knowledge and he is not conscious of it (Virtanen, 2011).

***Arguments for Tacit Knowledge Conversion***

Nonaka (1994) and his followers consider tacit and explicit knowledge as separate poles on a continuum, and that tacit knowledge is amenable to expression (Kothari, et al., 2011). They considered the transformation of tacit knowledge into explicit knowledge as one of the central dynamics of knowledge creation process. As tacit knowledge is considered as a key to firm’s competitive advantage and innovation in management literature, considerable attention has been devoted to finding ways to “capture” this resource (Ibid.). Externalization is generally based on metaphors, analogies, concepts, hypotheses, and models. It is claimed that externalization holds the key to knowledge

creation, because it creates new, explicit concepts from tacit knowledge (Chatti, et al., 2007; Nonaka and Takeuchi, 1995).

Most of the arguments of Nonaka and his followers focus on his SECI model, which described how tacit becomes explicit and then leads to new tacit knowledge. According to this model tacit knowledge can be converted or captured in several ways: from tacit knowledge to tacit knowledge (through socialization); from tacit knowledge to explicit knowledge (through externalization); from explicit knowledge to explicit knowledge (through combination); and from explicit knowledge to tacit knowledge (through internalization). Nonaka and his co-authors also proposed a theory of “ba” which is a shared space serving as a foundation for knowledge creation. This theory of “ba” can be associated with Polanyi’s view of how individuals and groups develop the relationships, trust and agreement that allow complex knowledge to be articulated and shared (Grant, 2007).

Social constructivism views knowledge, experience, realities and human understanding as socially constructed through interactions among people (Kothari, et al., 2011). Tacit knowledge comes about when our actions or communications are recursively emphasized. This can occur through a series of social interaction, personal reflection and insight, and through different forms of experiential learning (Tsoukas, 2003). One has to identify the relevant tacit knowledge before actually extracting and applying it in the innovation process. This identification becomes possible when ideas are exchanged and debated (Alwis and Hartmann, 2008). In the process of interaction, a group of diverse

individuals addresses a common problem where each skilled person frames both the problem and its solution by applying mental schemata and patterns (Ibid.). The varying perspectives and intellectual conflict between diverse viewpoints which involve tacit knowledge foster creativity and produces energy (Ibid.).

There is a possibility of visualizing tacit knowledge since it is argued that although tacit knowledge cannot be captured, translated or converted it can be displayed and manifested in what we do (Tsoukas and Vladimirou, 2001). In this regard, even if one does not agree and/or supports that tacit knowledge needs to be externalized, it can be claimed that externalization of tacit knowledge is demonstrated and reflected in its utilization (Sigala and Chalkit, 2007).

According to McIver, et al. (2012) although tacit knowledge is un-specifiable, it doesn't necessarily mean that the skills or know-how cannot be discussed, observed, and learned and it is learned by observation, imitative application, participating in routines, and personal experience. If the knowledge is more easily observed, taught, codified and disaggregated from its context, such kind of knowledge has a relatively low proportion of tacitness and is based on principles, rules, heuristics, and stable relationships that are limited in scope (Ibid.). Under situations where the proportion of tacit knowledge is significant it is hard to observe these forms of knowledge. Such kind of tacit knowledge can be learned and developed by recreating and rehearsing the experiences needed and through learning by doing or through trial and error, experiencing what works and what doesn't, and recreating activities through repetition (Ibid.). Such knowledge which is

difficult to articulate, and often operates at an instinctive or intuitive level is typically built on the unique talent of individuals participating in the practice or on the collaborative know-how and unique blend of complementary skills of a community of participants (Ibid.).

By referring to different authors He and Li (2010) also supported the argument that tacit knowledge can be explicated by deep talks including analogy, storytelling and metaphor; can be attained and transferred through learning and informal communication among people working in technical innovation, and can be exploited and applied using information technology.

All tacit knowledge may not be fully articulated since part of them are at the extreme of embodied knowledge and tied to our physiology and sensory and motor functioning (Nonaka and von Krogh, 2009). But such embodied knowledge enables us to transform certain aspects of our tacit knowledge into explicit through utterance, the articulation of which is experimented with words, concepts and linguistic relationships (Ibid.). A person becomes aware of his or her tacit knowledge while facing a certain situation or problem (Al-Qdah and Salim, 2013). This tacit knowledge becomes a “focal point” of attention or conscious attention and this consciousness makes articulation and thus, externalization of tacit knowledge possible (Tuomi, 1999).

Authors in the “Technocratic” school of thought (e.g. Earl, 2001; Davenport and Prusak, 1998) also suggest that converting tacit to explicit knowledge (codification) is a key objective for knowledge management and this can be done largely by using information

systems – which remove the tacitness (Grant, 2007). This school of thought supports the “social” view of knowledge, for example, the Communities of Practice approach.

Based on Polanyi’s (1966) division of tacit knowledge into focal awareness and subsidiary awareness, Gill (2000) indicated that there is externalization process which is embedded in the explicit knowing which is a result of the combination of focal awareness and conceptual activity. Polanyi’s view also signifies that tacit knowing is the primary source of all knowledge which emphasized a move from tacit knowing to explicit knowing (Ibid.). According to Gill (2000), the externalization process starts at the tacit knowing pole and ends at the explicit knowing pole. This means that the bodily activity of tacit knowledge can move to conceptual activity (concept creation) which together with the focal awareness can result in explicit knowing. Externalization through techniques like metaphors, analogies, demonstrations, stories and illustrative dialogue implies that the knowing subject focuses on his contents of the mind and in a reflective and creative manner analyzes and tries to articulate them (Virtanen, 2011; Martins and Martins, 2011). Such technique in which subjects aim to report their conscious experience is called introspection (Ibid.). Therefore, when Polanyi’s phrase “we can know more than we can tell” is combined with the idea of externalization of tacit knowledge, it seems to have transformed in the form ‘we know only what we can tell’ in the knowledge management literature (Gill, 2000). Polanyi’s subsidiary knowledge enables us to articulate what we can tell.

One of the critics of Gourlay (2006, p. 19) on Nonaka’s (1994) knowledge creation model is that "explicit knowledge is not 'externalized' tacit knowledge, but representations of abstractions from ongoing practices.....". But from the model of

knowledge creation perspective, practices are perceived as a social phenomenon and they allow individuals to acquire tacit knowledge through socialization (Nonaka and von Krogh, 2009). The social practices also constitute hidden “rules” of performance, procedures, problem understanding, problem solutions, and tasks that have the potential to be articulated (Ibid.). These elements lead practitioners towards explicating tacit knowledge and the creation of new explicit knowledge in the process of collectively acting to change practices (Ibid.). To externalize knowledge means to express shared practices and judgments through language (Nonaka, 1994) and a concept captures the blend of experience and imagination (Nonaka et al., 2000).

D’Eredita and Barreto (2006) argued that the same tacit knowledge can be reflected upon when directing the attention of others in an effort to empower them to act in a similar manner yet based on their own, distinctive, ineffable background of episodes with similar goals, interpretations and responses.

Linguistic theory doesn’t support the non-articulation of tacit knowledge (Zappavigna and Patrick, 2010). The authors criticized the linguistic basis of Polanyi’s assertion that tacit knowledge is not carried in language. They argue that there is a way knowledge may be ‘packed-up’ in spoken discourse due to the linguistic patterning employed by a speaker. A distinction is made between articulation and codification. Articulation is saying the words and codification is a post-articulation process of interpreting language according to a structural schema (Ibid.). When we talk, the linguistic patterns that occur are not directly apparent until linguistic analyses are undertaken. At the most elemental level, individuals use words within their mind and with others to think about something. This reflects the views of several researchers who emphasize that language strongly and

directly affects thought. Language is socially constructed and employed by a community of actors (Nosek, 2004).

Byosiere and Luethge (2008) identified four knowledge domains: basic knowledge, experiential knowledge, creative/emotional knowledge and innovative knowledge. They investigated how specific knowledge domains influence different knowledge conversion processes (i.e., socialization, externalization, combination and internalization) in organizations. They finally found out that basic knowledge which includes various explicit components of knowledge like discipline specific knowledge influences only the process of combination. Both experiential knowledge which is grounded in experiences and creative/emotional knowledge which is associated with intuition or technical capability influence three knowledge conversion processes, all of which contain a tacit component: socialization, externalization and internalization. This implied that the emotional and experiential domains of knowledge impact three of the four knowledge conversion processes and they would seem to have a significant impact on the knowledge spiral process described by Nonaka (1994). Innovative knowledge influences internalization since as explicit knowledge is converted into tacit knowledge through internalization, individuals are able to use that tacit knowledge to innovate. This study indicated which domains of knowledge prevail and how that knowledge impacts the conversion and growth of knowledge within an organization.

In the case of Nonaka and his followers, it is assumed that tacit knowledge can be effectively shared via highly dynamic interactions between those with specific tacit knowledge and those without (Brown and Duguid 2000). Articulation and transfer of tacit knowledge requires intense interaction (Oğuz and Şengün, 2011) since it is embedded in

actions, procedures, routines, ideas, values and emotions. It is created within social interaction between individuals, groups and organizations (Nonaka and Takeuch, 1995; Balestrin, et al., 2008). New knowledge comes about when practitioners seek to turn an unreflective practice into a reflective one through reflexive social interaction (Tsoukas, 2003). Tacit knowledge can be observed in actions or behaviors of individuals and become more visible when these actions and behaviors are openly reflected (Nosek, 2004).

Through collective reflection, a shared perception is articulated into words, words develop into phrases and further crystallized into concepts (Hussi, 2004). The conversion of tacit knowledge is therefore, first demonstrated in the process of concept creation which is triggered by dialogue, metaphor, or collective reflection (Chen, 2008). The articulation and amplification of individuals' perspectives through social interaction enhances the social acceptance of these perspectives and contributes to transformation of tacit knowledge into explicit one (Nonaka, 1994).

Our context is participatory innovation environment where individuals with diverse and complementary knowledge come together and collectively seek to articulate their ideas about a new product and technology. In such collective environment actors engage in discussion, reflection, observation, making sense of their findings and codifying what they have learned (McFadyen and Cannella, 2004). The convergence enhances the efficiency of exchange and codification of tacit knowledge of the group. Sharing of experiences and conceptualization through continuous dialogues facilitate externalization of tacit knowledge in the context of self organizing team (Nonaka, 1994). Articulation of idea is most crucial for innovation (Lawson and Lorenz, 1998) and this articulation

enable participants to clarify their ideas and to develop new and more adequate concepts or models about the technology they are trying to develop. Tacit knowledge is unique and context specific and once they are surfaced these tacit knowledge may be transferrable within the same context (Ambrosmi and Veronique, 2001).

Styhre (2009) identified three ways of explicating and sharing tacit knowledge. The first is through socialization and on-the-job training (i.e. practical engagement with material resources and processes). The second is through shared vocabularies and storytelling addressing the tacit elements of a practice. The third is by using artifacts that are capable of capturing elements of the work that is not easily expressed.

In order to understand the relationship between tacit knowledge and its explication by its possessor we need to model the underlying abstract representation and characterize the manner in which such representations are mapped through verbalization (Venkitachalam and Busch, 2012). Our study is based on Nonaka's concept of tacit knowledge, distinct from Polanyi's position, given its dominance and applied focus in the management literature. Based on the above reviewed literature we argue that at least parts of tacit knowledge can become conscious and articulable.

### **2.3.3. Mechanisms of Tacit Knowledge Externalization**

Tacit knowledge is hard to formalize and communicate since it is ingrained in the mind of an individual (Nonaka, 1994). But it can be extracted and shared through highly interactive group deliberation or conversation, metaphors, analogy, narrative or storytelling, hands-on experience, demonstrations, asking individuals the right question on what they do, close observation; mentoring and apprenticeship, cognitive mapping,

and collaborative critical thinking process mediated by a dialogue (Nonaka, 1994; Ambrosini and Veronique, 2001; Sunassee and Sewrya, 2002; Balram et al., 2003; Vat, 2004; Taylor, 2007; McAdam, et al., 2007; Yajun et al., 2008; Chun, et al., 2010; Wu, et al., 2010; Martins and Martins, 2011; Zhang, 2012; Mahrooian and Forozia, 2012; Guddins, et al., 2012). Gesture, body language, uttering, formulating sentence using words and capturing it in writing can also convert tacit knowledge into explicit (Nonaka et al, 1996; Wu, et al., 2010). Once tacit knowledge which is embedded in the human mind is explicated, it can be socially justified and integrated with other's knowledge (Massey and Montoya-Weiss 2006). The description of each mechanism and their roles in the externalization of tacit knowledge are discussed below.

*a) Metaphor*

“Metaphor” plays an important role in the externalization process. It is a figurative language that infers about least familiar concepts on the basis of other familiar concepts. It is a way of understanding and experiencing one kind of thing in terms of another. It is a figure of speech that actually transfers the meaning from a familiar field to an unfamiliar field or replaces the meaning of one word with another. It makes tacit knowledge observable through symbolic comprehension and generating new meaning. It is used when no appropriate word or formal language is available for articulation. For instance, in the expression “My job is a prison,” the term “prison” has two referents. One is the literal prison (the building used to confine prisoners), and the other is the metaphoric prison, the super-ordinate attributive category that the literal prison exemplifies (i.e., the category of things or situations that are unpleasant, confining, oppressive, etc). My job has been classified as belonging to the category “prison,” referring to confining,

oppressive situation. Metaphorical expressions are pervasive in everyday life, in language, in thought and in action. Metaphor relates concepts that are far apart in an individual's memory, associates abstract and imaginary concepts and contributes to elicitation of tacit knowledge. Metaphors help in bringing out tacit knowledge because metaphorical language gives tacit knowledge a voice, make vague and abstract ideas concrete and transmit the entire story visually using one image. Metaphors are vivid images and they may substitute for a large number of words. Metaphors are means of capturing the continuous flow of experience, hence they can be a means of capturing tacit knowledge. (Nonaka, 1994; Ambrosmi and Veronique, 2001; Hussi, 2004; Tsoukas, 2009; Chennamaneni and Teng, 2011; Guddins, et al., 2012; Al-Qdah and Salim, 2013).

Schön (1983) elaborated the role of metaphors in articulating abstract ideas as follows. Product development researchers were trying to find ways of improving the performance of a new paintbrush made with synthetic bristles. Following several conversations in the group and a lot of trial and error, a researcher observed that "*a paintbrush is a kind of pump.*" This is a metaphorical reclassification through which properties of the super-ordinate category "pump" are attributed to the topic "paintbrush." A pump is an instrument that moves liquid from one place to another by pushing or sucking it through a channel. A paintbrush can be described as being a pump because it is a pump, in the sense that it belongs to the super-ordinate category of tools that push or suck liquid through a channel. This reclassification has drawn new distinctions and researchers noticed the space between the bristles and think of them as channels through which paint can flow. Researchers had "unarticulated perception of similarity" derived from experience but through in search of the similarity they were able to articulate the

similarity perceived by formulating explicit metaphorical representation between a pump and a paintbrush. They were able to map a set of relations obtaining in the former onto the latter.

### ***b) Storytelling***

Storytelling or narrative is the process of narrating tales to explain a point and to effectively transfer knowledge about organizational managerial systems, norms, values and culture. It is a powerful tacit knowledge transformation tool since it is used to uncover, capture, organize and convey tacit knowledge by allowing participants frame their experiences in stories and add meaning and context to the ideas and facts. Narration is often considered as a useful insight to tacit knowledge and plays a central role when conveying it. Personal knowledge can be made explicit through telling a story on the failed attempts to the implementation of a technology. Narrative skills are important for collective mind because stories organize know-how, nuance, sequence, multiple causation, means–end relations, and consequences into a memorable plot. It serves as a repository of community’s tacit knowledge. Storytelling could be oral, written, filmed, or illustrated with a very specific structure and chronology. (Korgh, 1998; Ambrosmi and Veronique, 2001; Swap et al., 2001; Tsoukas, 2005; Styhre, 2009; Venkitachalam and Busch, 2012; Al-Qdah and Salim, 2013).

### ***c) Dialogue***

Dialogue is a joint activity between at least two speech partners, in which a turn-taking sequence of verbal messages is exchanged between them, aiming to fulfill a collective goal. It is a form of face-to-face communication between persons, is a process in which

one builds concepts in cooperation with others and it is a means for verifying one's ideas, hypothesis or assumptions (Nonaka, 1994). Through dialogue participants further articulate their tacit knowledge (experiences, feelings), achieve a common understanding through collaborative meaning making and generate novel conceptual combinations. In a dialogue social actors actively engage in sense making by interpreting the social world through conversation and textual accounts, explanations offered and accepted, and ongoing discourses that describe and make sense of the social world (Nosek, 2004). This group sense making is the basis for building shared meaning and externalization of thoughts. It facilitates the mutual co-development of ideas. In dialogue tacit perspectives are converted into explicit concepts. Participants address unsettled issues through reasoning, such reasoning definitely embeds tacit knowledge and tacit knowledge is externalized through verbal exchange of reasons. In productive dialogue individual contributions can be integrated and a common language can be easily built to deal with the issue at hand. Extensive dialogue among team members generates novel conceptual combinations. Concept creation involves a difficult process of externalization, i.e., converting tacit knowledge (which by nature is hard to articulate) into an explicit concept (Nonaka, 1994). This challenging task involves repeated, time-consuming dialogue among members (Ibid). Through dialogue participants further articulate their tacit knowledge where individuals take distance from their customary and unreflective ways of thinking and acting (Nonaka, 1994; Tsoukas, 2009).

#### ***d) Apprenticeship/Mentoring***

Apprenticeship is a method of learning a skill under the care and guidance of a master which facilitates the transfer of tacit knowledge not through language but through sharing

experiences, observation, imitation and practice. The specialized knowledge and skill can be transferred from the domain expert to the novice so that the novice can acquire the same level of competence as the expert within a specified period of time. Mentoring is also a means for transferring tacit knowledge through pairing a more experienced, or more knowledgeable person with less experienced or less knowledgeable person through an ongoing relationship of learning and dialog. In both apprenticeship and mentoring the master shows the apprentice the skill, over and over, while the apprentice then tries to imitate the skill that he/she sees. After widely practicing the skill for a specific period of time the apprentice acquires almost the same level of competence as the expert. Therefore, both systems are places where the novice gains tacit knowledge from the hands on experience passed on by the apprentice master. In the organization context it is possible to mix employees in different levels of experiences in order to guarantee tacit knowledge transfer among expert employees and novices (Hussi, 2004; Byosiere and Clarke, 2010; Al-Qdah and Salim, 2013).

*e) Exploration and Experimentation*

Active exploration and experimentation are the critical mechanisms for externalizing tacit knowledge (Gourlay, 2006). Exploration refers to learning and knowledge development through the exploration of new possibilities. Exploration can be thought of as the invention or discovery of a new technology. The essence of exploration is experimentation and new alternatives.

*f) Observation*

Observation is a means of building personal knowledge through observing the action of an expert and his/her explanation on how he/she performs a critical task. Such

observation is recognized as a fruitful form of learning. There are various types of behaviors that can be observed from individuals or groups. Some of these behaviors are converted from internal behaviors to external behaviors which represents externalization of tacit knowledge into explicit knowledge. The observer earns insights into expert's practices and builds his/her personal knowledge base. The observer, after observing the experiences of an expert, modifies his own behavior, to gain the needed results. In the group context when new actions (range of techniques, abilities or skills) are introduced, individual members observe the available actions and learn what works and what doesn't when initiating collective action. These observations remain part of people's group-related experience, but it may not need to be articulated to them. (Nonaka and von Krogh, 2009; Chennamaneni and Teng, 2011).

***g) Learning by Doing***

It refers to the capability to improve performances by regularly repeating the same type of action, through practice, self-perfection and minor innovations. Tacit knowledge can be activated in the process of learning new production methods and improving existing technology through minor improvements based on learning-by-doing, and based on learning-by-using. Therefore, tacit knowledge is learnt by doing. (Alwis and Hartmann, 2008; Al-Qdah and Salim, 2013).

***h) Best Practices and Lessons Learned***

Best practices are the ways of performing tasks that produces excellent results. They are the processes that have been established and perfected over a period of time. Lessons learned also involve identification, analysis and capturing of processes

that went well and the processes that need improvement. Results are shared with other team members so that they can learn from experiences of others and come up with innovative ideas for further improvement of the processes. They are considered as guidelines, points, or checklists of what went right or wrong, in a special event. (Chennamaneni and Teng, 2011a; Al-Qdah and Salim, 2013).

*i) Modeling techniques*

Modeling techniques such as concept mapping, repertory grid, etc. also elicit tacit skills by helping participants to reflect on their behaviors and by representing their mental models in graphical format (Ambrosini and Veronique, 2001; Rodhain, 1999; Carrico et. al., 1998). Representation of mental models in graphical format results in clear explanation and articulation of ill-structured problems.

Concept maps are very important techniques for representing individual's or several individual's mental models in graphical format to facilitate the elaboration and exploration of his/her own belief and value system in relation to particular issues (Al-Qdah and Salim, 2013). Concept maps are drawn using nodes and links, nodes representing concepts while links representing the relation between concepts. Most of the links are causal and can be none, uni- or bi-directional. Concept maps help individuals to externalize their tacit knowledge through continually asking them to reflect on their behavior and on what they are doing that's causing success. The repeated questioning and reflection help elicit respondent's tacit skills (Nonaka, 1994).

*j) Asking Question*

Asking question applies to the extraction of tacit knowledge of experts. Expertise develops through repeated exposure to similar problems, given prior explicit training. Asking experts the right question, how do you do that? is one way of transforming tacit knowledge into explicit. Through reporting experts can also externalize their tacit knowledge and guide decisions, plans, interventions, improved practices, etc. In this case, the skills are tacit simply because nobody has asked the right question, people never thought of what they were doing, they never asked themselves what they were doing, and nobody else ever asked it either. A good interviewing skill is required in order to surface the tacit knowledge held in the subconscious. An interview guide could be developed and it can be unstructured, semi-structured or structured. unstructured interviews provide a rough map of the domain expert's territory, semi-structured interviews provide a broad picture of the whole domain and structured interviews provide a clear picture of the specific part of the knowledge base. The experts' tacit knowledge which is externalized through asking question can be used to develop directives (rules, standards, procedures, and instructions) for efficient communication to non-specialists. (Alavi and Leidner, 2001; Ambrosmi and Veronique, 2001; Marra, 2004; Gourlay, 2006; Chennamaneni and Teng, 2011; Guddins, et al., 2012).

#### ***k) Visual Representation***

Visual representation is capable of communicating meaning symbolically and helps to articulate, exchange and understand tacit knowledge behind that visual representation. Effective use of visual representation for transferring tacit knowledge requires a great deal of shared understanding on what they are and how they can be used to denote the abstract world. It is claimed that picture is often worth 'a thousand words'. Multimedia

products provide rich contextualization of new knowledge in which viewers can witness events in great visual detail and approach the experience of the actual participants. Although optimal tacit knowledge transfer requires co-presence, it is possible to provide different media to meet the challenges of tacit knowledge transfer in a situation where co-presence is impossible. Tacit knowledge can be effectively transferred via rich media, such as simulation video, rich textual accounts (vignettes), imaging best possible actions, etc. For instance, commanders learn tacit nuances of emotional reactions and leadership tactics just by watching videotapes. It is possible to embed the tacit within explicit content by exposing members to multiple accounts, telling in multiple ways of the perspectives derived from real experience. A combination of digitized video and hypertext multimedia technologies may be best option for capturing and transferring contextual and tacit knowledge. (Daft and Lengel, 1986, Thomas, et al., 2001; Styhre, 2009).

### *1) Prototyping*

Prototyping is an iterative evaluation of the proposed system being built. It is extremely useful in eliciting tacit skills that are inexpressible in words but can be nevertheless be conveyed by pointing (Chennamaneni and Teng, 2011). In business organization, a typical model is the prototype that represents the product concept (tacit knowledge). The prototype's specification is then explicit knowledge (Nonaka, 1994). Prototypes provide a mechanism for recognizing the maximum level of information with a minimum of energy (Ibid.).

### *m) Analogy*

The term analogy come from Greek word, which means a cognitive process of transferring meaning or knowledge from a particular subject (the analogue or source), to another particular subject (the target). Analogies are used to compare knowledge or messages to determine their similarities and differences. It reduces ambiguity by highlighting the commonness of two different things and synthesizes diverse perception and images into a common expression. It also explores new concepts by referencing to things that are already understood. Metaphor and analogy are often confused. Analogies compare things so that you can see a relationship between them. They demonstrate how two seemingly different things are actually quite similar. However, the analogy isn't a figure of speech. An example of analogy is "sick is to healthy as happiness is to sad" or "Fire is to hot as ice is to cold" (based on the relationship between antonyms/synonyms). It is also possible to establish a relationship between words, such as parts of a whole, or cause and effect. Analogies are comparisons, and metaphors are mechanisms for making those comparisons using figures of speech. The association of meanings by metaphor is mostly driven by intuition, and involves images. On the other hand, the association of meanings through analogy is more structural or functional and is carried out through rational thinking. (Nonaka, 1994; Korgh, 1998; Chennamaneni and Teng, 2011, Al-Qdah and Salim, 2013).

### *n) Brainstorming*

Brainstorming is a process of generating creative ideas and solutions to the problems, through intensive group discussion. It is a popular technique for capitalizing on the

respective insights and intuitions (tacit knowledge) of a group of individuals. During the brainstorming process, participants are given free rein and are asked to produce any or all possible solutions to a given problem. Since everyone in the team participates, brainstorming usually results in generating a large number of ideas. Analysis, discussion, or criticism of the displayed ideas is allowed, only when the brainstorming session is over and evaluation session begins. Brainstorming helps participants break out of their thinking patterns, look at things in a new way and articulate their tacit knowledge. (Alwis and Hartmann, 2008; Al-Qdah and Salim, 2013).

*o) Reflection on Action or Behaviour*

Tacit knowledge emerges through open reflection on actions or behaviors since it can be explicitly shown as a skillful activity (Nosek, 2004; Chennamaneni and Teng, 2011).

#### **2.3.4. The Role of Collaboration and Social Interaction**

Innovation is the product of collective problem-solving leading to the development of new ideas (Farshchi and Brown, 2011). All human knowledge is thus, developed, transmitted and maintained in social situations and knowledge is seen to emerge as people interact recurrently in the context of established routines and procedures (Newell et al., 2004). Creation, sharing, amplifying, enlarging, justifying and utilization of knowledge takes place most effectively in groups and teams, which share common purpose and beliefs (Nonaka, 1994; Al-Qdah and Salim, 2013).

Collaboration allows assembling, integrating and applying of the diverse tacit knowledge and expertise of individuals in solving the problems at hand (Janhonena and Johanson,

2011). Therefore, collective knowledge is found in relationships and individuals contribute their tacit knowledge to the group. Collective relationship enhances building of common knowledge constituting language, symbolic communication, commonality of specialized knowledge, shared meaning, and recognition of individual knowledge domains (Nonaka and von Krogh, 2009).

It is claimed that due to its nature, tacit knowledge is more than likely to be externalized and integrated through social interactions than formal organizational structures and processes (Sigala and Chalkit, 2007). New knowledge is created in the process of interaction and building of shared understanding on the knowledge that each actor possesses. The tacit knowledge which is inherently rooted in individual members' experience, expertise and cognitions is converted into group level tacit knowledge through social interaction (Erden, et al., 2008; Robert, et al., 2008). Tacit knowledge is therefore, embedded in social interactions and is actualized in common practices (Bouwen and Taillieu, 2004).

### **2.3.5. Factors Affecting Tacit Knowledge Externalization Process**

The establishment of trust, incentive and sharing mechanisms; creating an interactive physical or virtual environment; building a knowledge-oriented culture and improvement of the knowledge entity's ability to absorb tacit knowledge are cited as determinant factors to the transfer efficiency of tacit knowledge (Senaratne and Sxton, 2008; Xu and Chen, 2010). Differences in personality, values, preferences, interests, experiences, or communication skills can also affect the smooth flow of tacit knowledge (Nonaka and von Krogh, 2009). The unconsciousness of tacit knowing and/or the difficulty in externalization may also cause loss of knowledge in the process of externalization

(Senaratne and Sxton, 2008). Tacit knowledge embedded in actors and artifacts may not be explicable in total and it is learned through ongoing interaction (Bossen and Dalsgaard, 2005). The determinant factors for externalization of tacit knowledge are discussed as follows:

*i. Creating Interactive Physical and Virtual Platform*

A specific context of time, space and relationship, which is termed by Nonaka (1994) as 'ba' or shared space or platform, is a pre-requisite for externalization and sharing of tacit knowledge. The concept of 'ba' represents a physical space (meeting room), virtual space (e-mail or a virtual community) and mental space (shared ideas and mental models) or any combination of these (Nonaka and Konno, 1998; Nonaka et al., 2006; Balestrin, et al., 2008). It is a space where innovations involving different stakeholders occur and their tacit knowledge is socially constructed, externalized and enacted through interactions (Hussi, 2004 and Harmaakorpi and Melkas, 2005). It promotes interaction, social learning, social capital formation, and collective action by involving diverse actors (Thiele, et al., 2010). Through this platform it is possible to achieve changes which none of its members could have achieved on their own (Thiele, et al., 2010).

Ba provides a place for the individual to move along the knowledge spiral – socialization, externalization, combination and internalization through originating ba, dialoguing ba, systematizing ba and exercising ba respectively (Nonaka, 2004; Nonaka, et al., 2002). For externalization, which is the focus of this study, the dialoguing *ba* enables individuals to share their mental models, experiences, emotions, know-how and abilities and convert them into new commonly accepted explicit terms and concepts by means of dialogue and collaboration (Hussie, 2004). The shared space accelerates the explication of tacit

knowledge which is shared by members (Nonaka, 1994). Solving the complex and multidimensional agricultural problems require divergent perspectives of key stakeholders and depends on nurturing the relationship and interaction of key stakeholders. This is manifested by the process of creation of concepts for new technologies in the dialoguing ba. Therefore, tacit knowledge is best shared and cultivated in a dialoguing ba energized by climate of love, care, trust and commitment (Tee and Karney, 2010).

*ii. Cognitive Competence/ Knowledge Capability*

When tacit knowledge is externalized there are five stages: provider's cognitive system, externalization, knowledge object, interpretation and receiver's cognitive system (Wu, et al., 2010). Tacit knowledge externalization is based on the provider's cognition characteristics and once tacit knowledge is externalized it becomes embedded in knowledge objects. Once tacit knowledge is externalized into the knowledge object, its interpretation and comprehension is likely carried out by the knowledge receiver through his or her cognitive system that stores and structures the received objects (Ibid.) Therefore, externalization and transfer of tacit knowledge depends on the cognitive competence or knowledge capability of both the provider and the receiver. The tacit knowledge provider is expected to have a cognitive status of understanding and explaining the tacit knowledge ingrained in his/her mind using his/her expression media including word, sentence, gesture, body language, etc. (Ibid.). The tacit knowledge receiver should also have the ability to absorb the externalized tacit knowledge (Xu and Chen, 2010). Absorptive capacity consists of acquisition, assimilation, transformation, and exploitation capabilities pertaining to tacit knowledge articulation and utilization

(Sigala and Chalkit, 2007). Absorptive capacity does not only impact on knowledge externalization, but also on the ability to use tacit knowledge.

Group tacit knowledge depends on the variety in capabilities of group members where each individual has specific strengths and weaknesses and the optimal way of doing things, solving problems, and performing tasks may change from person to person (Erden, et al., 2008). Despite the possible existence of discrepancy in knowledge capability among members a group with tacit knowledge may still act as a “collective body and mind” by compensating the weaknesses via dynamic coordination and heedful interrelating (Ibid.). The competency of insightful individuals in the group enables them to build influencing skills (communication, assertiveness, dealing with conflict, persuading and developing others) as well as to cultivate sharing attitudes (Choudrie and Selamat, 2004). These influencing skills and sharing attitudes assist them to externalize and diffuse their tacit knowledge through the medium of ideas, actions, reactions and reflections. In addition, there must be someone who translates the knowledge for the participants of the innovation process, called by Burt (2004) as brokerage. Actors who have suitable connections and/or skills can act as brokers, bringing together the members of heterogeneous groups (Burt, 2004). Such brokers play a key role in transferring best practices and help members of the innovation group to cross greater distance (Hennala, et al., 2011). Members of the innovation group who assimilated new knowledge are expected to actively process it by experimenting with its application to new problem domains and environmental contexts.

### *iii. Social Capital Factors*

The extent of embedded tacit knowledge in social interaction and its role in collaborative innovation depends on social capital. Social capital is defined as the interpersonal relationships of a person, as well as the resources embedded in those relationships (Nahapiet and Ghoshal, 1998). It is a collective resource emerging from and embedded inside a social network, as a result of the interconnected relationship of its members (Nov, et al., 2012). The three dimensions of social capital include structural, cognitive and relational capital.

#### *Structural Capital*

The major element of structural capital is the degree of closure or interconnectedness among members of the social network (Nahapiet and Ghoshal, 1998). It includes properties like tie strength, structural holes, and centrality (Zheng, 2010). Tie strength is strength of relationship among member of the social network. Strong ties among members of the group make the flow of tacit knowledge and innovation easier since it increases the level of trust and creates favorable condition to establish common norms and aims (Zhang, et al., 2012). The more the strength of social ties, the greater the amount of knowledge embedded in the network (Jun and Weigu, 2008). The strength of social network stimulates the process of creating new knowledge and innovative practices through transfer of experience and establishment of group knowledge and group skills (Natalya, 2010). Individual tacit knowledge, a critical element for building new knowledge, also proliferates through social networks (Costa et al., 2008). The embedded

knowledge is an asset both to the individual members of the network and to the social network as a whole (Ibid.).

Structural hole or sparse network allows the group to have access to new ideas from people with diverse perspectives, different outlooks, varying interests, and diverse approaches to problems (Rost, 2011). The innovation group may benefit most from widely dispersed and diverse knowledge networks with many non-redundant linkages outside the group (Büchel et al., 2013). Innovation in agricultural sector not only depends on scientific knowledge of agricultural researchers, but also on better visibility of local solutions developed by innovative farmers (Pattanaik and Chatterjee, 2009). Experiential, local and contextual knowledge of farmers can be embedded in to scientific and abstract or de-contextualized knowledge of the agronomist through social networking and interaction (Bouwen and Taillieu, 2004). The diverse tacit knowledge acquired in the diverse social practices is a source of creativity and can generate alternative scenarios during participatory group deliberations (Balarm et al., 2003; Nonaka and von Krogh, 2009).

Structural capital also constitutes hierarchies and the existence of power imbalance could inhibit the effective interaction and collaboration among stakeholders. A structure that is characterized by a high degree of decentralization is proposed by Wu (2008) as factors that facilitate tacit knowledge elicitation and sharing.

### *Relational Capital*

Relational capital refers to personal relationships individuals have developed with each other through a history of interaction such as trust, obligations and expectation, and

identification (Nahapiet and Ghoshal, 1998). Trust is defined as assuming the best when interpreting another's motives and actions (Zheng, 2010). High trust increases the willingness of people to engage in social exchange, cooperative interaction and innovation (Farshchi and Brown, 2011). It is the basis for successful negotiations, open communication, collaboration and knowledge sharing (Zheng, 2010). Articulation of tacit knowledge and the process of concept creation in a self-organizing team require interaction and strong social ties based on reciprocity and building of mutual trust among members (Venkitachalam and Busch, 2012). Exchange partners who trust each other and share competencies and expertise are in the best position to recognize knowledge and to create value: they understand each other, exchange tacit knowledge, show a higher willingness to take risks, and have greater openness (Nahapiet and Ghoshal, 1998). High degree of trust develops from strong ties which becomes the basis for greater resource commitments to the relationships. Norms are more related to organizational culture in the form of implicit rules that regulate members' behaviour by demonstrating what are appropriate or inappropriate attitudes and behaviors (Zheng, 2010).

### *Cognitive Capital*

Cognitive capital mainly refers to shared code that facilitates common understanding (Tsai and Ghoshal, 1998). It is embodied in attributes such as shared representations, behavioral and linguistic codes, systems of meaning, paradigms, understandings and interpretations (Ibid.). Cognitive dimension of common set of goals and values as well as shared languages, codes and practices facilitate the process of social interaction and thus, tacit knowledge articulation.

One of the pre-requisites for externalization of tacit knowledge is language which converts personal knowledge into explicit knowledge through concept creation (Korh, 1998; Chen, 2008; Gubbins et al., 2012; Virtanen, 2011). To serve this purpose the language has to be socially justified and known and accepted by the team members (Korh, 1998). Common language makes access to other peoples' ideas so easy. Ability to communicate and exchange ideas and shared language are essential to establish common understanding and facilitate participatory innovation process. With appropriate use of language most of the tacit knowledge can be shared between individuals who share a mutually agreed language (Gant, 2007). Linguistic presentations or expressions are requirements of externalization since they represent translations of experiences or mental representations that can be transmitted to other individuals (Virtanen, 2011). The role of language is significant in the articulation and codification of knowledge and central to any language are concepts and vocabulary (Lawson and Lorenz, 1998). When new knowledge is created innovative vocabulary is used to correctly represent it and make it easily understandable to the community. Metaphors, analogies, storytelling, etc. means linguistic presentation of the externalized concept. The degree of explicitness can be closely tied to the use of language. Where there is a high degree of acceptance on the use and specificity of the language used (spoken, written, represented) the knowledge can be highly explicit to most participants (Grant, 2007). The content of internal representation is identified by means of language, and an isomorphism is assumed between the internal representation and the relevant linguistic set of sentences (Ibid.). The concept of isomorphism is used to describe the relationship between the mental representation and the thing that is linguistically represented. From this perspective, Piantadosi (2016)

described that the mental representations we construct are likely to correspond to evolutionarily relevant structures, relations, and dynamics present in the real world. It also implies that the knowing subject (whose tacit knowledge is being externalized) is conscious of the source (the representation) to which his linguistic expressions refers, because we can only articulate and describe things that we are conscious of (Grant, 2007). Codification is complete if each component can be translated into a linguistic representation that successfully reflects its original meaning (Gubbins et al., 2012).

The sharing and exchange of tacit knowledge requires some shared system of meaning (Swan et al., 2000). In the context of participatory innovation where multiple actors participate the generation of novel ideas could create some differences among actors due to unclear and different interpretations. Shared meanings should be created in order to provide an adequate means of sharing and assessing knowledge. Developing semantic capacity and engaging in cross-functional interactions/teams are proposed techniques for building shared meaning (ibid.).

#### *iv. Communication Skill, Method and Media*

The smooth flow of tacit knowledge depends on communication skill (Nonaka and von Krogh, 2009). The chosen communication medium also affects the quality of information, in terms of its richness, spontaneity and speed (Zulaikha and Brereton, 2013). Different individuals prefer different learning formats which impact articulation and sharing of tacit knowledge (Guddins, et al., 2012). Some people rely more on images to learn while others learn better from verbal material and some are mixed processors whom can learn from either format.

**v. *Group Heterogeneity***

Modes of knowledge production are also changing from the conventional disciplinary based mechanism to a new model where knowledge is produced interactively at the point of application among heterogeneous groups (Swan et al., 2000). Heterogeneity in terms of demography, beliefs, education, social status, and occupation is one of the crucial success factors for creating innovation in groups or organizations. By bringing together different practitioners with different biographies, knowledge and interest from diverse areas and groups, it is possible to gain “fresh” ideas, insights, and experiences that allow them to reflect on events and situations (von Krogh et al. 2000). The consensus that can be built through social interaction enables people to converge in their divergent views, interests, objectives, values, beliefs, etc., build common knowledge, implement solutions and achieve outcomes (Balarm et al., 2003).

**vi. *Motivational Factors***

Incentives and stimuli are important for the partners to become involved in collaborative innovation activities and create a situation in which all parties perceive to benefit from the collaboration (Hennala, et al., 2011). The fact that tacit knowledge is by definition personal and context based, that the holder might stand to lose by making it explicit, and that explication requires a supportive environment involving trust and appropriate structures (McAdam, et al., 2007). Individuals may not be willing to give up their individual competitive knowledge advantage unless they are compensated by the benefit it could generate. An intrinsic motivation to generate and transfer tacit knowledge cannot be compelled but can only be enabled under suitable conditions.

***vii. Shared Mental Models***

Shared mental models or shared understanding of members of the innovation group on the subject under consideration enhance effectiveness at the collective level by aligning the expectations and behaviors of individuals (Büchel et al., 2013). If the represented tacit knowledge is familiar to all the stakeholders involved, collaboration and communication will be easy. Shared understanding (or shared cognitions) of the work and cultural context, particularly the behaviors and values that are normative for the group facilitates performance in groups by allowing the members to anticipate and respond to one another's actions in an efficient and coordinated manner (Ibid.).

***viii. Shared Experience***

Without some form of shared experience, it is extremely difficult for people to share each others' thinking processes (Nonaka, 1994). Direct understanding of other individuals relies on shared experience since it is the basis for building mutual trust (Ibid.). It enables team members to indwell into others and to grasp their world from inside (Ibid.). Shared experience also facilitates the creation of "common perspectives" which can be shared by team members as a part of their respective bodies of tacit knowledge (Ibid.). Therefore, shared experience is a pre-requisite for externalization.

## **2.4. ICT and Tacit Knowledge Externalization**

### **2.4.1. Introduction**

Tacit knowledge is mainly articulated through interactions between individuals and collectives. The transformation of knowledge from tacit into explicit should be performed through different types of network structures with the support of state-of-the-art information technologies (Natalya, 2010). Information systems research can play an important role in examining this situation, more specifically, in supporting individual and group level knowledge creation by the use of information systems ranging from storage to communication systems (von Krogh, 2009). Tacit knowledge is externalized for storing and diffusion by different systems. Today there has been much scientific interest in the technology of these systems (Mahroeian and Foroza, 2012). This interest in the information technology (IT) is reflected in the most recent paradigm of knowledge management (KM) and certain IT tools might be implemented to assist in retaining tacit knowledge (Ibid.). In order to evaluate the existing ICTs or to propose the design of new or improved ICT support system, the process of tacit knowledge externalization must be modeled (Wu, et al., 2010). The focus of IT support in a collaborative environment is on interaction and collaboration which facilitate externalization, storage and management of the externalized tacit knowledge (Ibid.). As far as tacit knowledge is communicated via face-to-face interactions there is a need to integrate these social activities within a technological environment. Merging the social with the technical aspect allows the development of knowledge extraction algorithms that attempt to gain a conceptual understanding of these interactions in order to extract tacit knowledge and codify it in a knowledge management system (Ibid.).

Some scholars argue that tacit knowledge is bound to people and, therefore, cannot be externalized, encoded or documented easily and sharing it necessitates the “here and now” interaction of people. These scholars further argue that ICT can never substitute face-to-face interaction where people can share their tacit knowledge (Fahey and Prusak, 1998). Nevertheless, other scholars still believe that ICT may have a major effect in facilitating tacit knowledge sharing (Erden, et al., 2008). ICT can support people to have access to past experiences, best practices, reflections, stories, etc. (Ibid.). The authors provided an example of a system called “Agronomic Brain” where communal and tacit knowledge of people at call centers is visualized while responding to questions from customers. The tool helps leveraging the value of tacit knowledge by linking together hitherto unrelated thoughts and providing comprehensive solutions to customer problems. New tacit knowledge can be created when these solutions are reused on related new problems and reflected upon by the call center agents. This example demonstrates how tacit knowledge can be converted into explicit knowledge and transferred to the community with the support of technology. Technologies like email, chat rooms, collaboration platforms, and bulletin boards, help to develop strong ties and to create group tacit knowledge (von Krogh, 2002). ICT mediated communication creates a forum for constructing and sharing beliefs, confirming consensual interpretation and allowing expression of new ideas (Alavi and Leidner, 2001).

It is recommended that e-agriculture involving conceptualization, design, development, evaluation and application of innovative ways of using ICT in the rural domain should be the primary focus for enhancement of agricultural and rural development (Franklyn and Tukur, 2012). Based on this basic principle we aimed at developing a mobile based

communication system architecture that enhances participatory innovation through articulation and integration of tacit knowledge of multiple actors. ICT supported tacit knowledge externalization and codification creates an important value based on the reuse, availability and fast access to the externalized knowledge (Janicot and Mignon, 2012).

#### **2.4.2. The Role of ICT in Tacit Knowledge Explication and Sharing**

There are two types of ICTs that can be used in the externalization and formalization of tacit knowledge (Janicot and Mignon, 2012). One is an interactive technology which provides shared space for individuals to exchange their tacit knowledge and the other is integrative technology that disseminates knowledge through a network in the form of a database. The representation of knowledge objects is an important element in the role of IT to tacit knowledge codification and interpretation (Wu, et al., 2010). As far as a component of tacit knowledge could be codified, one way of storing such knowledge would be through knowledge repositories (Venkitachalam and Busch, 2012). Tacit know-how particularly useful in solving a problem can be entered into knowledge base. In the process of tacit knowledge externalization metaphors, stories, analogies, etc. which are deployed by the provider can be stored as data objects. Therefore, from the perspective of the knowledge provider's cognitive system main consideration should be given to IT solutions consisting of database technique (Wu, et al., 2010). Application of database in the process of tacit knowledge externalization and storage should provide features for codification of tacit knowledge and integration of a real face-to-face knowledge interaction into a personalized knowledge transfer strategy (Ibid.). In the process of building such databases Wu, et al. (2010) proposed three steps. The first step is defining the techniques of acquiring tacit knowledge from experts, such as concept map, decision

tree, causal map, and metaphors. The second step is defining the attributes of the database used to model and manage knowledge objects and relations. The third step is, conducting the experiment based on samples (controlled and non-controlled), building tacit knowledge transfer environment, implementing test, collecting and analyzing the data and comparing the results. When tacit knowledge is externalized and stored in the database in a particular form, it must allow the retrieval and repeated operation of its codification strategy (Ibid.).

The coding and sharing of best practices and the creation of knowledge networks are considered as key potential areas for technological intervention pertaining to tacit knowledge management (Alavi and Leidner, 2001). In such technology enabled knowledge management process technology is used to aid in explicating, storing, and disseminating knowledge (Ibid.). The technology also creates an infrastructure and environment for actualizing, supporting, augmenting, and reinforcing knowledge processes at a deep level through enhancing their underlying dynamics, scope, timing, and overall synergy (Ibid.). People should be brought together virtually by providing online forums in order to exchange and build their collective tacit knowledge (Ibid.).

Through online communication and discussion assumptions can be surfaced and questioned, new constructs emerge and dialog among different perspectives supported (Venkitachalam and Busch, 2012). In this regard, ICT aids communication of individual tacit knowledge instead of storing it in repositories (Ibid.). Electronic networks or social media tools can help individuals transfer their tacit knowledge beyond the reach of formal channels. Technologies including intelligent agent, groupware, group decision-making support systems, internal and external networks, video conferencing, Web 2.0

technologies, chat rooms, bulletin boards, telephone and e-mail are serving as a tool to enhance interaction among individuals and share their tacit knowledge (Chennamaneni and Teng, 2011; Wu, et al., 2012). Internet also allowed dispersed individuals and groups to collaboratively create the knowledge required by a specific project and work on that same project in a distributed way (Ai and Du, 2007).

The rise of Web 2.0 technologies with more support for collaboration and networking provides new opportunities for social construction of knowledge (Chatti et al., 2007). It is a new generation of user-centric, open and dynamic technology that allows collaborative knowledge creation as well as peer production and sharing of tacit knowledge (Ibid.). Blogs for example support the externalization process by giving voice to everyone and providing a space to capture personal knowledge and distributed discussions across blogs (Ibid.). This technology immediately documents thoughts, and annotates information. Consequently, tacit knowledge that may be expressed but cannot be easily recorded into formal documents and manuals can be verbalized via oral communications (Ibid.). VoIP and phone/video-conferencing for example are powerful tools to trigger externalization via open participation, dialogue, and discussion (Ibid).

Through social networking technologies relevant experiences, lessons learned and other forms of tacit knowledge can be captured as stories, images, videos, audios or any other electronic document (Costa et al., 2008). Such systems can also be designed to support discussion among actors, to store the content and publish the conversation so that others can have access to it (Ibid). New knowledge can develop through dialogues about any subject related to the collective objectives, usually posted as a topic. The content of the dialogue can be stored and made accessible to other members of the group. Social media

facilitates online capturing of context-rich tacit knowledge through recording phone/video-conference and instant messaging sessions (Chatti, et al., 2007).

Pattanaik and Chatterjee (2009) conducted a study on how digital ecosystem approach (the provision of multiple interoperable ICT tools and techniques) can enhance co-creation and delivery of knowledge in the context of Indian agriculture extension system. The technologies were expected to facilitate interaction among different actors like scientists and farmers and to create new knowledge based relationships. Web 2.0 applications supported by mobile technologies were used to facilitate exchange of knowledge in an asynchronous communication mode among farmers, extension agents, practitioners and domain experts.

High-media richness and choice of appropriate communication media are the two important aspects of transferring tacit knowledge (Wu, et al., 2010). Multimedia technology may be more appropriate than text based system for certain areas of tacit knowledge transfer. Face-to-face communication is the richest communication medium with multiple cues (facial expressions, body language, general appearance, voice tone) and rapid feedback which is most appropriate for the articulation and exchange of high degree tacit knowledge (Ibid.). For such kind of rich environment real time online meetings such as groupware and Web 2.0 technologies are most appropriate. These technologies permit collaboration and exchange of high degree tacit skills efficiently with fast and focused feedback (Ibid.). The medium degree tacit knowledge can be supported by collaboration systems such as online chat, concept mapping systems, telephone and other groupware technologies. Communication media such as e-mail, voice-mail and

some applications of groupware can efficiently and accurately convey low degree tacit knowledge (Chennamaneni and Teng, 2011).

### **2.4.3. The Potential of Mobile Phone**

Mobile phone is one of the most relevant information and communication technology for low income countries since it has high penetration rate even to the remote rural areas and it is the dominant ICT use sector, where developing countries are quickly catching up. The improvement through the use of mobile technology can be derived from the capability to transfer richer media content in contrast to email and telephone (e.g. video conferencing) (Derballa and Pousttchi, 2004). With support of mobile technology in combination with video conferencing it becomes possible to work out solutions together as a team communicating richer content and thus creating new knowledge in that process (Ibid.). Ubiquity enables the creation of knowledge in a team situation with locally dispersed members (Ibid.). The key benefits of mobile phone are portability, flexible content delivery capability and two way communications to deliver low-cost but highly customized solutions (Mittal and Tripathi, 2009). Farmers in low income countries like India, Mozambique, Tanzania and Senegal are accessing critical agricultural data and they are making business decisions by using their mobile devices (Furuholt and Matotay, 2011). Mobile phones support problem solving through consultation and remote diagnosis and provision of information pertaining to managing their natural resources (soil, water, trees, growing crops, etc.), remittance, market price, government and legal requirements, etc. (Ibid.). Mobile phones are also used for voice recording and diffusion of agricultural lessons and best practices as well as for capturing phone conversations when remote diagnosis is provided for a group (Martin and Abbott, 2011).

When it comes to externalization process the most appropriate is an information system application which places emphasis on a dialogue-based digital conversational method that can assist interactive communication (Wu, Kao, and Shih, 2010). Mobile phone technology provides a huge potential towards enhancing social networking and taking advantage of social capital to exchange information and improve crop yields and livestock production (Martin and Abbott, 2011). It is contributing to the expansion and strengthening of social networks through engaging farmers in interactive communications and dialogues (Furuholt and Matotay, 2011). In India farmers call a hotline, ask questions, and receive responses from agricultural scientists and local extension workers. Callers can also listen to answers to questions posed by other farmers and respond to questions themselves. Semi-literate farmers can use such systems since mobile-based technologies are developed with features of a touch-tone navigation system with local language prompts.

Mobile phone can be used to capture significant proportion of rich case-story data using voice recording and still images. Both voice and still images are natural means for capturing fleeting thoughts and events. Many studies have also emphasized storytelling with digital photos and augmenting photo with audio has gained increasing interest (Goyal, 2011). Video technologies which are embedded in mobile phones can also support externalization and transfer of tacit knowledge by providing moving images, technical and conceptual data, etc.

## 2.5. Review of Related Works

### *Taxonomies of Tacit Knowledge*

Al-Qdah and Salim (2013) examined the present literature on managing tacit knowledge in Multi National Corporations (MNCs) and identified and defined different types of tacit knowledge including intuition, skills, insights, know-how, beliefs, mental models, practical intelligence and behaviors.

In their study on the dichotomies within tacit knowledge, McAdam, et al. (2007) examined the definition and conception of tacit knowledge in existing peer reviewed literature and suggested research agendas that facilitate the understanding of tacit knowledge for praxis. One of the areas they identified was the need for improved understanding of epitomes (subtypes) of tacit knowledge in order to better conceptualize and apply tacit knowledge. Based on their in-depth review of literature they identified the most frequently used epitomes of tacit knowledge that included practical intelligence, mental models, know-how, beliefs, intuition, skills, and insight. The authors supported that the degree of tacitness or abstraction varies from varies from completely abstract to quite concrete in the concepts used. An epitome such as intuition, hunches, gut-feelings, feelings, beliefs are considered abstract or intangible in the sense that they cannot be tapped into by others than those involved in the specific situation. Insights, talent, judgment, rules-of-thumb, and practical intelligence are considered intangible but more concrete results expressed in behavior or in the work outcomes and can appear in more tangible forms. Best-practice, skills, improvisation, instinctive, reaction and ability are considered as highly visible. The authors claimed that an extended concept of tacit

knowing and its associated epitomes offers new possibilities to study tacit knowing. They also supported that as far as tacit knowing is seen as less personal and abstract there are new possibilities to create methods that enhance tacit knowledge diffusion. In addition, they affirmed that if it is to be used in knowledge management systems, tacit knowledge needs to be made explicit.

D'Eredita and Barreto (2006) conducted a research on how tacit knowledge proliferates in the organization from episode perspective. They forwarded three propositions. One proposition is that tacit knowledge is episodic, thus personal, context-specific and acquired through experience. The second proposition is that experience results from the construction or relating of episodes, but does not necessarily result in specifically 'intended' tacit knowledge. The third one is that the proliferation of tacit knowledge within an organization is the result of a constructive and collaborative process by which two or more individuals collectively focus attention, thus collectively construct relatable episodes.

In their study on operationalization of tacit knowledge Ambrosini and Veronique (2001) also demonstrated the existence of different degrees of tacitness. They categorized deeply ingrained tacit skills under high degree of tacitness, tacit skills that can be imperfectly articulated under medium degree of tacitness and tacit skills that can be articulated and the explicit skills under low degree of tacitness.

### ***Tacit Knowledge Externalization***

AlMulhim (2017) studied the associations between knowledge creation processes and organizational performance in knowledge-intensive banks in Saudi. The author used four modes of knowledge creation of Nonaka's model, which include externalization, socialization, internalization, and combination. He administered 214 questionnaires to investigate the extent to which Saudi banks perform knowledge creation process and performance activities. The results of the study confirmed that externalization process had the most positive influence on organizational creativity followed by internalization, socialization, and combination processes, respectively. The result also demonstrated that externalization occurs through encouraging innovative and helpful discussions among individuals and groups which were facilitated by face-to-face and online discussions in the Saudi banks. Groupware was also identified as one of the preferred tools for externalization. The author also argued that the study backs the opinion that the Nonaka model (SECI) is universal, but the utilization of each process is subject to leadership support, type of task, and cultural context.

In their study on amplification (externalization) of tacit knowledge Slettli and Singhal (2016) demonstrated how tacit knowledge can be identified and amplified through a problem-solving approach known as Positive Deviance (PD). The study identified positive deviants as major carriers of the authentic experience and valuable tacit knowledge. The authors confirmed that tacit knowledge of these positive deviants can be externalized and amplified through breaking the existing "mental prisons" of the

community and creating favorable conditions to facilitate “paradigm shift”. They demonstrated how unearthing of tacit knowledge through PD serves as a source of creativity and inspiration for finding efficient solutions for intractable problems in communities or organizations. Breaking out of existing mental prisons, involvement of community members and their own self-discovery as well as representing solutions through social proof were identified as major mechanisms of knowledge amplification and conversion.

Rosário, et al. (2015) developed a methodology called Method for Acquiring Collective Tacit Knowledge (MACTAK) that can be used to transform collective tacit knowledge into the explicit one using knowledge elicitation techniques. A method called systemography was used to map and transform collective tacit knowledge into explicit one. Systemography was applied to structure the sequence of activities used for eliciting tacit knowledge as well as understand and interpret the phenomenon in a systematic way. Two expert systems were used to represent the elicited tacit knowledge in a symbolic language and production rules. The authors demonstrated that the collective tacit knowledge became explicit because it was modeled in the knowledge base of the expert system. They also argued that MACTAK methodology is different from other methods of Knowledge Based Systems and was developed for exclusive use in industrial processes.

Bratianu (2016) perceived knowledge dynamics (its conversion from tacit into explicit) from a new perspective of energy metaphor and the theory of multifield knowledge spectrum. From multifield theory of knowledge the author took the assumptions that

three fields of knowledge - rational, emotional, and spiritual knowledge exist at individual and organizational level. Using energy metaphor they argued that the three fields of knowledge are in a continuous interaction and knowledge from each field can be transformed into the knowledge of any other field. They assigned transformation of potential mechanical energy into kinetic energy to represent conversion of tacit knowledge into explicit knowledge and vice versa. Transformation of mechanical energy into thermal energy was used to represent the transformation of rational knowledge into emotional knowledge and vice versa. Transformation of mechanical energy into electrical energy was used to represent the transformation of rational knowledge into spiritual knowledge and vice versa. Transformation of thermal energy into electrical energy and vice versa was used to represent the transformation of emotional knowledge into spiritual knowledge and vice versa. The author concluded that transferring the main attribute of energy and the main principle of transformation coming from thermodynamics in the knowledge domain overcome many barriers from the knowledge dynamics model proposed and developed by Ikujiro Nonaka and his colleagues.

Al-Qdah and Salim (2013) identified mechanisms for creation of new tacit knowledge and to externalize that tacit knowledge in a way that will be transferable to other individuals. The mechanisms include community of practice, observations, apprenticeship, mentoring, metaphors, analogies, storytelling, expert interviews, best practices, lessons learned, learning-by-doing, concept maps, casual map and brainstorming.

Being grounded in knowledge creation theory, social cognitive theory and media richness theory Chennamaneni and Teng (2011) examined the characteristics of tacit knowledge and developed an integrated framework for effective tacit knowledge transfer. Their study focused on identifying the appropriateness and relevance of various knowledge transfer mechanisms and the communication media types for different degrees of tacitness. The framework they proposed mapped knowledge transfer mechanisms and communication media to varied degrees of tacitness in knowledge. They finally proposed the need to validate the framework through an assessment by panel of experts as well as by lab experiments.

Goffin and Koners (2011) conducted a study on tacit knowledge, lessons learnt and new product development. Their core argument is that much of the knowledge generated in new product development is tacit and requires a close look and understanding based on empirical evidence which is lacking in the extant literature. They conducted five in-depth case studies at leading German companies using repertory grid technique, inspection of company process and project documentation and observation. They supported that metaphors and stories are an important aspect of articulating tacit knowledge which is generated in the form of lessons. They recommended further research to demonstrate the importance of tacit knowledge and the frequency of metaphors and stories in the context of new product development.

In their study on enabling tacit knowledge diffusion through meta-abilities for organizational learning, Choudrie and Selamat (2004) demonstrated how individual's

ability to externalize and share tacit knowledge can influence the diffusion of this knowledge. They conducted an in-depth interviews and structured questionnaires by involving the top and middle level managers and came up with a framework. According to the framework the meta-abilities (cognitive skills, self-knowledge, emotional resilience and personal drives) create individual influencing skills and sharing attitudes, and the influencing skills and sharing attitudes externalize tacit knowledge through the medium of ideas, actions, reactions and reflection (I-A-R-R). They concluded that future focus when examining the diffusion of tacit knowledge should be towards an individual's meta-abilities development.

Hemmecke and Stary (2004) introduced a conceptual framework (activity theory) and a procedural framework embedding repertory grids that enable externalization of tacit knowledge. A special interview technique, the repertory-grid technique was applied to the elicitation of expert knowledge. Critical-incident interviews were also used to relate repertory grids to work activities. They used formative evaluation to test and redesign the mechanisms for tacit knowledge externalization. They tested the framework and methods on trial in two case studies. They proved that the repertory-grid and critical-incident interview technique were effective in externalizing and sharing tacit knowledge. They argued that “in order to facilitate knowledge sharing between communities it has to occur partly decontextualized from the actual work practice and background of the involved communities. Such a process can only happen when the socially embedded tacit knowledge can be externalized and encoded by explicit knowledge.” They claimed that through repertory-grid members of the involved communities might engage in the

generation of new knowledge co-operatively leading to the co-construction of knowledge.

Ambrosini and Veronique (2001) supported that tacit skills can be imperfectly articulable or articulable if one could find the right trigger to allow the individuals to express them. They proposed causal mapping as a useful method to elicit tacit knowledge. The method includes continually asking participants to reflect on what they are doing in order to uncover skills that they would not normally talk about. Encouraging participants to tell stories and employ metaphors are also recommended as part of the method.

### ***Factors Impacting Tacit Knowledge Externalization***

From prior research Al-Qdah and Salim (2013) discovered several factors which influenced the transferability and applicability of tacit knowledge. Some of the factors that affect knowledge transfer include nature and characteristics of knowledge, characteristics of knowledge senders, characteristics of knowledge receivers, characteristics of the relations between knowledge senders and receivers, transfer channel and role of managers. The authors also discovered the characteristics of highly transferrable tacit knowledge. Some of them include low level of tacitness and indecisiveness, convenience, uniqueness; high absorptive capacity of the receiver; high disseminative capacity of senders; appropriateness of communication channels, etc.

Mahroeian and Foroza (2012) examined the challenges of managing tacit knowledge by emphasizing on aspects of externalization and diffusion of organizational tacit knowledge. The study sets a theoretical foundation for an empirical analysis by identifying different difficulties are to be found related to perception, language, time, value and distance.

Zhang, et al. (2012) conducted a study on mechanisms of tacit knowledge integration from the perspective of the role of social ties and transactive memory system (TMS). They considered that social networks and TMS are effective to explain tacit knowledge articulation and integration. The finding of their study indicated that expressive tie, tie strength and value similarity have significant and positive impact on TMS which consequently affect tacit knowledge integration.

Wu, et al. (2010) found that the cognitive systems of both knowledge receiver and provider have the highest and second highest importance in the efficiency of tacit knowledge transfer.

### ***The Role of ICT in Tacit Knowledge Externalization***

Amid, et al. (2015) conducted a review of literature to understand the significant role of social media in eliciting and disseminating tacit knowledge by considering Wiki as an example. They argued that since Wiki is collaborative and conversational Web 2.0 technologies it significantly contributes in eliciting and sharing tacit knowledge including

peoples' insights. It facilitated the development of virtual communities of practice (CoP) and the generation of content, sharing, co-creating, co-editing and co-construction of knowledge which reflect the collective intelligence and common interests of the users. It also assists in developing the community through dialogs and discussions, through sharing and understanding of each other's experiences. New ideas can be created in the course of performing a task and in the process of solving problems and such new ideas could be shared as developments to the community using social media. According to the authors, different studies indicate that socialization occurs with Web 2.0 platform, when individuals or groups share experiences, methods, understandings and skills through observation, imitation, practice and participation in different social communities. Social media provides the opportunity for new ways of elicitation and externalization of knowledge and these can be: self-initiated through blogs or wikis, or requested by others through forums or open questions. Social media offers an environment for members to articulate their stories and discuss about their experiences more easily in wikis, blogs and other social networking sites. Authors finally concluded that information technology particularly social web platforms have a compelling part in tacit knowledge sharing.

By taking e-learning system as a case Khan and Khader (2014) proposed an approach that externalizes tacit knowledge of a subject expert by creating a dynamic query handling system that automatically transfers a user query to the best subject expert. The dynamic query handling system serves as a tool for ranking the experts based on their performances maintained in the system, capturing expert knowledge, ensuring the best solutions for the query and providing a user-friendly environment to learners. The central

belief of the authors is that the externalization of tacit knowledge in an e-learning environment takes place using the mechanism of capturing and sharing of knowledge with the right person at the right time. They proposed a framework of a dynamic query handling system that can take a query from a user to an appropriate expert automatically, without the use of manual routing parameters such as subject expert IDs or expert group IDs, and so on. The authors found out that the mechanisms offered a path to reaching a potential expert for solution of a problem and the opportunity to collect valuable knowledge from the expert and store it in the knowledge repository. They also claimed that this approach can satisfy most of the needs of knowledge seekers by directly connecting to domain expertise for collection of tacit knowledge and transforming it into externalized knowledge.

Wu, et al. (2010) conducted a study on the suitability of process and information technology in supporting tacit knowledge transfer. In their hierarchical framework they assigned efficacy of knowledge transfer at the goal level; provider's cognitive system, externalization, knowledge object, interpretation and receiver's cognitive system at the process level; and software tool, database technique, internet technique and information system applications at the support level. Based on the analysis of the scholars' and specialists' assessment the authors found that (1) for goal level, both the knowledge provider's and receiver's cognitive system are of more importance, (2) for process level, database techniques and information system applications obtain the higher importance in supporting the provider's cognitive system and externalization, and (3) software tools and information system applications are more likely to support the receiver's cognitive

system and interpretation. In terms of IT types, the database technique and information system applications are found highly important for the 'providing' part. On the other hand, the software tool and information system applications are the most important ones for the 'receiving' part.

## 2.6. Summary

Knowledge is associated with experience, values, contextual information, expert insight, state of knowing, hierarchy of data, information and knowledge (or the reverse). It plays significant role to innovation and socio-economic development. Knowledge is divided into explicit and tacit based on its codifiability, method of articulation and acquisition. Tacit knowledge has become the focus of study since it constitutes significant proportion of the whole body of knowledge capital and its increasing strategic importance. It plays significant role in generation of new ideas, creation of new knowledge, innovation and development of new product and processes, contextually adapt codified knowledge and flexibly solve contextual problems. It also plays a dominant role in agricultural research, extension, and advisory services which are the most knowledge-intensive elements of agricultural innovation systems.

Tacit knowledge is further classified into high, medium and low degree of tacitness. It is argued that such classification facilitates understanding of tacit knowledge, identification of mechanisms of its externalization and designing of systems that support the process. Externalization which is the process of converting tacit knowledge into explicit is considered as key element to knowledge creation, diffusion and utilization. Debate on tacit knowledge externalization revolved around the meaning of tacit knowledge and

whether it can be captured or not. Some consider tacit knowledge as ineffable and can't be explicit while others believe that tacit knowledge can and must be explicit for sharing. Those who deny externalization of tacit knowledge argue that it is deeply ingrained in the human mind, individualistic in nature, less attended by the individual, difficult to trace, inseparable from explicit knowledge and integral part of all knowing. They also argue that it is known by looking at the outcomes of its application. Those who are in favor of tacit knowledge externalization argue that certain aspects of tacit knowledge can be transformed into explicit through utterance, the articulation of which is experimented with words, concepts and linguistic relationships. They also argue that it can be observed in actions or behaviors of individuals and become visible when these actions and behaviors are openly reflected. According to these authors, tacit knowledge comes about when our actions or communications are recursively emphasized through reflexive and intense social interaction and when ideas are exchanged and debated. It is also manifested in what we do, demonstrated and reflected in its utilization and learned by observation, imitative application, participating in routines, and personal experience. They also recommended different mechanisms of tacit knowledge externalization and emphasized the role of collective reflection in which shared perception is articulated into words, words develop into phrases and further crystallized into concepts. The following table summarizes the mechanisms of tacit knowledge externalization.

Table 2.2: Summary of Tacit Knowledge Externalization Mechanisms

<b>Mechanisms</b>	<b>Descriptions</b>	<b>Authors</b>
Metaphor	A figurative or imagery language that infers about least familiar concepts on the basis of other familiar concepts and makes tacit knowledge observable through symbolic comprehension and generating new meaning.	Nonaka, 1994; Ambrosmi and Veronique, 2001; Hussi, 2004; Chennamaneni and Teng, 2011; Al-Qdah and Salim, 2013
Storytelling/ Narrative	It is one of the forms of implicit communication used to uncover, capture, organize and convey tacit knowledge by allowing participants frame their experiences in stories and add meaning to the context.	Ambrosmi and Veronique, 2001; Styhre, 2009; Venkitachalam and Busch, 2012; Al-Qdah and Salim, 2013
Dialogue	It is a collaborative process of reasoning, meaning making and concept building which allows participants to further articulate their tacit knowledge by generate novel conceptual combinations.	Nonaka, 1994; Tsoukas, 2009
Apprenticeship or Mentoring	A process of transfer of tacit knowledge through sharing experiences, observation, imitation and practice.	Hussi, 2004; Byosiere and Luethge, 2008
Exploration and Experimentation	Exploration which is discovery of new possibilities and new technology through experimentation support externalization of tacit knowledge.	Gourlay (2006)
Observation	A means to build personal knowledge by observing actions of an expert and his/her explanation on how he/she performs a critical task.	Chennamaneni and Teng, 2011
Learning by Doing	Tacit knowledge is learnt by regularly repeating the same type of action, self-perfection and minor innovations.	Alwis and Hartmann, 2008; Al-Qdah and Salim, 2013
Best Practice Lessons learned	Constitute element of tacit knowledge from which others learn from best practices that produce excellent results and processes that went well and/or that need improvement.	Chennamaneni and Teng, 2011a; Al-Qdah and Salim, 2013
Modeling Technique	It elicits tacit skills by representing mental models in graphical format using techniques like concept maps.	Ambrosini, et. al, (2001)
Asking Question	Tacit knowledge is transformed by asking experts the right question and reporting expertise.	Gourlay, 2006; Chennamaneni and Teng, 2011; Guddins, et al., 2012
Visual Representation	Helps to articulate and exchange tacit knowledge via rich media, such as pictures, simulation video, imaging best possible actions, etc.	Thomas, et al., 2001; Styhre, 2009
Prototyping	Tacit skills which are inexpressible in words are elicited through prototyping (by pointing). It represents the products' concept and it is converted into explicit by its specifications.	Chennamaneni and Teng, 2011; Nonaka, 1994
Analogy	A way of expression through compare and contrast and determining similarities and differences and synthesizing diverse perception and images into a common expression.	Nonaka, 1994; Korgh, 1998; Chennamaneni and Teng, 2011, Al-Qdah and Salim, 2013
Brainstorming	It is a process of generating creative ideas and solutions through intensive group discussion and free rein based on insights and intuitions of a group of individuals.	Brassard and Ritter, 1994; Alwis and Hartmann, 2008, Al-Qdah and Salim, 2013
Reflection on Action or Behaviour	Tacit knowledge emerges through open reflection on actions or behaviors since it can be explicitly shown as a skillful activity.	Nosek, 2004; Chennamaneni and Teng, 2011

Social interaction facilitates articulation and integration of individual tacit knowledge through building shared understanding, actualizing and converging views, experiences, expertise, cognitions and common practices. Communication skill, shared language, overlaps in knowledge of actors and knowledge brokerage are essential inputs in articulating and integrating tacit knowledge of actors.

Shared space/'ba' is a precondition for the externalization and sharing of tacit knowledge. The physical, virtual or mental space serve as a platform for different stakeholders to share their feelings, abilities, emotions, experiences, know-how and mental models. The shared space accelerates the explication of tacit knowledge which is shared by members. But tacit knowledge externalization process is influenced by various factors which are summarized as follows.

Table 2.3: Summary of Determinant Factors

<b>Factors</b>	<b>Descriptions</b>	<b>Authors</b>
Creating Interactive Physical and Virtual Platform	A shared space or platform ('ba'), is a pre-requisite for externalization and sharing of tacit knowledge. It could be physical, virtual or mental space.	Nonaka and Konno, 1998; Nonaka et al., 2006; Balestrin, et al., 2008; Horton et al 2009; Critchly et al., 2006
Cognitive Competence or Knowledge Capability	Cognitive competence of the provider to understand and explain tacit knowledge ingrained in his/her mind and the absorptive capacity of the receiver to absorb, interpret and comprehend the tacit knowledge transferred affects externalization, transfer and use of tacit knowledge.	Wu, et al., 2010; Sigala and Chalkit, 2007, Xu and Chen, 2010; Kalling, 2003
<b>Social Capital Factors</b>		
• Structural Capital	It constitutes tie strength and structural hole. Tie strength increases mutual trust, establish common norms and aims and thus, facilitates the flow of tacit knowledge. Structural hole provides access to widely dispersed and diverse knowledge networks with many non-redundant linkages outside the group.	Zheng, 2010; Zhang, et al., 2012; Jun and Weiguo, 2008
• Relational Capital	Refers to trust, norms, obligations, expectation, and identification which affect articulation and sharing of tacit knowledge by increasing willingness to engage in social exchange, cooperative interaction, negotiation, openness, etc.	Nahapiet and Ghoshal, 1998; Zheng, 2010; Farshchi and Brown, 2011; Venkitachalam and Busch, 2012
• Cognitive Capital	Refers to shared representations, behavioral and linguistic codes, systems of meaning, paradigms, understandings and interpretations. It affects the process of social interaction and thus, tacit knowledge articulation.	Tsai and Ghoshal, 1998; Korgh, 1998; Chen, 2008; Gubbins et al., 2012; Virtanen, 2011; Gant, 2007
Communication Skill and Media	Communication skill and the richness of communication medium impact articulation and sharing of tacit knowledge	von Krogh, 2009; Zulaikha and Brereton, 2013; Guddins, et al., 2012
Group Heterogeneity	Heterogeneity in terms of age, gender, beliefs, education, social status, etc. allow to gain "fresh" ideas, insights, and experiences	Balarm et al., 2003; von Krogh et al. 2000; Swan et al., 2000
Motivational Factors	Incentives and supportive environment in which all parties perceive to benefit from the collaboration facilitate generation and (Hennala, et al., 2011)	Hennala, et al., 2011; McAdam, et al., 2007
Shared Mental Models	Shared understanding and familiarity on the represented tacit knowledge affects collaboration, communication and thus, externalization of TK.	Büchel et al., 2013; Mondo, et al., 2007
Shared Experience	Shared experience enables individuals to share each others' thinking processes and serves as a basis for building mutual trust and common perspectives.	Nonaka, 1994;

ICT plays key role in facilitating externalization and formalization of tacit knowledge by providing shared space for individuals to interact and exchange their tacit knowledge. It also facilitates capturing, storage and management of the externalized tacit knowledge. Technologies like groupware, video conferencing tools, Web 2.0 technologies, internal

and external networks, chat rooms, bulletin boards, telephone, e-mail, etc. are serving as a tool to enhance interaction among individuals and share their tacit knowledge. Those technologies with richest multimedia features like groupware and Web 2.0 technologies support articulation and exchange of high degree tacit knowledge. Technologies like online chat, telephone and other groupware technologies support medium degrees of tacit knowledge. E-mail, voice-mail and some applications of groupware support explication and exchange of low degree tacit knowledge. From the context of agriculture in low income countries where there is poor electricity and network infrastructure, mobile phone is the most appropriate technology to create virtual shared space. Mobile is most appropriate due to its high penetration into rural areas, its capability to transfer richer media, its portability, flexibility and two way communications. Currently mobile phone is being used in the areas of remote diagnosis and provision of information on market price, rural credit, government and legal requirements, etc. The design of new ICT support system requires the conceptual understanding of social interactions and modeling the process of tacit knowledge externalization.

Most of the extant works in the area of tacit knowledge externalization focused on theory building and forwarding propositions, understanding taxonomies of tacit knowledge based on degrees of abstraction, proposing possible mechanisms of externalization, identifying dimensions of tacit knowledge integration and the impact of abilities of individuals to externalize and share tacit knowledge. Some of them targeted at addressing the debates on organizational knowledge creation theory and proposing potential research areas. Those studies that dealt about ICT focused on its potential in supporting tacit knowledge transfer efficiency by considering cognitive system of both receivers and

providers. Studies also developed a framework that mapped different communication media to different degrees of tacitness but without any empirical research and validation. From the extant works we learned that there is no empirical study conducted on mechanisms of tacit knowledge externalization and associated factors that impact the externalization process. Authors claimed that interaction of tacit and explicit knowledge via knowledge conversion processes warrant empirical and conceptual grounds. In addition, no prior study focused on how ICT based support system can be designed and developed based on conceptual understanding of the nature of social interaction and modeling of tacit knowledge externalization process. From the technology intervention perspective we are envisioning the design of a system that enhances the human capability to better articulate their tacit knowledge by making such deeply engrained tacit knowledge a focal point of individual's attention (by directing the human thinking to the unattended tacit knowledge in their mind).

## **CHAPTER THREE**

### **METHODOLOGY**

This study examined a participatory agricultural research process that involves articulation and sharing of tacit knowledge of multiple actors. It is a process oriented research approach exploring the mechanisms used to externalize and share different types of tacit knowledge and the factors that impact this process. It also addresses how these mechanisms and factors inform the design and development of mobile based system of communication. A positivist qualitative case study methodology and design science research principles were followed to attain the study's objective. The chapter is divided into eight sections which include rationalizing why qualitative study, research design, selection of research sites and respondents, description of research context, data collection, data analysis, design science research principles and validity.

#### **3.1. Why Qualitative Study**

Qualitative research is descriptive and exploratory in nature. It is deployed when the issues are not much explored in the literature, when little is known about a phenomenon or when present theories need revising (Kuechler, et al., 2009). Positivist quantitative study emphasizes causality (cause-effect relationship) but causality with certainty in explaining social phenomena is problematic and discretionary judgment is unavoidable in science (Tavakol and Zeinaloo, 2004). Qualitative study explores deeply complex social phenomena which are socially constructed and constantly changing and uses human perceptions, understandings, and beliefs to explore the behaviours (Ibid.). It is used to understand the phenomenon by collecting detailed data based on individual, and

sometimes collective experiences and understandings (Kothari, et al., 2011). The theories generated from qualitative research either develop ‘explanation’ about reality, or an attempt to build ‘prescription’ about issues (Kuechler, et al., 2009). It is also claimed that the study of people and their institutions call for methods that are very different from those of natural science or positivist quantitative method (Lee, 1991).

In our context qualitative approach was chosen because 1) developing a theory for externalization and sharing of tacit knowledge in general and the unique context of participatory agricultural research in particular are not explored in the literature; and 2) study on the potential of mobile technology in supporting tacit knowledge externalization in the given context is also lacking. In addition, the complex social interaction among multiple actors with varying cognitive level and language diversity warranted deeper investigation and understanding of the social phenomena of tacit knowledge externalization and sharing. Therefore, the qualitative research approach using semi-structured interview allowed us to gather rich data. Based on the qualitative study conducted we finally generated a conceptual framework representing causal relationship among constructs.

### **3.2. Research Design**

The study followed a positivist qualitative case study research method. We followed positivist rather than interpretivist or social constructivist approach because: first, our research supported the objectivist view of knowledge, i.e., the conversion of non-codified, sub-conscious tacit knowledge into codified, formal and standardized explicit knowledge. We have accepted the possibility of externalizing tacit knowledge as a

universal truth. Therefore, from the perspective of such very assumption we believed that positivist approach is more relevant to our study.

Second, we focused on identifying taxonomies of tacit knowledge and mechanisms of externalization by taking individual as unit of analysis rather than a group. This is because an individual should be able and willing to articulate his/her tacit knowledge (Nonaka et al., 2000) before it is transferred to the group and enhanced through social interaction. Polanyi (1966) also suggested that to be able to share tacit knowledge the possessor of it must first become conscious of the knowledge he/she possesses and then find a way to express the knowledge. Therefore, assuming that an individual is willing to articulate his/her tacit knowledge, we focused on his/her personal ability and strategy/mechanism to articulate tacit knowledge embedded in his/her mind. Therefore, when it comes to identifying taxonomies and mechanism in articulating tacit knowledge our focus is on individual. We focused on the personal efforts of articulating the embedded knowledge by using different mechanisms. We considered individual (researcher, extension agent and farmer) within each FRG as a unit of analysis to explore how these actors externalized and shared their tacit knowledge. Focusing on individual member of the research group enabled us to generalize to the individual's ability in externalizing and sharing tacit knowledge using different mechanisms. Therefore, our focus is not on the process of social construction rather on the personal efforts of articulating the embedded knowledge by using different mechanisms.

We believed that positivist approach is relevant to our research question, because our aim is identifying taxonomies of tacit knowledge, the externalization mechanisms and factors affecting the process. The positivist case study approach we followed used a prediction

about the possibility of externalizing different forms of tacit knowledge using different mechanisms based on previously explained constructs and their inter-relationships in the literature. The three constructs (taxonomies, mechanisms and factors) were empirically tested using case study approach. The constructs also guided qualitative analysis to determine their applicability in practice. In the analysis we focused on what respondents said or did, rather than on what (we thought) they meant through our interpretation. From the point of view of collecting and analyzing data we just classified what respondents said under each construct. Our aim is to obtain new information about the three constructs stated above and supporting them with segments of interviews as well as documentary evidences. We used pattern matching in qualitative data analysis to deductively test whether the predictions made holds true or not (matching the predictions derived from the literature with patterns found in the data). According to Yin (1994) the technique of pattern matching involves qualitative but logical deduction wherein an empirically based pattern is compared against a predicted pattern derived from theoretical perspectives. In the study, we have demonstrated that the taxonomies of tacit knowledge and most of the mechanisms observed in the externalization process at different FRG platforms match the taxonomies and mechanisms predicted by the literature, example, theories of knowledge conversion by Nonaka and his followers. Deductive testing on the validity of each construct was reported by listing evidences from relevant empirical data or detailed descriptions of the case and justifying the conclusions. Generalizability is applied to the statements (or theories-in-use). We applied the positivist case study strategies, guidelines, and tools suggested by Yin. We finally came up with testable theoretical framework. Therefore, we followed the realist ontology rather than a social

constructivist. Prior studies also confirmed that positivist, deductive case studies are important research approach within information systems and provide a very sound and systematic approach for conducting research (Shanks, 2002).

It is also followed an exploratory case study research that involved a deeper investigation of the mechanisms and factors impacting tacit knowledge externalization in the context of participatory agricultural research. Case studies are rich, empirical descriptions of particular instances of a phenomenon that are typically based on a variety of data sources (Yin, 1994). Case study research is now accepted and most widely used qualitative research method within the Information System research community (Lawrence, 2010). It is appropriate for the study of IS development, implementation and use since it provides rich and contextual data as well as detailed situated knowledge (Eisenhardt, 1989; Mayers, 1997; Lawrence, 2010). It is also more appropriate when there is limited understanding and few or no theory explaining the phenomenon under investigation due to the dynamic and immature nature of the phenomenon (Benbasat, et al, 1987).

Yin (1994) identified three main aims of case study. One is to elicit qualitative information. The second is to produce an in-depth and holistic study which gives the reader sufficient contextual and environmental descriptions to allow them to transfer the case studies based on conceptual applicability. The case studies can be reported with sufficient detail and precision to allow judgments about transferability. The third is to generate theory which is fully grounded in the data (Lawrence, 2010).

Case study research is a method which is more appropriate for exploratory study than confirmatory (Styhre, 2009). Therefore, the method provided us a focused vehicle to explore how different actors in a participatory research process externalize and share their tacit knowledge. It also provided us rich phenomena associated with the externalization of tacit knowledge.

According to Yin (2009), case study can involve single or multiple cases and numerous levels of analysis. Both multiple and single case designs are variants within the same methodological framework and no broad distinction can be made between the two case studies (Ibid.). Our study was a single case (the case of Farmers Research Group or FRG). But this single case covered highly diversified FRG projects. The projects include: *Seed Spreader Technology, Seed Varieties Selection, Seed Purification, Seed Sorting, Seed Treatment, Seed Multiplication, Plant Breeding, Agricultural Tools Development, Forage Development, Fattening, Apiculture, Poultry, Organic Fertilizer, Different Agronomic practices (Row Planting Vs Broadcasting, Spacing between Seeds), etc.* Projects vary in their levels of complexity and intensity of engagement which had implications to the process of tacit knowledge articulation and sharing. Such diversity increased the possibility of deriving different perspectives pertaining to the process of tacit knowledge externalization and the potentials of different mechanisms.

The major critics in case study research is that it allows more room for researcher's subjective and arbitrary judgment than other methods and it is often seen as less rigorous than the quantitative method (Flyvbjerg, 2006). But scholars also argue that such critics arise from lack of knowledge of what is involved in case-study research. It is claimed that case study has its own rigor, no less strict than the rigor of quantitative methods. "The

advantage of the case study is that it can “close in” on real-life situations and test views directly in relation to phenomena as they unfold in practice (Ibid. p. 235)”. By citing the works of other researchers the author also confirmed that in-depth case studies have the power to disprove the preconceived views, assumptions, concepts, and hypotheses. Quantitative researcher does not get as close to those under study as does the case-study researcher (Ibid.).

The difference between large samples and single case is also specified in that if the researcher dwells in a single case study and if the purpose is to understand and learn about the phenomena being studied, it is claimed that “most advanced form of understanding is achieved when researchers place themselves within the context being studied. Only in this way can researchers understand the viewpoints and the behavior, which characterizes social actors (Flyvbjerg, 2006, p. 236).” The advantage of large samples in quantitative research is breadth, whereas their problem is one of depth. For the case study research, the situation is the reverse.

### *Unit of Analysis*

The study primarily used individual as a unit of analysis since it explored how different actors in the participatory innovation platform externalized and shared their tacit knowledge. The specific research questions, identifying the type of tacit knowledge externalized and the mechanisms used to externalize them, are also quite relevant to the individual as a unit of analysis. Focusing on individual as a unit of analysis enabled us to generalize to the individual’s ability and mechanisms in externalizing and sharing tacit knowledge using different mechanisms.

### 3.3. Selection of Research Sites and Respondents

#### *Selection of Research Case and Sites*

The principle of theoretical sampling was followed to select a case which is more suitable for analytical generalization (Yin, 1994). Theoretical sampling is a technique where a case is selected as a unique exemplar of a particular phenomenon to bring key dimensions to light (Ibid.). Such cases are particularly suitable for illuminating and extending relationships and logic among the key dimensions (Eisenhardt and Graebner, 2007). Cases are selected for theoretical rather than statistical reasons. “Cases are sampled for theoretical reasons, including revelation of an unusual phenomenon, replication of findings from other cases, contrary replication, elimination of alternative explanations, and elaboration of the emergent theory (Ibid., p. 3).”

In order to study about tacit knowledge articulation and sharing a context with intensive experimental or innovative collaboration between two or more individuals can be identified as a case (Vaccaro, et al., 2008). Joint RandD centers or projects, integrated incubators, joint centers or projects of technology transfer, joint training centers, etc. are also potential contexts to study tacit knowledge articulation and sharing (Wang, Z., 2012). Therefore, we selected participatory agricultural research platform as a research context and, Farmers Research Group (FRG) projects as research cases.

Agricultural sector in general and the specific FRG projects as research cases in particular are representations of extreme cases with respect to the subject of the study (i.e. externalization and use of tacit knowledge) because of: the huge contribution of the sector to the nation’s economy; high recognition given to tacit knowledge (including

indigenous knowledge and practical intelligence of farmers) to participatory agricultural innovation; the widely dispersed nature of tacit knowledge in the minds of key stakeholders who are spatially distributed; and significant gap in levels of cognitive as well as absorptive capacity because of the inclusion of farmers in the innovation group. Farmers play significant role in the participatory research process and this makes the case of FRG unique, unusually revelatory and extreme exemplar (Yin, 1994). Therefore, by taking FRG as a case we exploited opportunities to explore a significant phenomenon (Eisenhardt and Graebner, 2007).

The environment avoids the obstacles of secrecy and confidentiality since it is a forum of collaboration rather than a field of competition, i.e., it is a group with legal status that bring together voluntary enthusiasts (Rix and Lie`vre, 2008). Every member of the platform wishes to integrate his/her expertise, experience, talent, etc. with others' to come up with viable solution to persistent agricultural problems. The researchers' request is therefore welcomed with pleasure by the actors who quite often solicit and demand such participation themselves (Ibid.).

Ethiopian Institute of Agricultural Research Center/Japan International Cooperation Agency (EIAR/JICA) Office assisted us in identifying research sites and individual FRG projects which are exemplar in terms of effective collaborative technology generation and adoption. The selected sites include Melkasa Agricultural Research Center, Adami Tulu Agricultural Research Center, Holeta Agricultural Research Center, Assosa Agricultural Research Center, Welayita Sodo University and Mekelle University. The sites selected for this study provided a rich environment for investigating tacit knowledge

externalization and sharing. Tacit knowledge used in such collaborative environment is valued as critical input to innovation.

### *Selection of Respondents*

Patton (2002) argued that it is necessary to carefully select naturally acute observers and well-informed people about a setting or situation so that they assist the researcher to deeply understand the phenomenon. Therefore, key respondents who had dominant role, status and experience in FRG projects were included in the study. Highly pertinent and relevant data was gathered as a result of inclusion of these key respondents. The study didn't involve sampling and statistical generalization since the cases that we selected are not "sampling units" (Yin, 2009). Cases are selected for doing deeper investigation. According to Yin, when an individual is selected as a case, it is not equivalent to a single respondent in a survey or a single subject in experiment. Regarding the selection of participants we used purposive, non-random sampling technique mainly, snowballing in order to pick appropriate respondents for the in-depth interview and focus group discussion.

The study also applied the criteria of theoretical saturation which refers to a sampling decision that directs the researchers to extend their sample until they are confident that no additional data can be found that contributes to the development of properties of a category. In other words, it is bringing new participants continually into the study until the data set is complete, as indicated by data replication or redundancy (Marshall, et al., 2013). Researchers should stop adding samples when theoretical saturation is reached

(i.e. the point at which incremental learning is minimal because the researchers are observing phenomena seen before) (Eisenhardt, 1989).

Creswell (2007) recommended no more than 4 or 5 cases and 3 to 5 interviewees per case study. Yin (2009) recommended at least six sources of evidence. Guest, et al. (2006) also confirmed that most of the data saturation had occurred by 12 interviews. Marshall, et al. (2013) also recommended that single case studies should contain 15 to 20 interviews. Having too much samples and data can be counterproductive and hinder deeper and richer analysis of the data which are the central purposes of qualitative research (Ibid.). Therefore, the maximum should be considered when additional interviews fail to produce substantial new insight. They argued that adopting these practices can benefit researchers by adding the credibility of the research and saving significant amounts of time. Focusing on getting the right amount of data can save hundreds of hours which could have been committed in establishing relationships of trust, transcribing, coding, etc.

Therefore, based on the stated principles of theoretical sampling and theoretical saturation we included 22 respondents – 14 multi-disciplinary agricultural researchers and extension agents and 8 farmers. From the 14 researchers 4 of them were PhD holders and 10 of them were M.Sc. holders. All the 3 extension agents were Diploma holders. Three of the farmers were 7<sup>th</sup>, 8<sup>th</sup>, and 9<sup>th</sup> grade complete and 5 of the farmers were illiterate.

### 3.4. Description of Research Context

Participatory research approach was introduced to address the weakness of conventional agricultural research approach which failed to meet farmers' needs and resulted in poor adoption of technologies generated by research centers. Under participatory approach multiple actors are involved to combine their diverse perspectives to generate solutions for multidimensional problems of agriculture (Zerfu, 2004). Active role of farmers in developing technologies has been largely recognized. It was also felt that farmers have the capacity to provide relevant indigenous knowledge, innovative ideas, skills, etc. and run their farming enterprises productively, profitably and sustainably (Ibid.). Therefore, farmers became key partners in the process of technology generation, transfer and adoption (Ibid.). The involvement of stakeholders including farmers in the innovation process contributed a lot in the generation of technology that is appropriate and matching to the needs of farmers.

By giving a special emphasis to farmers' participation in technology development, verification, transfer and adoption, a project on farmer research group (FRG) approach was launched in 2004 (Habte, et al., 2009). FRG approach is a research approach by which *multi-disciplinary research team, extension workers and groups of farmers* jointly conduct a research on selected topics, on farmers' needs and on farmers' field. Farmers and extension workers are involved from the planning to the final stage of implementation and dissemination of the final output. Research centers, district agricultural offices, NGOs and private companies also participate in the collaborative innovation process in order to make the output more comprehensive and sustainable.

Some of the topics of the FRG projects include technology development and improvement, selection of varieties, seed treatment, row planting, fertilizer application, improving dairy technology, community based seed multiplication, water management, agro-forestry, forage, fattening, poultry and provision of market information using mobile phone (Emana, 2009). The projects are based on on-farm activities including field experiments, observations, making presentations, discussions, analysis, collective decisions, and taking appropriate actions.

In the process of participatory research, the initial stage is diagnostic studies (situation analysis) where the farming systems, problems and opportunities are analyzed, understood and prioritized. Then, multi-disciplinary research team is formed at research centers to identify various technical options to be proposed for farmers. Farmers' research group (FRG) is also established with whom the collaborative research is going to be conducted. Size of each farmer group is recommended between 15 and 20 households. When FRG is established due consideration is given to age, sex and wealth balance (Bedru, et al., 2009). Detailed discussions are normally held with local farming community and DAs to match needs and options and select a research topic. This is the basis for identifying areas of joint research and development interventions. Priorities are also assigned to the problems and opportunities identified. Then, a research proposal is formulated by researcher in order to secure the required budget. Participatory on-farm research is then initiated and implemented which include on-farm trials, training (at different timing of the cropping season or livestock cycle), field days and exchange visit jointly conducted by researchers, farmers, extension workers and other stakeholders. At the stage of implementation trial farmers are selected from the FRG members based on

the representativeness, willingness and capacity of managing trial, their interest in the research topic, their willingness to share cost, the consensus among the members and their willingness to share information with others. Trial sites are also selected based on representativeness, accessibility and consensus among the group members. After implementation, monitoring and evaluation are conducted at various levels and stages by the research teams, stakeholders and member farmers. Dialogues are held while evaluating treatment effects, justifying the causes of differences in treatment effects and identifying whether the differences occurred due to field or other management practices.

Finally, consolidating and communicating FRG outputs are carried out which include activities like converting technical outputs into extension materials for wider impact of the technology (Bedru, et al., 2009). Frequent meetings are held during the collaborative experiment process for the purpose of addressing problems and indicate future actions. It is supported by visiting of on-farm activities and monitoring of the performance of members. In addition to the meetings consultative workshops, seminars, trainings, demonstrations and field days are organized (Anchala, et al., 2004) to discuss the results of joint experiments and to review the challenges and opportunities faced.

Field day is an event on which better as well as worse examples of farmers' practice are open for people, such as non-FRG member farmers within and outside of the community, other stakeholders particularly who are working in extension, to visit and learn. While conducting field days, farmers explain all the activities they were doing up to the end and Development Agents (DAs) provide guidance. It is an important forum to share experiences, practices and knowledge among farmers.

There is also exchange visit which is one of the experience sharing and learning tools by farmers visiting each others' farms where good, as well as worse practices, is observed and discussions are made. A trial is usually conducted with more than one trial farmers placed at different locations within a given village or district. Experiences with trial performance, therefore, may not be the same as it is determined by locations, farmers' experience and so on. Hence, it is very important to enable farmers learn from each other and share different experiences through arranging exchange visits. Non-FRG farmers participate in the process during a joint periodical field monitoring and evaluation (field visit). The field visits could be conducted up to four occasions during the growing season at different growth stages of the crop. The forums also served as learning places where different actors gained experiences on how to experiment, evaluate, select, adopt and disseminate better technology. Farmers are expected to provide timely feedback and share experience with other farmers. Farmer to farmer interaction at the end of every trial also facilitated knowledge sharing.

Agricultural research centers and universities have been conducting farmer participatory research using FRG approach on variety of subjects in crop, livestock, natural resource management, livelihood improvement, farming tools and marketing. Between 2004 and 2009 Melkasa Agricultural Research Center (MARC) and Adami Tulu Agricultural Research Center (ATARC) established 80 farmer research groups with more than 1,400 members including 800 female farmers. More than 50 researchers from nearly 20 disciplines formed a number of multidisciplinary teams and conducted 41 research topics in partnership with development workers and farmers as well as many other public and private sectors. Participatory approach enhanced the functional and institutional linkages,

improved interactions among key stakeholders, and improved the relevance, quality, effectiveness and sustainability of agricultural knowledge generation, sharing and uptake (Habte, et al., 2009). It allowed the capturing of the physical and socio-economic setup of farmers and integration of their felt needs, innovative ideas and indigenous knowledge (Ibid). It also provided a mechanism for developing and nurturing farmers' capacities to innovate, experiment and cope with environmental changes (Ibid).

### **3.5. Data Collection**

Qualitative research methods are designed to help researchers understand people and the social and cultural contexts within which they live using a number of data collection methods such as semi-structured interviewing, observations, document analysis and the researcher's impressions and reactions (Styhre, 2009; Mayers, 2009). As von Krogh (2009) recommended, if tacit knowledge assumes a move from tacit to increasingly explicit through reflection and communicated to others by speaking, drawing, or writing, qualitative interview is an appropriate research method.

Our fundamental assumption is that tacit knowledge is converted into explicit knowledge. Therefore, we deployed an in-depth semi-structured interview technique in order to get valuable insights into the process of tacit knowledge externalization and sharing in participatory research process. The interview remains the principal means for understanding how individuals make sense out of their everyday experiences (Styhre, 2009). Focus group discussion and document analysis were also used as complementary data collection tools. In the context of studying tacit knowledge externalization surveys and structured interviews are inappropriate in so far as individuals cannot be asked to

state what they can not readily articulate (Ambrosmi and Veronique, 2001). Each of the data collection techniques used are discussed as follows.

### *Interview*

“Interviews are a highly efficient way to gather rich, empirical data, especially when the phenomenon of interest is highly episodic and infrequent (Eisenhardt and Graebner, 2007, p.4).” Semi-structured interviews were used with probing and snowballing techniques. Since the subject of the study is tacit knowledge externalization, a critical incident and/or storytelling interview approach was deployed to surface the kind of tacit knowledge that was articulated and shared during the collaborative innovation process (Haron and Noordin, 2010; Kothari, et al., 2011). The respondents were encouraged to recall and tell stories about incidents they encountered that resulted in unexpected results (good or poor performances) and shaped their understanding, perception, views and behaviors. It is argued that humans make sense of the world by telling stories, and human action is portrayed in these stories (people make sense of their life experiences by telling stories) (Kothari, et al., 2011). Involving respondents (researchers, extension workers and farmers) who have rich experiences enabled researchers to uncover the details of the process of tacit knowledge externalization through narrative inquiry. Experts were giving assurances about the high value and relevance of tacit knowledge that were articulated by farmers during the collaborative innovation process.

The interview protocol included series of questions pertaining to the respondent’s experiences and practices of externalizing and sharing his/her tacit knowledge in the process of participatory innovation. It was adopted from previous studies conducted by

different scholars in the areas of tacit knowledge elicitation and sharing. All of the questions adopted satisfied acceptable reliability and validity level from past research. Although semi-structured in-depth interviews were guided by a predetermined theme and questions, there was flexibility in the order or form of questions in order to reveal deeper insight into respondents' experiences (Martin and Abbott, 2011).

Twenty two informants participated in the interview and focus group discussion. Each interview took a minimum of one hour and a maximum of three hours duration. Rules of interviewing and data handling, recommended by Yin (1994), were applied. Interviews were recorded with digital recorder with the permission of the interviewee. Assurance was given to the interviewee on the confidentiality of their responses before the interview. Such assurance minimized the digital recording drawbacks. All the interviews were translated from Amharic/Oromefa into English and transcribed verbatim for analysis.

#### *Document analysis*

We also collected data from documents – reports, manuals, guidelines, etc. in order to triangulate the information gathered from the informants and validate our interpretations of the interview data. The documents reviewed also provided background information about the cases.

#### *Focus Group Discussion*

Focus group discussion was conducted with eight farmers who had long years of experiences in the implementation of FRG projects by being member of Farmers Research Group. The focus group protocol was developed and feedbacks were collected

by discussing it with researchers and extension agents. Focus group discussion allowed different perspectives and experiences to emerge from participants. The focus groups were composed of two groups with 4 participants each and the discussion was digitally recorded to ensure accurate description.

### *Observation*

We participated in one field visit conducted on one FRG project at Mariachare Kebele around Wolayita Sodo area. We took field notes on how farmers actively participated in the FRG projects from the beginning to the end and how they allot their own plot to conduct their own experiment side by side with the experimental plots allotted for the recommended inputs. We also took note on how a model farmer articulated his idea during the presentation he made to the participants of the field visit and on what was happening during the question and answering session after the presentation.

### **3.6. Data Analysis**

More than 200 pages of translated and transcribed qualitative data was available for analysis. Therefore, in this section we presented the description of the way the data was analyzed and how we moved from huge transcribed qualitative data to the final conclusion which was recommended as a major step by Eisenhardt (1989). Our main purpose was identifying unique patterns from the data that represents the form of tacit knowledge shared and the mechanisms used for articulation and sharing. The initial categories or dimensions used for searching patterns were based on the research problem as well as the existing literature (Ibid.). Participants were sharing their experiences and

telling stories on different FRG projects. This helped us to compare variations in the type of tacit knowledge being articulated and shared, the degree of tacitness and the mechanisms used to articulate it. Such comparisons resulted in new patterns and relationships from the data which we didn't anticipate (Ibid.).

### **3.6.1. Preliminary Steps in Coding Process**

Digitally recorded interviews were transcribed verbatim and transcripts were sent to the respective respondents for confirmation and approval. After getting feedbacks on the transcriptions each interview transcript was reviewed line by line. We followed an inductive analysis approach which mainly focused on building categories, themes and patterns from the data in order to come up with concepts and relationships (Kuechler, et al., 2009). The inductive approach is relevant because there is no theoretical support from the existing literature that guides the development of a conceptual framework that represents the process of tacit knowledge externalization and sharing in the context of participatory agricultural innovation. Researchers also believed that novelty could emerge from the data gathered and the inductive analysis conducted.

Before we started the coding process we thoroughly reviewed the interview transcripts and other recordings in order to establish a good understanding of the transcripts and recordings (Yin, 2009); explored similarities and differences in the data as well as relationships among them; and identified possible key terms, categories and themes (Paré, 2001). We repeatedly reviewed the interview transcript in order to deeply understand what is happening in the research context. This thorough review of data also aimed at identifying possible features which are distinctive to our study, relating the collected data with the original research questions and identifying potential emergent new

insights (Yin, 2010). One method suggested by Paré (2001) to achieve the stated objectives is entering a reflective remark into the interview transcript within brackets [ ]. The reflective remarks helped us to start thinking about the emergent patterns even at the initial stages of reading the interview transcript. The reflective remarks were later compiled, grouped and inserted as 42 names in memos of NVivo 10. Such memos were used when we conducted analysis, interpretation and discussion in chapter five.

After understanding the data thoroughly the interview transcripts, archival records and other forms of data were systematically compiled, sorted and grouped into meaningful set of files using Nvivo 10 (Interviews, Archival Documents, Field visit, Workshops, etc.). This systematic organization of the qualitative data before formal analysis ensured proper analyses and ultimately a more rigorous qualitative research (Yin, 2010).

Themes were identified by linking codes to the constructs, the objectives and the research questions and by using the hierarchical coding structure provided in NVivo. The themes were repeatedly revised in order to come up with refined data and description of the stakeholders' practice of articulating and sharing their tacit knowledge.

### **3.6.2. Thematic Coding and Thematic Analysis**

Thematic analysis involves the identification of themes from qualitative data and used to organize the possible observation and to interpret aspects of the phenomenon or guide analysis (Martin and Abbott, 2011). It is important to read the interview data multiple times, both to identify appropriate thematic coding, and to uncover new or unique themes not identified in prior research (Ibid.).

Themes can be also identified from prior research. We reviewed and summarized the works of five authors, Yin (2011), Thomas et al. (2001), Paré (2001), Haron and Noordin (2010) and Lawrence (2010), on how to conduct rigorous qualitative analysis techniques. A tabular matrix was developed where rows constitute Levels of Codes and Columns constitute Authors' Name and the cells consist description of each level.

Table 3.1: Summary of Methods to Conduct Rigorous Qualitative Analysis

Authors Levels of codes	Yin (2011)	Thomas, et al. (2001)	Paré, G. (2001)	Haron and Noordin (2010)	Lawrence (2010)
<b>Level 1 (Open Codes)</b>	Using <b>exact words</b> from the original verbatim transcript	Extracting <b>key terms</b> from verbatim notes	Extracting a <b>priori codes</b> from prior research and <b>adding</b> during data analysis	Identifying key <b>themes</b>	Identifying <b>patterns</b> from the issues <b>repeatedly</b> raised
<b>Level 2</b>	Identifying <b>categories</b> within which the Level 1 codes may fall	Creating <b>first order domains</b> based on semantic relationship (connections) b/n terms	Dividing the codes into <b>broad categories</b>	Clustering themes into <b>broad themes</b>	Identifying <b>similarities</b> and compare <b>differences</b> by analyzing data
<b>Level 3</b>	Identifying <b>themes</b> within which Level 2 codes fall	Creating <b>second order concepts</b> through abstraction and conceptualization of domains or relating various domains and labeling	Identifying <b>pattern</b> or <b>inferential</b> codes – during analysis	Creating <b>Concepts</b> by summarizing and generalizing broad themes	Developing <b>concepts, properties</b> and <b>relations</b>
<b>Level 4</b>	Identifying <b>theoretical concepts</b> within which Level 3 codes fall	Creating <b>analytical dimensions</b> or super-ordinate framework by aggregating second order concepts (to be used for organizing the emergent findings)	-----	-----	Developing <b>broad categories</b> and associated <b>concepts</b>

We identified Yin's (2011) four levels as a benchmark for comparing and integrating the different levels of coding developed by other authors. Based on the comparisons and integrations we came up with the following guidelines and applied the coding scheme:

**Level 1 Coding:** We identified *key terms* from the original verbatim interview transcription based on the issues raised repeatedly. We also extracted and included a priori codes from prior research.

**Level 2 Coding:** We created *broad categories/domains* based on the semantic relationship (connection) between *key terms* (level 1 codes). Categories are systematically developed and linked with subcategories (key terms).

**Level 3 Coding:** We developed *broader themes* by relating various *categories/domains* based on generalized labels assigned to linked categories or domains.

**Level 4 Coding:** We developed *theoretical concepts* based on abstraction and conceptualization of *themes* or by relating various *broader themes*. The theoretical concepts were used as analytic units and to organize the emergent findings.

Patterns were identified during level 3 and level 4 coding through identifying emergent themes, new insights, relationship among theoretical concepts or constructs and linking them to the research questions and objectives of the study.

Based on the above coding scheme we started by identifying a priori codes from previous research or from the literature for both Level I and Level II codes. In addition to using

exact words from original verbatim transcript for Level I codes, we decided to extract predefined or a priori codes from literature for the sake of standardizing the key terms in the original verbatim transcripts. As we go through the literature review of the study we have initially identified 189 terms/phrases under 11 broad categories without being refined. This was used as a database of terms/phrases and broad categories that can be used as a reference for the Level I and Level II coding.

The next step is to go through the interview transcript in order to identify key terms repeatedly raised by respondents. We identified 252 key terms and phrases from the interview transcript that were used for Level I coding. In order to ensure that Level I codes stick closely to the original items, the exact words in the original item were compared to the predefined or a priori codes to find similarity and standardize the terms. In the case of Level II category codes our purpose is to move to higher conceptual level and we preferred to use predefined constructs or concepts extracted from the literature. Through repeated revisions we came up with 87 level II Category codes. Then, under Level III coding we developed broader themes by grouping the categories identified under Level II coding. Under level III coding we came up with 16 broader themes. Finally the Level IV coding resulted in six theoretical concepts (analytical dimensions) by merging broader themes. These theoretical concepts are closely related to the research questions and objectives of the study and were used as analytic units and for organizing the key findings of the study. The four levels of coding were done iteratively in order to ensure that enough categories and associated themes and concepts were created to explain what was observed in the data and no additional data was found to develop or add to the set of concepts and categories (Lawrence, 2010). The concepts were organized into trees

in NVivo and each tree node represents the themes. The contents of documents that constitute reflections, innovative ideas, best practices, experiences, indigenous knowledge, etc. of member of FRG or researchers were also included in NVivo's codes. Due care was taken not to lose the important features embedded in the details of case study data because of summarization. This was done by closely examining the details and presenting those that have general significance as narratives in their entirety (Flyvbjerg, 2006).

### **3.7. Design Science Research Principles**

There are two research paradigms or distinctive worldviews that follow certain epistemological and ontological assumptions – behavioral science research and design science research (Hevener et al., 2004). The behavioral science research primarily focuses on the development and justification of theories on human-computer-interaction while design science research focuses on creating IT artifacts intended to solve organizational problems (Ibid.). The former is problem understanding paradigm and the latter is problem solving paradigm. The former focuses on developing and justifying theories which explains or predicts organizational phenomena surrounding the analysis, design, implementation, management, and use of information systems. The latter aims at creating innovations that define ideas, practices, technical capabilities and product through the analysis, design, implementation, management, and use of information system (Ibid.). In the IS research both behavioral and design science research paradigms are considered as complementary since theories about IS related issues can explain and predict human behaviour and information system functions (Ibid.). The understanding of

the real world problem through the theories presents the basis for the design of one or more IT artifacts which address a given problem situation.

Our study addressed both the behavioral and design science aspects of the information system development and we applied multi-methodological approach to IS research recommended by Nunamaker, et al. (1991). We applied their framework to integrate the results of the qualitative research with the design of the system architecture. Our qualitative exploratory research aimed at identifying problems as well as gaining insights and increasing familiarity with the problem area (Nunamaker, et al., 1991). The results of the qualitative research (theory) served as a basis for developing system requirement specification and architecture (artifacts) for mobile mediated tacit knowledge externalization and sharing.

Nunamaker, et al. (1991) also identified a research lifecycle of the form: concept – development – impact which most IS research demonstrates. According to this model theories are needed to identify what broad classes of things can be automated, instantiation is needed to provide a continuing test bed for the theories, and the evaluations of particular instances (systems) are needed to quantify success or failure of a system in both technical and social terms. Therefore, concepts are formulated with methodologies like qualitative research. Concepts become the basis for system development that is expected to bring a certain impact. The impact of the information system need to be further assessed, for example through a research into user acceptance, system efficiency, etc. Difficulties and constraints encountered during the systems development processes can also be used to modify the concepts and theories from which

the application systems are derived. The developed system can serve both as a proof-of-concept for the fundamental research and provides an artifact that becomes the focus of expanded and continuing research (Nunamaker, et al., 1991).

Nunamaker, et al. (1991) stated that theory building includes development of new ideas and concepts and construction of conceptual framework. In theory building we conducted a case study to identify mechanisms and factors pertaining to tacit knowledge externalization and sharing and finally came up with a conceptual framework. The constructs extracted from the qualitative data is considered as 'intermediate' artifacts that create the terminological and meta-model foundations for the system of relevant artifact (in our case, the architecture). Hevener et al. (2004) also considered constructs as part of an artifact. Therefore, in our case, based on the results of the qualitative case study research we developed design constructs and integrated them into the design of the architecture. According to Nunamaker, et al. (1991) system development consists five stages: constructing conceptual framework, developing system architecture, analyzing and designing the system, building prototype and observing and evaluating the system. Therefore, we adopted the following framework of Nunamaker, et al. (1991) that combined both behavioral and design science approaches.

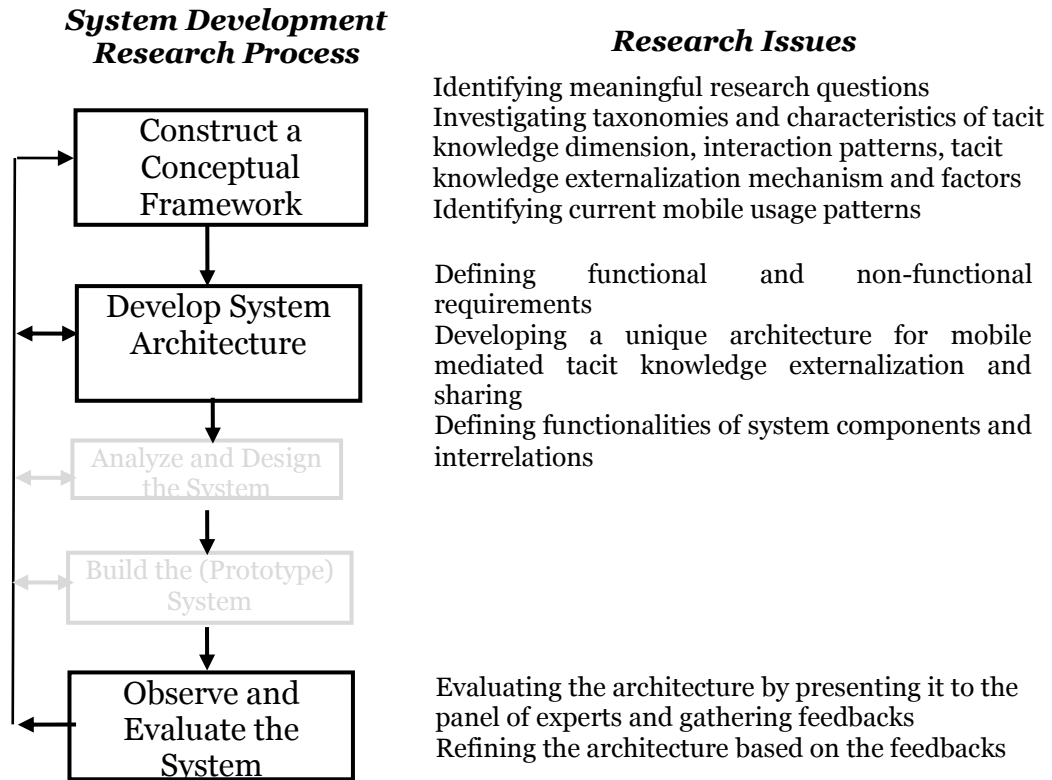


Fig. 3.1: A Process for Systems Development Research Adopted from Nunamaker, et al. (1991)

From the above five process steps we focused on the three – *constructing a conceptual framework, developing system architecture and evaluating the architecture*. The first component was developed in the exploratory qualitative case study research that identified typologies of tacit knowledge, the mechanisms of externalization and factors that impact the externalization process. The system architecture was then developed based on the design constructs derived from the conceptual framework. According to Nunamaker, et al. (1991) a system architecture provides a road map for the systems building process by identifying system components, specifying system functionalities and defining the structural relationships and dynamic interactions among system components.

Multi-methodological approach was applied in different IS research areas. Mirza and Sundaram (2016), Tilvawala, et al. (2016) and Tilvawala, et al. (2014) conducted research on crowd-sourced knowledge management approach to language preservation and revitalization, designing value based digital game platform and designing organizational ubiquitous information systems respectively. They deployed four mutually connected phases to support the creation and validation of the information system they proposed. The first phase comprises understanding concepts, models, processes, frameworks and existing applications in the existing academic literature and clarifying the research domain. This phase involves gathering and analyzing current and related research. The outcome of their observation was comparison of existing applications and synthesis on existing concepts, models, processes and frameworks. The second phase deals with theory building or creating theoretical artifacts for guiding the design and implementation of the system. The outcome of this phase is adapting and developing ideas and concepts, creation of conceptual models, processes, frameworks and architectures. The third phase is concerned with designing and implementing the proposed information system based on the concepts, models, processes, and frameworks in the theory building phase. The prototype developed at this phase can be used as a basis for validating and proposing revised theoretical artifacts. The fourth phase is conducting controlled lab experiments to evaluate the system implemented. This phase also aims at validating the conceptual and system artifacts using design science, qualitative and quantitative methods.

Tilvawala, et al. (2014) argued that selecting such multi-methodological approach was in concurrence with several researchers' call for IS research to look beyond a single

methodology in order to explore a research domain adequately (Adams and Courtney, 2004; Mingers, 2003; Mingers and Brocklesby, 1997; Nunamaker et al., 1990 cited in Tilvawala, et al., 2014). Because of such emphasis on multi-methodological approach Bai, et al. (2013) reviewed and analyzed the existing representative multi-methodological design science approaches, identified the strengths and weaknesses and proposed a framework.

According to Peffers, et al. (2008) we need to define the specific problem and justify the value of a solution. In our study the specific problems were defined and justified using the respondents' specifications of the existing challenges. Alarcon, et al. (2006) also suggested that identifying general interaction scenarios among group members is also required in order to determine which of them necessitate mobile support. Such interaction scenarios indicated users' communication needs for transfer of textual, voice, video and image data. Therefore, the constraints /problems/ and the functionalities and the requirements of the resulting system were defined.

### **3.8. Validity**

Validity in qualitative research mainly refers to the truthfulness or credibility of the explanation and the extent to which the explanation is well grounded representing the social phenomena to which it refers (Kuechler, et al., 2009). Qualitative research is characterized by in-depth explorations of a limited number of situations than larger samples of data and statistical techniques of proving validity (Ibid.).

Internal Validity

As far as the researchers collect, interpret and analyze the data, there is an inherent subjectivity and a certain amount of bias might be unavoidable (Yi, 2006). Internal validity for a qualitative study is therefore, associated with the credibility or believability of the results from the perspective of the participants in the study (Ibid.). We ensured internal validity first, by sending the translated interview transcript back to the respondents for the verification and gathering their feedback (Tee and Karney, 2010). Secondly, the data gathered through interview was triangulated with extensive review of documents and reports on FRG projects as well as observations (Goffin and Koners, 2011). Third, sufficient concepts were also chosen in order to explain the topic which is considered by Dane (1990) as criteria for ensuring internal validity. Fourth, although we didn't conduct comparative analysis across two or more cases, the comparable results that we gained on the issue of tacit knowledge articulation from different respondents who participated in different FRG projects also ensure internal validity (Ritchie and Lewis, 2003 in Kuechler, et al., 2009). Fifth, we archived all relevant documents including verbatim interview transcripts, audio recordings, pictures of research sites and interviewees, different documents and reports pertaining to FRG projects, etc. in order to increase confirmability and dependability.

According to Eisenhardt and Graebner (2007), one of the approaches to limit bias in the interview data is involving highly knowledgeable informants who view the focal phenomena from diverse perspectives. We involved high profile agricultural researchers with long years of rich experiences in coordinating and leading FRG-based participatory research. We also included highly experienced model farmers and extension workers. Most of the informants were selected from the two leading research centers which are

pioneers in implementing FRG projects (participatory research approach). The regular interaction with my advisors at different stages of the study also contributed to the strength and credibility of the findings.

### ***External Validity***

External validity refers to the degree to which the results can be generalized to other contexts or settings (Yi, 2006). One of the major critics in qualitative study, particularly case study approach is lack of generalizability of the results. The variability and context bounded nature of social phenomena makes empirical generalization more difficult (Patton, 2002). The external validity of a qualitative data gathered can be ensured by providing detailed description of the research context, interviewing wider number of pertinent stakeholders and providing detailed description of the points of the empirical evidences or in-depth analysis of data (Vaccaro, et al., 2008; Kuechler, et al., 2009). Exhaustive examination of cases and finding regularities in physical and social worlds can prove universal and causal generalizations (Kuechler, et al., 2009). Providing thick description of different aspects of the context enables readers to make judgments for themselves as to the transferability or applicability of the study (Tee and Karney, 2010).

In this study a thick description was provided on the process of tacit knowledge externalization and sharing as well as the mechanisms used to articulate it in the context of participatory agricultural innovation. The identification of mechanisms and factors pertaining to externalization may provide theoretical constructs or propositions for further study on collaborative innovation and tacit knowledge in agriculture or other contexts. In addition, generalization could also be viewed as replicating the results of the study across

multiple FRG projects or to agricultural innovation system as a whole although the context is the same – participatory innovation. Readers could also learn from the results of this qualitative case study and extend their pool of embedded knowledge which is called by Stake (1995) as naturalistic generalization.

Qualitative case study research relies also on analytic generalization where the investigator is striving to generalize a particular set of results to some broader theory, not to a population (Yin, 2009). Nonaka's (1994) theory of knowledge creation through tacit knowledge externalization is the basis for the case study and therefore, this theory would be the domain to which the results could later generalized.

## **CHAPTER FOUR**

### **DATA PRESENTATION AND ANALYSIS**

The fourth chapter of this study presented and analyzed the qualitative data. It constituted three major parts. The first part focuses on presentation and analysis of data on epitomes or taxonomies of tacit knowledge in terms of high, medium and low degree of tacitness. The second part of the chapter extensively discussed data on different mechanisms of tacit knowledge externalization including experimentation and evaluation, apprenticeship or mentoring, metaphor, storytelling, dialogue, asking question, localization, observation, modeling technique, on-farm demonstration, reflection-in-action (non-verbal practices), learning by doing, and lessons learnt. The third part focused on factors influencing tacit knowledge externalization process including creating interactive platform, cognitive competence, complexity/abstraction, social capital factors, communication quality, group dynamics, motivational factors and resource and infrastructural problems.

#### **4.1. Taxonomies of Tacit Knowledge**

From the interview result it was identified that multiple stakeholders contribute their tacit knowledge in the process of technology generation, verification, transfer and utilization. Farmers, as key partners in the participatory research process, provide their own perspectives, experiences and indigenous knowledge as an input for solving the local problems. As RES 11 explained:

*... farmers were providing valuable inputs based on their indigenous knowledge. We had access to deep and rich indigenous, practical and experience based knowledge as well as innovative ideas from farmers. Such knowledge of farmers*

*was integrated to multidisciplinary scientific knowledge in order to come up with relevant agricultural technology responsive to farmers' needs.*

*RES 7 Added: Farmers have their own knowledge, experience and preferences. They have their own criteria or way of rating different technologies based on their indigenous knowledge.*

*RES 2 witnessed that:...As a research team we are composed of experts with diverse discipline specializing in soil, plant science, disease and socio economics. But each farmer is the owner of all these disciplines and specializations due to his/her long years of rich experiences and indigenous knowledge.*

In addition to farmers, tacit knowledge is articulated and shared by other stakeholders. As RES 10 confirmed, divergent perspectives were also solicited from multidisciplinary research team, extension agents and other pertinent stakeholders involved in participatory research. It is claimed that they have their own unique perspective regarding what the problem is and what constitutes the solution. Such perspectives are based on individual's expertise, past experiences and contexts and are dominantly tacit. Therefore, participatory research mainly involves experiential and indigenous knowledge of farmers as well as multiple perspectives of different actors and groups which are tacit in nature.

One of the purposes of this study is identifying types of tacit knowledge commonly shared in participatory innovation process based on the degree of tacitness or degree of abstraction. The literature identified three degrees of tacitness – high degree of tacitness (*intuition, gut-feelings or hunches, beliefs, taste and artistic-vision*), medium degree of tacitness (*insights, talent, judgment, mental-models, practical intelligence*) and low degree of tacitness (*know-how, skills, experiences, expertise, best practices, rules-of-thumb, improvisation, instinctive reaction and ability*). Based on this theoretical framework we explored the extent to which ideas and knowledge shared in the participatory research process can be classified under these categories. The overall

finding indicated that most of the ideas and knowledge shared fall under the category of medium and low degree of tacitness. This is mainly due to the nature of agricultural research being conducted. Regarding this aspect RES 08 claimed that:

*Unlike basic research, applied research is not as such complex and abstract. We focus more on applied research that involves more of practical aspects. They are related to productivity, disease prevention, fertilizer application, land preparation, etc. These practical issues are not highly abstract.*

In relation to this fact the data didn't show much evidence on ideas or knowledge that fall under high degree of tacitness/abstraction.

#### **4.1.1. Low Degree of Tacitness**

Knowledge types with low degree of tacitness are associated with practical work and they are highly visible for individuals and groups. They can be easily articulated, discussed, observed, taught/learned, codified and disaggregated from its context. Know-how, skills, experiences, expertise, best practices, improvisation, and rules-of-thumb are included in this category. Evidences from the data indicated that experiences, skills and rules-of-thumb are the dominant forms of tacit knowledge being articulated and shared in participatory research context.

##### ***Experiences***

Experience is knowledge or skill that farmers gained through being involved in or exposed to agronomic practices over a period of time. The following recounts by different respondents are examples of experiences which are linked to different forms of tacit knowledge:

RES 07: ... farmers didn't accept the 10cm spacing between onion seedlings recommended by the research since they had experience in planting with 5cm spacing. Based on farmers' experience the experiment was conducted between 4 and 6 cm and it perfectly worked with 5 cm. We learned that farmers' knowledge which is gained through long years of experience is better than what the research recommended.

RES 09: .... in the sweet potato project, after farmers gained experience from first year's experiment in the planting pattern, growth and performance of the plant they modified the size of plot and spacing between plots which were well tested by research and nationally recognized standards. They recommended that the size of the plot and the distance between plots should be doubled since sweet potato required more space when it was growing. Their suggestion was found valid.

Therefore, experiential knowledge of farmers was an important component that contributed to participatory innovation process.

### ***Skills***

Skill is the learned capacity to carry out pre-defined results, often with minimum time, energy, or both. In other words, it refers to the abilities that one possesses. The extent of the involvement of skill in participatory research was signified by the following excerpts from different respondents:

RES 07: *Farmers' hand is already trained (skilled) and they know how many times they throw a handful of seeds when they are sowing. They also synchronize the number of their walks with the number of throw since seed spreading depends on the number of walks. Based on this skill they can estimate how much kilogram of seed is required to cover a hectare.*

DA 02: *Farmers have developed a skill of conducting germination test to check whether the seed can grow or not. They do the test within seven days by planting it in a small plastic container. They learned this skill from researchers. Many farmers do this experiment by themselves before sowing the seed on a plot.*

DA 01: *Farmers made their own cost-benefit analysis to justify how the benefit of developing organic fertilizer from locally available leaves by far better than using chemical fertilizer which is so costly. They did their own computation to justify their preferences.*

RES 01: *Farmers conduct their own analysis of the data they gathered during evaluation of the varieties under experiment. They use this analysis skill to judge that one variety or technology is better than the other.*

Therefore, the findings indicated that participatory research involved farmers' unique skill of doing experiments, computational and analytical skills, problem solving skills, etc.

### ***Rules-of-thumb***

In the context of participatory research rules-of-thumb is a kind of tacit knowledge which is developed through farmers' wisdom of long years of practice or experience as opposed to a principle developed through specific scientific calculation or estimate. It serves as a broad practical guide or principle for doing farming activity or making rational decision. Like experience or skill, it can be easily learned and easily applied for making some decision. In the context of this study it refers to principles embedded in farmers' customary practices. The following excerpts emphasized the role of rules-of-thumb in participatory research:

RES 08: *While conducting experiments one plot is dedicated to farmers' existing principle of customary practices (rules-of-thumb) so that it is possible to compare. Such rules-of-thumb were considered as control.*

RES 11: *.... such farmers' principles of customary practices had influenced the standardization of row-planting ... increasing the row spacing between rice seeds from the recommended 20cm to 30cm. Farmers' recommendation which was influenced by the rules-of-thumb was supported by experts from Uganda.*

#### **4.1.2. Medium Degree of Tacitness**

Tacit knowledge under medium degree of tacitness is knowledge type which is intangible and unrecognized but can be articulated differently through the use of metaphor,

storytelling, analogy, etc. It leads to concrete results, expressed in behavior or in the work outcomes and can appear in more tangible forms. *Insights, talent, judgment, mental-models, practical intelligence* and *indigenous knowledge* are classified under this form of knowledge. Based on this theoretical framework the findings of this study signify that there are innovative ideas and knowledge of actors that can be classified under medium degree of tacitness.

### ***Insights***

The dictionary meaning of insight is the capacity to gain an accurate and deep understanding of something. As RES 07 recounted on the insightfulness of farmers he cited the following example:

*..... A farmer explained how the fruit should be positioned when it is planted in order to get high production. Researchers were not clear about the relationship between the position of the plant and its productivity. They conducted a research and proved that there is a relationship since the position represents optimal angle of the sun shine that makes the fruit more productive.*

The farmer didn't have anything to say about why that position became appropriate and make the fruit productive. Researchers didn't also have the same feeling or justification at the time of farmer's presentation. It is after conducting a research that a scientific explanation was provided.

Insight is synonymous to perception and it is common that farmers' perception and understanding about the phenotype of a plant can be different from that of researchers. As RES 11 explained:

*Researchers came up with a rice variety with shorter height in order to avoid logging. But farmers rationalized that there is no logging problem in the rice variety with longer height since the stalk of rice is strong. Therefore, they preferred longer height in order to use the biomass for other purposes.*

Researchers also have their own insights and perspectives when they initiate FRG projects, conduct experiments together with farmers and come up with a solution for context specific problems. RES 11 and RES 02 explained about the role of innovative insight of the researcher as follows:

*The researcher may add additional treatments based on his insights;.... Participatory experiment requires the creative insight of the researcher for manipulating the existing practices and generating new ways.*

*...Developing organic fertilizer from locally available natural leaves ('Bisana' and 'Korch') was based on the creative thinking of the researcher when it comes to maintaining optimal mix and appropriate timing of application.*

Therefore, empirical evidences demonstrated that creative insights of both farmers and researchers are important elements of participatory research process and the forum is contributing to the integration of such valuable insights of the actors.

### ***Indigenous Knowledge***

Indigenous knowledge is a shared tacit knowledge that has evolved over time by the local community, through trial and error in a particular environment. It may be informally expressed in local customs, experience, technology, and wisdom. The following excerpts from different researchers illustrate the use of indigenous knowledge in participatory research process:

*RES 03: .... A farmer treated a disease affected cow by piercing the skin of the cow and pushing air into the skin through the hole. This is an indigenous knowledge. The farmer didn't explain why he pushed air into the skin and how it cures the disease. At that moment researchers couldn't also give scientific*

*explanation to this treatment method. After further exploration veterinarians proved that the bacteria that caused the disease reside between the skin and flesh of the cow and it doesn't resist oxygen. But farmers cured the disease without having explanation for why and how the method cured.*

RES 06: *...when it comes to storage pest management project farmers had their own indigenous knowledge – they mix grain with pepper.*

RES 05: *In maize project termite problem was so common in the area. We saw one farmer solving the problem by cutting a unique weed found in the area and broadcasting it on the farm plots. This was an indigenous knowledge which the science has not yet traced.*

RES 11: *... one farmer was using oxen driven plowing between rows in order to prevent weeds from growing (such weed management system is known as 'shilshallo' or inter-row cultivation using oxen). Although this method is not recommended by science as it may damage the root of the plant, the way the farmer used this method to avoid weed without affecting the root was considered innovative, effective and labor saving.*

Therefore, findings indicate that there are wealth of indigenous knowledge which can solve the local problems and serve as an input to FRG projects. The participatory research process has contributed to the extraction of such valuable indigenous knowledge that can be either directly used as a solution to local problem or improved and integrated with scientific solutions.

### ***Farmers' Judgmental Knowledge***

Judgmental knowledge of farmers refers to their ability to accept or reject certain technology based on their own unique selection criteria, reasoning or justifications. This is a common practice in FRG projects during evaluation and selection of technology after participatory experiments are conducted. The episodes recounted below by the respondents represent examples of articulations of farmers' judgmental knowledge in the participatory research process:

RES 08: *farmers were provided with three options of planting – broadcasting (the existing practice of farmers), manual/conventional row planting and machine based row planting. After doing experiment farmers preferred manual row planting instead of machine based since it was time and labor saving. They justified that the manual system has greater precision than the machine based system since there was wastage of space when they use the machine. They also confirmed that the machine was unfriendly, noisy to the oxen, and inconvenient when it was mounted on the plow. This decision of farmers was unexpected.*

DA 01: *In a project on reducing seeding rate using seed spreader technology farmers rejected the use of sand. They rationalized that its continuous application may change their fertile soil into sandy soil. Limited availability and the labor required to sieve the sand were also mentioned by farmers as reasons for rejection. They recommended sieved soil as an option.*

DA 1 also added: .... *In the process of evaluation farmers judged that when the plant has wide leaves it is possible that it becomes more productive. This is equivalent to the scientific criteria of high photosynthesis.*

RES 04: ... *farmers rejected wood-made milk churning technology developed by the research center. They justified that the wood absorbs the butter at the time of churning and they recommended plastic made churning tool.*

The findings confirm that farmers apply their judgmental knowledge as to whether to accept or reject a particular technology and they articulate it in the form of selection criteria, reasoning or justification.

### ***Practical Intelligence***

Practical intelligence is a person's ability to apply components of intelligence to everyday life. This includes improvements of agronomic practices by farmers based on their own experiments, farmers' ability to manipulate treatment methods and controls to come up with better result, and manipulation of the existing practice to come up with new and productive agronomic practices. The following excerpts from different respondents

demonstrated how farmers use their practical intelligence to introduce better techniques to improve their agronomic practices:

*RES 07: ....in the evaluation of the productivity of different varieties of maize a farmer was looking at the distance between the stalk and the cob and he demonstrated that if the distance is wide it is productive while if the cob is very close to the stalk it is less productive. Gauging productivity level using the angle between the stalk and the cob was a unique measurement technique which has never been used in the scientific method. We checked across all the maize varieties under experiment using farmers' innovative technique and it was perfect. This is the practical intelligence that a farmer developed through long years of observation.*

*RES 07 also added: .... when farmers evaluated a newly introduced donkey driven cart developed by the research center they commented that it is heavy for donkey and it is better to be designed for oxen since they are stronger and have hump to support the pulling of the cart. They also suggested that if it is designed for donkey it should be made of tire rather than metal and it should have one beam rather than two in order to make it easy for the donkey to pull. Their feedback was very logical and contributed to the redesigning of the cart in an efficient way. Farmers were intelligent enough to provide design ideas which are useful in technology development.*

*RES 07 also added: ... research recommended row by row watering technique. But farmers introduced circular watering technique which was innovative, efficient, labor saving and valid input to the research.*

*RES 10: farmers were able to maintain the recommended 20cm distance and planting in row by introducing innovative way of plowing with oxen-driven hoe. Farmers' method improved a highly labor intensive and time taking method recommended by the research which involved measuring of the 20cm distance between seeds using rope, drilling the ground, dropping each seed into the hole and turning over the soil.*

*RES 04: ... a farmer introduced a new way of planting, zigzagging, and was able to reduce the recommended 4cm distance between onion seeds to 2cm and achieved more yield than expected with limited space.*

The above excerpts indicate that farmers have multi-dimensional practical intelligence that was applied in diverse areas – seed selection, seed breeding, row planting, watering,

fertilizer application, design and development of mechanical tools, etc. Extraction and application of such practical intelligence of farmers was possible due to the participatory innovation process (FRG approach).

#### **4.2. Mechanisms of Externalizing and Sharing Tacit Knowledge**

Section 4.1 presented findings on different epitomes or types of tacit knowledge which were commonly articulated, shared, integrated and applied by actors in the participatory research process. Identifying the mechanisms used by actors to externalize or articulate their tacit knowledge is another major objective of this study. Literatures indicate that tacit knowledge can be extracted and shared through highly interactive group deliberation or conversation, metaphor, analogy, narrative or storytelling, sharing experiences, demonstrations, coaching or mentoring, apprenticeship, asking question, cognitive mapping and collaborative critical thinking mediated by figurative/illustrative dialogue. Literature also says that the use of a particular mechanism depends on the degree of tacitness or degree of abstraction in knowledge being shared. Therefore, this section presents the findings on different mechanisms that actors used to articulate and share their tacit knowledge in the participatory innovation process.

##### ***Metaphor***

It is figurative or imagery language that infers about least familiar concepts on the basis of other familiar concepts and makes tacit knowledge observable through symbolic comprehension and generating new meaning. It is used when no appropriate word or formal language is available for articulation. Farmers commonly use metaphorical expressions to articulate their ideas and it is part of their culture. As RES 08 claimed:

*Communication is framed in the culture of the people in a particular area. When farmers present their idea they use their own metaphorical expression (ዘይቤ, የዋ አግላላጽ) that enables members or participants to easily understand the issue.*

One farmer used metaphorical expression to explain his understanding about the reaction of the plant to fertilizer application. When he justified his ranking in the evaluation of experimental results FAR 01 said:

*In the first round evaluation we ranked the plot where organic fertilizer was applied 8 weeks before sowing as 1<sup>st</sup>. In the second round a plot with organic fertilizer application 4 weeks before sowing was ranked as 1<sup>st</sup>. The 8<sup>th</sup> week plot is like an extravagant rich farmer. Just as the farmer wastes whatever he has within short period of time because of his extravagancy, the 8<sup>th</sup> week plot had already consumed all its food (the organic fertilizer) in just few weeks before the seed matured. During the first evaluation period or at the seedling stage of the plant it was getting excess food and the leaves of the plant were deep green and wide. But now it is a starvation time for the plot since there is no sufficient food in the soil and that is why the leaves were turned into white.*

FAR 01 also added another metaphorical expression: *During an annual holiday called ‘Meskel’ or a wedding ceremony, excess amount of varieties of food is served in the house of a rich farmer for at least one week. The face of every member of the family and relatives changes during that week. But this doesn’t last longer. The time of abundance pass and the time of shortage comes. The face of every individual turns back to normal. The same logic applies to the 8<sup>th</sup> week plot.*

RES 02: *During field visit, when farmers expressed their observation and understanding about the new experimental practice, they tried to associate the issue with what they are familiar with and explain their idea. For example, to explain about a land without fertilizer they use statements – it is like a child who lost his mother, it is like a poor person, etc.*

RES 11: *Farmers used the term ‘Jimla Cherash’ which is close to the English meaning of ‘mass distracter’ to represent a chemical called pesticide. Their terminology exactly represents the function of pesticide. It is applied before sowing and it kills every plant type on the plot.*

Not only farmers but researchers also use metaphorical expressions to transfer their ideas and knowledge to farmers about technical issue involved in collaborative experiment.

RES 01: ... *to explain to farmers about a disease which is common to rice I used metaphorical expression - a rice which is affected by this disease looks like 'በእሳት እንደ ተለበሰ ሃር'. Through such expression, farmers were able to visualize the symptoms of the disease.*

RES 11 also added: ... *I used a metaphor of the food requirements of the human being at different stages of development – childhood, youth and elderly in order to explain about the difference in the amount of fertilizer applied at different stage of the growth of the plant. At tillering stage the plant requires many food since the seed generates many shoots. The amount of food required also increases at panicle initiation stage (flowering stage) since the number of individual stalks having a series of single flowers increase.*

### ***Storytelling***

It is one of the forms of implicit communication used to uncover, capture, organize and convey tacit knowledge by allowing participants to frame their experiences in stories and add meaning to the context. In the participatory research process storytelling is one of the important means to articulate and share tacit knowledge among the group. The following excerpts specify how farmers use stories to articulate and share their experiences and practices:

RES 09: *Most of the time, farmers present their practices or experimental results in the form of stories – how they applied the new technique in their own way and how that technique affected production in a positive or negative way.*

RES 07: *Farmers tell stories on what they attempted before on similar solution in their own way and how that same solution failed. This is based on their undocumented knowledge.*

Researchers also transfer the knowledge behind the new technique or technology by way of telling stories. RES 02 said:

*... we tell to farmers a story about similar projects accomplished by others within or outside the country. ... when we start a project on lowering Teff seeding rate we told farmers how others achieved the optimal seed rate using seed spreader technique and we related the story to farmers' contexts and actual practices.*

### ***Dialogue***

It is a joint activity between at least two speech partners, in which a turn-taking sequence of verbal messages is exchanged between them, aiming to fulfill a collective goal. It involves reasoning and allows participants to further articulate their tacit knowledge (experiences, feelings), achieve a common understanding through collaborative meaning making and generate novel conceptual combinations. Participatory research process is a collaborative innovation platform that involves multiple actors from diverse discipline, social and cultural background, and diverse educational level. Each member of the group has his/her own unique perspective on the prevailing problem and possible solutions for the problem. These multiple perspectives can be articulated, reconciled and integrated through social interactions that involve multiple rounds of discussions, dialogues and building shared meanings. There are evidences from the findings of the study that indicate the use of dialogue as a means to articulate innovative ideas and knowledge of actors involved in the participatory research process. The following excerpts from different respondents confirm this fact:

*DA 01: ... during evaluation stage 3 – 4 subgroups of FRG members independently evaluate and rank the performance of different varieties being experimented. A variety ranked as first by one sub-group may be ranked as second or third by the other sub-group. Each sub-group engages in extensive dialogue to justify the ranking. After a series of deliberation the sub-groups reach consensus and select a variety with the highest rank and with reasonable justification. From this dialogue the research got many innovative ideas and unique selection criteria which were not part of the scientific criteria.*

RES 02: ... *when new technologies or agronomic practices are introduced to the farmers by researchers, they may not accept it by considering their contexts, resources, perspectives, practices, etc. Researchers and farmers engage in dialogue until one convinces the other and decide on better option.*

Therefore, through productive dialogue actors may articulate new ideas, perspectives, experiences, expertise, etc. to arrive at optimal solutions for problems and achieve common goals.

### ***Apprenticeship or Mentoring***

Apprenticeship or Mentoring is formal arrangement where specialized knowledge or skill from a domain expert is transferred to a novice. It is a form of recreating and rehearsing the experiences of others through repetition. It facilitates the transfer of tacit knowledge through observation, imitation and practice. This approach is common in the participatory research approach. In the collaborative experiment conducted by researchers, farmers and extension workers researchers mentor and transfer knowledge and skill to experimental farmers (members of FRG) and then experimental farmers mentor the non-experimental farmers (members of FRG) to transfer the same knowledge and skill. As RES 02 explained:

*We show to farmers what we have done in the lab experiment and then we make them to do what they have seen. This is different from demonstration since farmers redo what the researchers have done.*

AS DA 02 added: *Researchers practically showed farmers how to implement the standard length and width of plots to be prepared, the planting method (row planting Vs broadcasting), the distance among seeds, application of fertilizer and its timing. Then, all members of FRG implemented each step when they conduct the experiment under close support and follow-up by the researcher.*

RES 03: .... *the non-experimental FRG member farmers learned about the new method by way of observing what experimental farmers did and implemented the same method on their plot.*

### ***Experimentation and Exploration***

In the literature it is indicated that active experimentation is one of the mechanisms that facilitates externalization of tacit knowledge. In participatory field experiment process technologies are tested on experimental plots, evaluated and selected. It is extremely useful in eliciting tacit knowledge that are inexpressible in words but can be nevertheless be conveyed by pointing. Innovative ideas and new selection criteria are extracted and shared in the process. The following excerpts provide support to this argument:

RES 09: ... *farmers started to question the recommended method when they were experimenting its implementation. They started to introduce their own ideas and tested it side by side to the recommended one.....*

RES 08: ... *in the process of participatory experiment farmers became highly motivated to give feedback which enable them to articulate their hidden knowledge.*

RES 07: ... *when farmers were experimenting application of urine of different animals for seed treatment they demonstrated that the emergency of the crop retarded when they treated the seed using goat's urine and proved their assumption that all types of animal urine may not equally treat seeds...*

RES 11: ... *farmers articulate their reasons for rejecting a particular variety by doing their own experiment .... they did experiment on a rice variety called FKRS and proved that the variety is not appropriate for their area because it requires a lot of water to mature. One farmer did the same experiment on a variety called "Kukit" and demonstrated that the variety is good in terms of production and seed color but during harvesting it shatters and causes product wastage.*

As FAR 02 argued: ... *I was not comfortable with measuring everything (spacing between seeds, distance between rows, etc.) since it was difficult and tiresome in the context of oxen-driven plowing. I allotted one plot near to the experimental plot on which scientific measurement was applied and did my own experiment. I*

*did this to demonstrate that there is a possibility of estimating the recommended measurement using the conventional oxen-driven plowing system .....*

It is also found that researchers use on-farm controlled experiment to articulate and share their idea or knowledge to the farmers in a way they can easily understand. This is common when the reason behind the occurrence of a certain incident becomes highly abstract or invisible (e.g. when causal agents of a particular plant disease and their symptoms are so invisible). The experiment makes the case more understandable and more observable to the farmers.

Therefore, it is clear from the evidences that either farmers or researchers apply experimentation and exploration as a means to articulate, clarify, prove or disprove ideas, perspectives, assumptions and explanations behind the occurrence of incidents.

### ***Observation***

Observation is a means to build personal knowledge by observing the action of an expert and his/her explanation on how he/she performs a critical task. Through observation the observer gains insights into expert's practices and builds his personal knowledge base. The internal behaviors are also converted into external behaviors through observation. Farmers observe the phenotype of the plant and reflect on their observation that represents their internal understanding. This is evidenced by the following excerpts from different respondents:

*RES 10: ... farmers were able to observe a plant disease known as rust which was caused by fungus. They recognized that the occurrence of rust is less in purified seed than in non-purified seed due to salt content in the soil. Researchers' group didn't observe this. Based on their observation farmers were also able to tell that the stalk is thicker in purified seeds than that of non-purified one. They*

*considered this as indicator of greater productivity and they were correct since thicker stalk indicate high stored food.*

DA 01: ... *at germination stage farmers considered the variety as productive when the leaves became deep green and this was just based on their observation.*

RES 11: .... *Farmers make observation on their own experimental plot on a daily basis and reflect on the results of their observation – ‘this is not deep green’, ‘this is thin’, ‘this doesn’t resist disease’, ‘this requires a lot of water’, ‘this variety easily shatters’, etc. ...*

But all farmers may not have equal capacity to observe and correctly reflect on the phenotypic characteristics of the plant. As RES 11 recounted:

*A group of farmers were observing change on the panicle of the plant. Most of the farmers considered that the plant was attacked by disease. But one conscious and active farmer closely observed and said that it is rather termite problem, not a disease. This farmer properly observed, understood the phenotypic characteristics of the plant and expressed the exact problem of the plant.*

Therefore, farmers articulate their hidden ideas, perceptions, skills, intelligence, etc. through observation.

### ***Learning by Doing***

Learning by doing refers to the capability to improve productivity, by regularly repeating the same type of action. The increased productivity is achieved through practice, self-perfection and minor innovations. Therefore, tacit knowledge is learnt by doing. In the context of participatory research the experiment is done on farmers’ plot and they learn the tacit skills and knowledge behind the new technology through direct participation or practicing and self-perfection. The same experiment is repeated for three years and this is a good opportunity for learning by doing. As RES 04 recounted:

*... through repeated experiment and practice farmers learned how proper positioning of sweet potato contributes to higher productivity....*

RES 02 also added:

*... we make farmers to learn, understand and change by themselves through involving them in all stages of the experiment (from the stage of planting to harvesting) which is conducted on their own farm plot.*

Therefore, tacit knowledge which couldn't be learnt through discussion and demonstration can be easily learnt through direct participation in the actual practices. Farmers get a chance to repeatedly practice and observe the actual process which facilitates their learning.

### ***Lessons Learnt***

Results gained are shared with other team members, so they can learn from others' experiences. The lessons learnt are considered as guidelines, points, or checklists of what went right or wrong, in a special event. It involves identification, analysis and capturing of processes that fits well and the processes that needs improvement. Identification and sharing of best practices often result in generating and exchange of innovative ideas. In FRG projects exchange visits and field days are conducted in order to allow farmers to learn from each other. RES 10 said:

*... through the exchange visit farmers learned from other farmers how they purify seed using machine, about weed management and many other lessons.*

RES 03 also recounted:

*Two or more FRGs conducting experiment on the same crop came together and evaluated the results of each other. The most successful FRG explained how it achieved the best result while the least achiever explained what factors inhibited the group to achieve the best result.*

RES 03 also added: ... *we learned a lot from the failure of the sweet potato project caused by unexpected damage with typical virus that attacked the root of the plant. We didn't realize the effect till the harvesting time since the leaves were normal. We learned about the typical feature of the virus, the need for periodic checking and sample planting and the need for using cleaned seeds.*

RES 11: .... *termite became big problem in the area ... the chemical was not sustainable and environmental friendly... I learned that we have to come up with resistant variety or develop biological agents/biological controlling methods through research.*

### ***Modeling Technique***

Modeling technique can elicit tacit skills by helping participants reflect on their behaviors and by representing their mental models in graphical format. From the context of FRG approach it includes farmers' abilities to graphically depict their understanding about their environment and processes involved in different activities. The following excerpts from respondents provide evidences in this area:

RES 03: ... *based on their long years of experience farmers depict the map of their district on the ground indicating boundaries, main roads, schools, main water streams, forests, soil texture, crop type appropriate to specific area, etc.*

RES 10: ...*during training sessions farmers were capable of drawing process maps on flipchart for activities involved in dairy production – feeding, milking, churning, storing, selling, etc.*

Researchers also develop simulation as a modeling technique to clearly demonstrate the processes involved in the implementation of the new technology. As RES 04 said:

*...simulation was developed and presented to farmers to deliver abstract and technical issues in a more simplistic and understandable manner.*

### *Asking Question*

This applies to the extraction of tacit knowledge from researchers. Researchers have expertise that they developed through repeated exposure to similar problems, given prior explicit training. Asking researchers the right question is one way of transforming tacit knowledge into explicit. The study proved this by posing questions to the respondents (researchers) – Given the most important project you were involved in what would you do differently if you are given a chance to do it again?

Some of the excerpts from the respondents' response to the question:

RES 10: *...I would have continued working on developing techniques or technologies for ensuring storage quality and avoid physical contamination of seeds in storage for the purified seed; ... through creating moisture and pest free area, etc.*

RES 03: *... I would have developed an economic analysis for both maize and dairy products and enable farmers to compare the economic benefit of maize with that of dairy products commodity wise.*

RES 07: *... I would have introduced better group formation scheme for FRG members by considering geographical proximity and minimizing income and educational disparity as major determinants*

RES 11: *... I would have engaged different FRGs on the same project to derive highly diversified knowledge from different FRGs that could significantly contribute to the enhancement of the new technology. ... I would have also engage farmers in experimenting and selecting better post-harvest processes and techniques since it is linked to the preceding stages of participatory research processes.*

RES 01 also emphasized the need to ask farmers in order to tap their tacit knowledge built for long years in the form of lived experiences and indigenous knowledge.

*By asking farmers, researchers may have conceptualized their knowledge and experience.*

## ***Visual Representation***

Tacit knowledge can be effectively articulated and exchanged through communicating meaning symbolically using pictures, simulation video and other multimedia technologies. RES 05 stated that:

*Posters are the best mechanisms for delivering skill and knowledge to farmers by illustrating each step involved in the implementation of the new technology.*

Different respondents identified pictures as major visual tools to present the new knowledge and skill to farmers.

*RES 03: ... in order to explain about the benefit of Vitamin A we used a picture that demonstrated the effect of Vitamin A deficiency on vision. The training manuals are more of picture-based and easily facilitate understanding.*

*RES 04: When the researcher makes presentation on disease, farmers better understand picture based explanation rather than verbal presentations. But developing pictures in a way farmers can easily understand is not easy and it is part of the challenge.*

## ***Localization***

One of the major roles of FRG approach is solving the local problems with methods or techniques using locally available resources. The purpose is introducing new technology or agronomic practice that enables farmers to achieve high levels of productivity and improved livelihood with very minimum cost. In the process of experimenting and evaluating localized solutions, researchers and farmers articulate and apply their tacit knowledge and generate innovative ideas. As RES 10 recounted:

*... deploying seed purifying machinery is unaffordable in our context and we introduced salt solution to purify wheat seed ... it was implemented in a highly localized way, low cost but with high productivity gains (gaining 6 to 8 quintals more from the purified seed than non-purified one with a cost of only Birr 40 or*

*USD 2). Many new ideas arising from both farmers and researchers were incorporated to refine the application of this technique.*

RES 02 also complemented:

*... by introducing seed spreader technology using locally available materials - sand or soil, empty bucket and plastic sheet and applying it innovatively we reduced the seeding rate from 35 kg per hectare to 10 kg per hectare.*

DA 01 also elaborated how organic fertilizer was developed from locally available natural leaves with a significant contribution to the reduction of the huge cost committed on chemical fertilizer. Therefore, the effort to introduce cheap localized solutions based on locally available resources to bring changes in the livelihood of farmers involved articulation and integration of innovative ideas of researchers, farmers and extension workers.

### ***On-farm Demonstration***

Practical on-farm demonstration is one of the most important methods used in participatory research approach to exchange tacit knowledge. The primary advantage of such demonstration activity is that farmers will have the chance to observe, evaluate, and adopt the technology and easily understand the new idea and knowledge embedded in the technology. Farmers can easily visualize the difference between traditional farming practices and improved ones and provide their feedbacks and innovative ideas important for enhancement of the newly introduced technologies and practices. Demonstrations are organized first for FRG member farmers and then for non-FRG member farmers in the surround areas. Regarding the role of demonstration in sharing new ideas and knowledge

RES 01 Said:

*Practical demonstration is a powerful means for conveying message to the farmers. Researchers apply demonstrations on farmers' field. Farmers are there and they can observe and participate in all the activities. So, in addition to training, meeting and explanation farmers themselves experience. They see, touch and perform by themselves. Farmers compare different treatment. They themselves observe directly. That is a very powerful means of transferring knowledge.*

Different respondents illustrated the role of demonstration in the articulation and transfer of new ideas and knowledge by referring to real experiences:

*RES 07: ... a farmer demonstrated his innovative method of measuring the productivity of different maize varieties using distance between the cob and the stalk ...*

*RES 07: ... we enabled farmers to visualize the hidden nature of the bacteria and methods of curing the plant through demonstrating the effect of the application of pesticide...*

*RES 08: ... based on their practical intelligence innovative farmers came up with a hybrid of the traditional (broadcasting) and new (row) planting techniques and practically demonstrated how it significantly saved their time and labor and increased their productivity.*

To sum up, from fourteen mechanisms of tacit knowledge externalization identified from literature eleven of them were supported by empirical findings. Two mechanisms were found unique to the participatory agricultural research environment. This implies that participatory agricultural research is a collaborative platform where tacit knowledge is widely articulated and shared using multitude of externalization mechanisms. The following table summarizes the empirical support to different mechanisms.

Table 4.1: Summary of Empirically Supported Mechanisms of Tacit Knowledge Externalization

<b>Mechanisms from Literature</b>	<b>Empirically Supported</b>	<b>Mechanisms from Empirical Finding</b>
<i>Metaphor</i>	<i>Y</i>	<i>Localization</i>
<i>Storytelling</i>	<i>Y</i>	<i>Practical on-farm Demonstration</i>
<i>Dialogue</i>	<i>Y</i>	
<i>Apprenticeship or Mentoring</i>	<i>Y</i>	
<i>Observation</i>	<i>Y</i>	
<i>Learning by Doing</i>	<i>Y</i>	
<i>Best Practices and Lessons Learned</i>	<i>Y</i>	
<i>Modeling Techniques</i>	<i>Y</i>	
<i>Asking Question</i>	<i>Y</i>	
<i>Visual Representation</i>	<i>Y</i>	
<i>Exploration and Experimentation</i>	<i>Y</i>	
<i>Prototyping</i>	<i>N</i>	
<i>Analogy</i>	<i>N</i>	
<i>Brainstorming</i>	<i>N</i>	

### 4.3. Factors that Impact Externalization and Sharing of Tacit Knowledge

It is evident from the findings of the study that participatory approach has great potential to facilitate articulation and sharing of tacit knowledge of multiple stakeholders and contributed a lot in integrating such valuable knowledge into innovation process. But there are challenges that limited the effective articulation and sharing of tacit knowledge. Some of the broad categories of factors identified by the study include creating interactive platform, variation in cognitive competence or knowledge capability, social capital factors, communication quality, degree of complexity in the ideas being shared, group dynamics, motivational factors, personal factors /attitude/ and resource and infrastructure problems.

### 4.3.1. Creating Interactive Platform

A common platform or shared space ('ba') is a prerequisite for collaborative innovation and serves as a foundation for articulation, sharing and integration of tacit knowledge of multiple stakeholders. In the case of FRG approach there are different platforms which facilitate sharing of tacit knowledge among researchers, farmers, extension agents and other key stakeholders. The platforms include meetings, field visits, field days, field demonstrations, exchange visits, training, etc.

#### *Meeting*

It was found that there are different formal and informal meetings during the process of participatory experiment. The formal meetings are regular meetings at different levels which are organized to share ideas and discuss the issues and problems raised during trials. Such regular meetings are scheduled and include all researchers, FRG member farmers and extension workers. Regarding such regular meetings RES 11 said:

*We have a formal meeting with farmers four times a month. Farmers reflect on their performances and challenges as well as feedbacks on the new technology.*

DA 2 also added:

*In the first meeting researchers make presentations on the technology, each procedure involved in land preparation, sowing, weed and pest management, harvesting, etc. ... open discussions and question-answering sessions are common. Such kinds of meetings are limited because researchers were unable to travel to the field frequently due to distance. But it is conducted at least three times in one season – at the time of sowing, in the middle and during harvesting time.*

Therefore, it is clear from the excerpt that distance is one of the major factors that limited the frequency of meetings and thus, the possibility of articulating and sharing more tacit knowledge through frequent meetings.

It was also found that FRG member farmers organize themselves and conduct their own formal and informal meetings to discuss their ideas and share their experiences, learn from each other and come up with their shared innovative idea and selection criteria. The frequency was high in the first year's experiment since farmers were new for the new technology or agronomic practice introduced and then reduced in subsequent years.

Regarding the informal meetings among farmers RES 11 said:

*.... sub-groups of FRG members share their ideas not only in a formal meeting but also in informal meetings like in a coffee ceremony or similar occasions. They exchange all the negative and positive impacts and their proposed solutions informally and then reflect them on the formal scheduled meetings.*

Researchers' team with multidisciplinary background also conduct its own regular research review meetings to report progress, share experiences to improve each other's activities, support each other if there are problems. These review meetings provided inputs which were so critical to the experiment being conducted. As RES 10 recounted:

*In the first year experiment we didn't wash the purified seed using salt solution since the team of researchers didn't understand its negative impact. When we present it in the research review meeting at the university other researchers expressed their concern. If we continuously apply the unwashed purified seed with salt content it may gradually increase salt concentration in the soil and negatively impact crop productivity. Based on such feedback we started washing in the second year of the experiment. This concern was raised by farmers when we initially introduced the method and the feedback from researchers also addressed the initial concerns of farmers.*

### ***Field Days***

Field day is one of the major platforms in FRG projects. It is an event on which better as well as worse examples of farmers' practice are open for non FRG member farmers within and outside of the community and other stakeholders. Field day can exhibit good technologies side by side with local practices to relatively large number of people. Participants learn new technologies by observing personally and ask about successful farming practices. For a field day held on farm, the host farmer plays a prominent role in presenting the results of the experiment and facilitating the sharing of experiences and lessons. Regarding the role of farmers RES 01, RES 02, RES 03 and RES 10 said:

*.... Trial farmers took the responsibility of explaining their experiences and lessons on field days. .... Participants observed, asked questions and took experiences and best practices. ... Such presentation and experience sharing sessions enabled the non-experimental FRG members and non-FRG farmers to adopt the technology in the coming season. The role of researchers in such forums is only moderating the discussion.*

### ***Field Visits***

Field visits are forums where farmers who are members of FRG in the same village visit each others' plots. These were the major forums where farmers share their experiences and learn from each other. As it was described by DA 01:

*Field visit is a forum where the processes and results of experiments are presented in detail. Many ideas, experiences and knowledge are exchanged in these forums. In the field visit, after observing the performance of the plot on which the new technology was experimented we discuss ideas on how to replicate the same experience in other areas.*

Like the field days, the role of farmers in field visits was significant in terms of making presentations, explaining about technologies, comparing the new agronomic practices with the old one and leading the discussion. Farmers used their own language and examples in their presentations and responses to questions. Researchers took only

facilitation role in this forum too. In addition to FRG members, authorities from Agricultural Bureaus and Research Centers also participate in the field visit and the presentation and discussion is followed by series evaluation of the project that includes interviewing of individual farmers independently.

### ***Exchange Visit***

Exchange visit is one of the experience sharing and learning tools by farmers visiting each others' farms where good, as well as worse practices, is observed and discussions are made. An experiment is usually conducted with more than one trial farmer placed at different locations within a given village or district. Experiences with trial performance, therefore, may not be the same as it is determined by locations, farmers' experience and so on. Hence, it is very important to enable farmers learn from each other and share different experiences through arranging exchange visits. As RES 09 described:

*One important and exceptional method we followed was exchange visit – farmer to farmer experience sharing. Farmers coming from different villages share their experiences and visit each others' plots.*

### ***Training***

Farmer training is one of the important components of FRG approach. Training is meant to introduce a new way of doing things and/or to fill observed gaps in performance or undertaking some agricultural activity. Training is also given to farmers and extension workers when some basic knowledge and skills is required to carry out planned experiments. Training can be given at different times in the course of FRG research activities. As RES 03 and RES 10 explained:

*... Training was given to farmers on the technological packages and new agronomic practices before the actual experiment. We train the model farmers (experimental farmers) first and then, the model farmers train the remaining members of FRG. The training given at these two levels is one way of transferring knowledge.*

RES 08 added:

*... the content of the training commonly include information about the technology, technical issues involved in the implementation of the technology, how land should be prepared, how the seed should be planted, etc.*

### **Workshops**

Workshops are commonly organized for researchers and experts to share ideas on FRG projects, major performances and challenges. As RES 08 recounted:

*In workshops ideas presented include what was done? What was the outcome? What lessons have we learned? What was the reaction of farmers? What are we going to do in the future? What is the prospect of the new technology in terms of scaling up to other areas? When it comes to the technology which was not accepted by farmers we discussed about the problem of the technology and the need to conduct further research to take corrective action. When issues were discussed on a failed project in forums like workshops, approaches of experiments were commonly criticized and new ideas were generated in the form of recommendations for improvement. Farmers also participated in the discussion and they forward their reasons why they rejected or accepted the technology.*

### **4.3.2. Disparity in Cognitive Competence or Knowledge Capability**

There is high discrepancy in cognitive competence or knowledge capability among members of participatory research. This is mainly because farmers, extension agents and researchers who are at different levels of education and experience are involved in the process of innovation. This factor resulted in variation in levels of understanding, conceptualization or interpretation of ideas or observations. RES 06 explained about the

impact of different literacy level of farmers and its impact on level of understanding as follows:

*One of the challenges in FRG approach is the educational level of farmers. Some of the farmers are illiterate while some of them are literate. They have diverse knowledge and skill. This resulted in diverse ways of sharing and understanding ideas. They may interpret our ideas in different way. These factors may hinder the knowledge flow.*

Farmers are classified into three groups based on their levels of understanding – innovative (model) farmers, farmers with moderate level of understanding and slow learners. As RES 06 recounted:

*There are innovative farmers who understand the idea quickly. There are farmers who are modest in understanding the idea presented and take more time to understand. Others become uncertain about the technology and hesitate to accept because they may not grasp the new idea or see the benefit of the technology.*

RES 05 and DA 02 shared similar experiences:

*The level of understanding varies across members of FRG and the idea presented may not be clear to all. Some of them just accept the technology by understanding its benefits from theoretical presentations. These are innovators or model farmers. There are also adopters that learn from the model farmers and implement the technology. The third group consist slow learners that make decision through wait and see approach. Many rounds of discussions are required to convince these farmers to accept the new ideas or knowledge or technology.*

Because of the difference in cognitive capacity and poor levels of understanding various forms of misconceptions were created which affected the smooth flow of ideas and knowledge. The misconceptions could be in the whole process of the experiment or in the representation of their observation. RES 03 illustrated farmers' misconception in terms of representing their observation:

*... farmers mentioned that there was disease problem. They couldn't distinguish different kinds of disease (leaf disease, root disease, disease caused by seed, disease caused by soil, etc.).*

RES 07 also added:

*.... Farmers tend to apply excess chemical fertilizer like Urea, just by looking at the leaves becoming deep green and the plant growing succulent... but this doesn't necessarily mean that it will finally end up with higher yield ... it may even aggravates disease and affects yield negatively. Farmers wrongly judged by the visible effects of the use of more fertilizer and wrongly interpreted their observation since they couldn't anticipate the negative consequences.*

*In addition, the cause for dried leave could be due to disease, insect or due to the strong sun. But farmers give it a single name – 'Mich' (ཤོ་ཚོ).*

DA 01 shared similar experience:

*... based on their observation of dispersed seed at germination stage, farmers rejected the idea of applying seed spreader technique and decided to re-plough their plots and replant another crop. ... this was because farmers were unable to anticipate the positive impact of more spacing between seeds on yield.*

Because of their low level of understanding farmers may fail to foresee the future benefits of the technology or agronomic practice. As RES 03 illustrated:

*In forage development project farmers preferred to plant maize rather than grass. This was because they couldn't anticipate an immediate economic benefit from grass as compared to maize. Farmers were comparing the value of maize with that of grass, rather than the value of maize with that of butter or milk. Because of this factor we failed to successfully implement FRG's forage development project.*

***Solutions suggested:***

Respondents argued that farmers' knowledge capacity or cognitive competence can improve when they gain more experience in the project's idea. As RES 03 claimed:

*Initially, farmers couldn't easily visualize the complete cycle of forage production. They developed this capacity and increased their demand for forage*

*through experience. This implies that farmers developed the skill of doing economic analysis and comparing the value of maize with dairy products.*

RES 03 also argued that training, multiple rounds of discussions and practical demonstrations contribute to the improvement in farmers' cognitive competence. Provision of supplementary extension materials, close interaction with extension workers, allowing open and free expression of ideas as well as taking farmers to areas where similar technologies have been adopted were also cited as mechanisms that can improve the level of understanding of slow learners. Involvement in experiments and observation of the results of experiments also enhanced farmers' understanding.

It is also claimed that farmers with prior exposure to new technologies and mechanized farming have better understanding than other farmers. As RES 03 explained:

*Farmers in the rift valley area were more advanced since they use mechanization, irrigation and other modern technologies before FRG project. They were not new for technology and they can easily understand when new idea or knowledge is presented.*

#### **4.3.3. Social Capital Factors**

Social capital refers to the interpersonal relationships and the resources embedded in those relationships. It consists three dimensions including structural, relational and cognitive capital. The findings of the study indicated that the three dimensions are impacting the process of eliciting and sharing of tacit knowledge of actors involved in participatory research process.

### ***Structural dimension***

In the context of this study the structural dimension of social capital refers to hierarchy, strength of linkages among actors (closeness among actors), intensity of team's network (amount of social interactions), and more open and participative team discussions.

From hierarchy perspective, FRG approach is a more collegial approach where farmers, who are involved in organized two-way communication with researchers and make decision collectively. Researchers facilitate the collective or individual decision-making of farmers. The power distance between researchers and farmers has been narrowed down through such collegial relationship. As RES 02 said:

*We created conducive environment for farmers to fully and freely express their ideas. Researchers and farmers equally debate and express their ideas .... and the kind of collegial relationship between farmers and researchers avoided feelings of differences ... we encouraged farmers to take full part in the discussion.*

DA 02 added:

*Researchers didn't impose their idea. The forums urged farmers to express their ideas and feedback as freely as possible.*

The attitude of researchers also changed towards considering farmers as knowledgeable partners. As RES 07 emphasized:

*Through long years of working with farmers, we learned that we don't teach farmers. Teaching implies that researchers are knowledgeable and farmers are ignorant. This was wrong. The term 'sharing' is better since we share our knowledge with each other.*

The linkage among farmers was also strong as it was demonstrated by DA 02:

*... Coupling of slow learners with model farmers for supporting each other, sharing knowledge and skill among themselves and building equal level of understanding was a key mechanism for creating stronger linkage among farmers ...*

Respondents indicated that farmers need openness, close and frequent interaction with researchers to freely express their innovative ideas. As RES 09 explained:

*... It was after researchers made close and repeated interaction that farmers started to freely express their ideas. I believe that an increase in the relationship between researchers and farmers enhance articulation and sharing of farmers' accumulated knowledge.*

### ***Relational capital***

In the context of this study relational capital includes trust and confidence, collective bonds, group solidarity and reciprocity, norms. Norms refer to implicit rules of behavior referring to what most people do, compliance with local rules and customs, ways of expressing ideas, being reserved to speak or express ideas openly in public.

### ***Trust***

Farmers have to trust researchers and the technology they proposed in order to successfully proceed with collaborative experiment and sharing of their tacit knowledge in the process. Lack of trust hinders the process of building shared meanings and reaching consensus. As DA 01 recounted:

*Most of the time the misunderstanding is not due to the way the idea was presented but it arises from being suspicious to accept the new technology introduced.*

Farmers build more trust on the newly proposed technology or agronomic practice as far as other farmers or extension workers supported it. As DA 02 said:

*To clear their doubts we used model farmers and extension workers for presenting the new idea to other farmers since they have more trust to them than to the group of researchers during the first year experiment. In the second and third year experiment farmers became fully confident on researchers, openly participated in collaborative experiment and contributed their experiences and skills.*

RES 07 also added:

*... Farmers' trust and understanding increased when they were communicated by their own friends using their common language.*

Farmers' trust also increased with their direct involvement in the research process and with the integration of their indigenous knowledge in to technology development process.

As RES 02 elaborated:

*....farmers' trust increased when their indigenous and experiential knowledge was integrated in the process of technology generation and evaluation. ... our initial face-to-face interaction was also important to the building of basic trust.*

The results of first year's experiment also enabled farmers to build more confidence and trust. DA 02 said:

*The output of the new technology significantly increased the trust of farmers in the technology and in the experiment being conducted.*

### ***Norms/culture***

The culture or norm within which farmers operate can hamper the smooth flow of knowledge among groups of farmers and researchers. RES 10 illustrated this fact as follows:

*... Harvesting the plant at vegetative stage (before flowering), drying it and finding its weight was part of the processes involved in collaborative experiment. It was important to anticipate and compare the level of productivity of each variety. But farmers rejected this idea because harvesting a plant at this stage was considered as culturally unacceptable and out of the norm. Therefore, we failed to harvest and test the possible dry matter yield at vegetative stage which hindered the possible transfer of knowledge and skill.*

### ***Reciprocity***

The basic principle of participatory research approach is that researchers and farmers can mutually complement each other through exchange of their innovative ideas, knowledge, experiences, expertise, etc. Such relationship based on mutual exchange may not be realized if one of the two parties fails to do so. RES 06 said:

*Some of the farmers may not be willing to share their ideas in their mind. Sometimes, we may not get as much idea as we expected when they become hesitant.*

Farmers may not share their idea if they feel that it is the source of competitive advantage in the market. As RES 01 argued:

*Farmers may not be willing to share their ideas or knowledge or experience if they feel that it is highly strategic. This is because most of agricultural activities are becoming market oriented. If more farmers use the same technique or technology and produce more output they fear that they lose their market share.*  
....

It is also indicated by respondents that the reciprocity may be affected by the perception of some researchers towards farmers – how they behave and to what extent they respect farmers. As RES 01 said:

*... researchers must believe that farmers have been doing farming activities for long years and they have very rich knowledge and experience that complement the scientific knowledge. They have to believe that science may not solve all agricultural problems. Therefore, researchers must give adequate time and listen to the farmers.*

### ***Cognitive Capital***

In the context of this study cognitive capital mainly constitutes shared language, shared interpretations and system of meaning and shared understanding. In FRG approach language has been the major challenge to articulate and share tacit knowledge in cases

where there is no shared language between groups of farmers and team of researchers. RES 08 claimed that “Being unable to speak the local language hinders the proper transfer of knowledge”. RES 02 also added:

*I know only Amharic and I don't speak the local language – Wolayitigna. Farmers don't speak Amharic too. It was difficult for me to directly communicate with them as much as I need. Farmers were also unable to fully express their feelings to me.*

Language may not be a problem when team of researchers and group of farmers share the same language. As RES 05 confirmed:

*Language was not as such a problem. We communicate farmers in their own language. There are members of researchers' group that can speak more than one language.*

When there is no shared language between researchers and farmers, researchers use interpreters. Different respondents confirmed that most of the time researchers use extension workers as interpreter. In some cases model farmers served as interpreter. But there were challenges in transferring knowledge through Interpreters since the whole message may not be correctly translated and communicated to farmers. There might be inconsistencies in translations and distortions and losses in the ideas and knowledge transferred. In order to address these problems of inconsistency and misunderstandings in translation respondents made suggestions regarding the qualities of interpreters. As RES 06 said:

*It is better to have an interpreter who has equivalent expertise or knowledge so that all of my ideas are properly presented.*

It was also suggested that involving the interpreters in the research process enhance the quality of translation. RES 02 said:

*Since we were working as a team by involving those who served as interpreters in the discussions and research processes, they fully presented our ideas.*

The experience of the interpreter also had an impact on the quality of translation. As DA 02 claimed:

*I have been serving as an interpreter for many years. I was fully transferring the ideas and knowledge from researchers to farmers and vice versa.*

Participation of farmers with diverse local language (e.g. Amharic and Afan Oromo) in one FRG project was also a challenge to exchange knowledge. RES 03 said:

*... Researchers may speak multiple languages and may use those languages alternatively. But switching from one language to the other by the same presenter negatively affected the proper transfer of knowledge. This problem was difficult in the training.*

Even if researchers speak the same local language farmers use their own terminologies and accent when they communicate their idea which may not be understood by the researcher. As RES 09 illustrated:

*I am a speaker of Afan Oromo. But the way Afan Oromo language is pronounced and the kind of specific terms used may differ from place to place. Due to this problem, when I was working in a project implemented in one district I couldn't understand farmers although they were speaking Afan Oromo. We understood each other after they elaborated the points further. For instance, in order to say "the person has already left" farmers in particular locality say "Lufe Yira". But in our area we say "Asira Derbe" or "Asin Derbe". When they want to say "where do you go" they say "Ese Edda". But in our area we say "Ese Demta". I was so confused at the initial stage. But through time I learned these terminologies.*

In order to address such problem researchers are expected to be close to farmers and understand their terminologies. RES 11 said:

*We are expected to understand farmers' terminologies. This requires staying with farmers for longer time. The terminologies used by farmers may confuse us but*

*when we ask them to clarify, they explain it and we understand. We also try to associate the terminology to the scientific representation or process. We are expected to reconcile the indigenous knowledge with the scientific one.*

RES 07 also added:

*From my experience I know the local language and I can easily understand what the farmers say. If I am confused in some of their typical words, I ask for further elaboration and they present it clearly. They also complement each other to make things more clear.*

In addition to lack of shared language among team of researchers and group of farmers there is also a challenge in translating scientific and technical terms into local language.

As RES 10 emphasized, “it is difficult to get direct translation of a scientific term in Tigrigna (the local language).” RES 11 also said:

*If the scientific name cannot be translated into local language we force farmers to learn and use the scientific name. For instance, Nerica is a scientific name for rice seed variety. We couldn't find a substitute name in local language and thus, we forced farmers to use the same name.*

Researchers try to present the scientific or technical terms in simplified way so that farmers can easily understand the technology or agronomic practice proposed. As RES 06 explained:

*When we present technical issues we try to simplify it as much as possible in order to make it more understandable to farmers. We use equivalent local terminologies for our scientific/technical terms if we get one. Since we have two way communication there is an opportunity for farmers to ask if the presented idea is not clear. Had it been one way communication it would have been a problem for farmers to understand the exact meaning of our idea.*

RES 08 also added:

*Since we are working with farmers we use highly simplified language which is quite equivalent to their language and which can be easily understood by farmers.*

Inexperienced researchers may fail to anticipating the level of understanding of farmers and use inappropriate terms. As RES 10 said, “Researchers who are fresh graduates mix technical jargons and use English terms when they communicate with farmers.”

Although researchers and farmers have different linguistic representations for some phenotype of a plant or agronomic practice from scientific and indigenous knowledge perspective, both may have shared interpretation and system of meaning on the linguistic representations. As DA 02 illustrated:

*From scientific representation perspective, at the seedling stage we say that when the number of tillering is higher, there will be more heading at each tillering and thus, it is more productive. Farmers use the term ‘Dasha’ in their own local language to perform the same evaluation and gather productivity data in their own way. Both evaluation criteria are one and the same and both farmers and researchers understand each other. Surprisingly, for an indigenous knowledge which is owned by farmers we find an equivalent scientific knowledge. We convert the criteria derived from farmers into scientific terms. Those which couldn’t be converted will remain the same in the language of farmers.*

Therefore, under cognitive capital it was found that the linguistic factors are dominant. Language related problems including lack of shared language between researchers and farmers, inconsistencies/distortions/losses of meanings and ideas during translations by interpreters, lack of shared system of meaning within the same language and the use of scientific and technical jargons impact proper articulation and sharing of tacit knowledge. But there are instances where farmers’ linguistic representation and scientific representation about something match. Use of well experienced interpreters, simplified linguistic representation and substituting the scientific and technical jargons with equivalent local terminologies may also address challenges of linguistic variation and build shared system of meaning.

#### **4.3.4. Communication Skill, Method and Media**

The findings of the study indicated that communication skill and media are important determinant factors in the process of articulation and sharing of tacit knowledge. Communication skill contributes to the establishment of actors' relationship based on mutual understanding. Communication facilitation skill and modes of communication also impact the effectiveness of interaction and thus, articulation and sharing of tacit knowledge.

##### ***Communication Skill and Communication Facilitation Skill***

Respondents emphasized that the communication skill of researchers affect the smooth flow of ideas and knowledge among actors involved in the participatory research. Respondents claimed that researchers with socio-economic background have better communication skill than researchers with pure science background since they can better deliver the socio-economic aspects of the technology. In addition, socio-economic and agricultural extension professionals can communicate ideas and knowledge to farmers in a more simplified and understandable manner. Those researchers with pure science background focus more on technical aspects of the technology and they are not as good communicators as socio-economists to deliver the required knowledge and skill to farmers. As RES 05 claimed:

*... The main focus of experts with biological and botanical background is more on the technical aspects of the technology and they disregard the socio-economic aspects. This became the source of misunderstanding between researchers and farmers. I believe that the socio-economic and agricultural extension experts have better communication skill and should lead the research process in order to fill the gap...*

RES 11 also emphasized that:

*The success of the project depends on the understanding of farmers about the new scientific knowledge introduced. ...Their understanding depends on the communication skill of researchers, their presentation approach and use of proper terminology that can be easily understood by farmers.*

Regarding the role that researchers should play in extracting tacit knowledge of farmers and the challenge in this respect, RES 01 claimed that:

*Researchers are expected to ask farmers and conceptualize their knowledge and experience. Such kind of interaction is very important for the articulation and sharing of the knowledge of farmers. But such communication is difficult or not very easy. Most of the researchers are not trained in how to interact with farmers and integrate farmers' knowledge with scientific knowledge. This has been the biggest challenge.*

RES 01 also claimed that researchers need to have communication facilitation skill to enhance sharing of ideas and knowledge among FRG members.

*Learning from practical demonstration and direct observation can be further improved if the researcher can facilitate. A good researcher guides farmers to focus on critical aspects and let them compare. Therefore, skill of facilitating communication was also another determinant factor from the side of researchers.*

### ***Communication Method and Media***

The way the new idea is presented by researchers is also another factor. In participatory research approach both researchers and farmers are presenters and they choose a particular method depending on the nature of knowledge they are transferring and the type of audience. Researchers most commonly use theoretical or verbal presentations supported by pictures and practical demonstrations. Farmers have been using verbal communication and practical demonstration when they presented their ideas to other farmers. The same method was applied by researchers. When the required knowledge and skill couldn't be properly delivered through verbal explanation and if farmers fail to

understand the whole process, they learn and understand through practical demonstrations in the actual implementation of the new technology or agronomic practice. As RES 07, RES 03 and RES 06 shared similar experience:

*All farmers reached at the same level of understanding during practical implementation of the technology and when they actually see and practice. The discussion during the implementation process also created more understanding..... Therefore, verbal presentation supported by practical demonstration on field experiments was found a better way of sharing knowledge.*

As RES 07 said, “experimental farmers also prefer practical demonstration to transfer their ideas to other farmers and stakeholders.”

Repeating the same experiment on the same technology for three subsequent years was also cited as a major means for effective transfer of knowledge and skill for farmers. Farmers refine their knowledge and experience about the new technology and agronomic practice when they conduct repeated experiment. As DA1 said, ‘all members may not equally understand especially in the first year of the experiment. But their understanding increased from year to year as they gain more and more experiences.’ As RES 10 illustrated:

*Because the project was flexible and has three rounds of implementation in three years, we had a chance to further explore and make things more clear.*

RES 07 also confirmed that ‘by conducting experiments on the same technology for subsequent years it is possible to extract many innovative ideas.’

Different communication tools were also used to support verbal communication or practical demonstration. Some of the communication tools indicated by respondents include posters, brochures, fliers, extension materials, etc. RES 05 stated that:

*Posters are the best mechanisms for delivering skill and knowledge to farmers by illustrating each step involved in the implementation of the new technology. But it is costly to prepare them since it is highly supported by visual presentations. We are not developing such kind of material due to shortage of resources. Extension materials are equally important communication tools to present the procedures that farmers should follow in implementing the new technology.*

Different respondents identified pictures as major visual tools to present the new knowledge and skill to farmers.

#### **4.3.5. Group Heterogeneity**

Evidences from the study indicated that group heterogeneity in terms of varying size of group members, age and gender disparities within members of FRG affected the articulation and sharing of tacit knowledge. FRG approach involved group of farmers with different levels of understanding, knowledge and experience as well as different age group and gender. The approach also constitutes team of researchers with multidisciplinary background. These diversities have both negative and positive impacts on the levels of understanding. RES 06 said:

*The knowledge and experience of farmers, their education status and their level of understanding is so diverse and it is a challenge. In this case farmers may not have equal understanding.*

RES 07 also added:

*Variation in personal interpretation of new ideas was common since members of the FRG were highly diverse.*

Farmers' level of intelligence varies and impacts the innovativeness of the group. For instance, as RES 05 stated "the predominance of FRG by model farmers makes the group more active and innovative" by enhancing its capacity to elicit, share, assimilate, transform and exploit the wealth of knowledge embedded in the minds of members of the

group. He also added that “if the group is dominated by laggards, unless a different approach is devised to raise their level of motivation and understanding it is difficult to make it sustainable, let alone becoming innovative.” RES 11 also added:

*When we select FRG members we included model farmers or innovators who could easily understand and implement the technology we introduced. This was because, we expected them to teach and transfer knowledge to other farmers....*

The age disparity among member farmers had also its own impact on the level of understanding and innovativeness of the group since more age means more practical knowledge and experience. As RES 07 illustrated:

*Elderly farmers have better understanding and analytical skill than younger farmers because of their rich experience. I remember one incident. Two farmers were involved in the selection of better crop variety – one was young and the other was elderly. When the young farmer was asked to select among the three maize varieties, he selected variety A and B and he didn't want to see variety C. When the elderly farmer was asked to do the same he chose all the three varieties. When he justified, he explained that this year the weather has been conducive and that is why the growth of the two varieties (A and B) became attractive. Last year the weather was bad and during that time variety C gave us good result and therefore, we need the third when the weather becomes bad.*

When it comes to gender, the involvement of female farmers in the participatory research has contributed a lot in terms of generating and sharing innovative ideas as well as better decision making. As RES 07 recounted:

*In the process of selection of variety by a group consisting both female and male the result was biased to one variety. Then, we divided them into two groups of male and female. Male farmers focused on productivity and selected a variety that gave higher output with longer duration and rejected the other variety that gave lesser output with shorter duration. But female farmers selected both. Their justification was that since a large portion of maize is consumed fresh, it is good to have a variety that gives less output but matures within shorter period of time for consumption purpose. They also said, we need the variety with high productivity in order to get more yield. Therefore, female farmers gave*

*convincing justification in relation to their selection criteria by taking risk into consideration.*

RES 04 also added similar experience:

*We formed FRG consisting only female farmers to evaluate milk churning technology. But beyond this original intention, they formed their own association and started to sell their milk together and established small scale milk factory by contributing their money. Because of their innovative business model they changed their life and the life of their family.*

In terms of the attitude towards sharing their idea or knowledge or experience, female farmers were found better than male farmers. As RES 04 confirmed:

*In general terms, based on my experience I can say that female farmers are more open and share their ideas without reservation. They are more ready to disclose the knowledge they have than men. They feel that others should have the same experience. Such behavior makes them feel better. Therefore, the behaviour of female farmers is more convenient for sharing personal knowledge and experience. Such behavior is less when it comes to men.*

But respondents indicated that limited exposure of female farmers to different agronomic practices and the cultural influences made female farmers to be shy of speaking their mind in public and this may negatively impact their potential contribution to the success of participatory research process.

Respondents also argue that the size of the group is one of the factors that impact the efficiency of the group in terms of generating and sharing innovative ideas based on consensus building. RES 05 said:

*...repeated experiment was done on different options of group size: 1 – 15, 1 – 20 and 1 – 25 members per group and it was found that the optimal size is 1 – 15 in terms of creating greater group cohesion and group consensus.*

It was also evidenced by the findings of the study that the more the number of educated farmers in the group, the greater the innovativeness of the group. As RES 07 illustrated:

*... FRG members around Arsi Negele invited us for a field day. The members were very active. Their performance was amazing. Their plot handling, the way they conducted the experiment with different treatment conditions, their explanation about the results of their experiment was so exceptional. They were real researchers. They were far above average farmers. The key factor contributing to this was the leadership which was composed of educated farmers. They were advanced in terms of performing any group activity.*

Researchers involved in participatory research approach are also composed of experts from multidisciplinary background. Such composition had its own impact on generation of new ideas and providing adequate solution to agricultural problems. As RES 11 said:

*Diverse perspectives and insights were generated from researchers' team with multi-disciplinary background – Pathology, Plant Breeding, Agronomics, Socio-Economics, etc. Such diverse perspectives and insights addressed multi-dimensional problems and enquiries of farmers. Hidden ideas were extracted when we engaged as a team.*

#### **4.3.6. Motivational Factors**

The findings of the study indicated that there are different factors that motivated or demotivated farmers, researchers and extension agents to engage in collaborative innovation as well as eliciting and sharing of their tacit knowledge. Some of the factors identified include incentive, perceived benefit and sustainability of the new technology, market demand for the technology, and extra burden on researchers and extension agents.

Farmers need incentive for engaging in collaborative innovation, articulating and sharing their innovative ideas, rich experiences and indigenous knowledge. But it was found that there is no incentive mechanism in participatory research approach. RES 02 said:

*Farmers need to get some sort of incentive. We don't have any incentive to provide except the technology and our knowledge.*

Farmers engage in participatory research and provide their land for experiment if they are

sure that there is perceived benefit in the technology to be experimented. This benefit could be in terms of value, impact, sustainability, etc. As RES 03 said:

*Farmers preferred to plant maize rather than providing their land for forage experiment since they couldn't see an immediate economic benefit of forage. In the case of maize they can earn an immediate economic benefit after production.*

RES 01 also added:

*Research is for the farmers' benefit. If the technology is amazing but if farmers couldn't value it and recognize its benefit they don't involve in collaborative experiment and adoption of the technology.*

Introducing new technologies with high market demand makes sharing of new ideas to farmers more easy. RES 06 said:

*Low land pulses like haricot bean and coffee had high demand in the market. So, such crops had more chance to be taken up by the farmers. In this case, the challenge in delivering the new ideas or knowledge was very minimal.*

Farmers are also motivated in participating in collaborative research if it solves their actual problem. In this case, researchers can easily present their idea and convince farmers. DA 01 said:

*We started from their problem. Fertilizer was one of the critical problems that often create conflict between farmers and the government. When we provide them solution for addressing fertilizer related problem they became eager to hear us and therefore, we didn't face any challenge in presenting our idea. They also easily accepted the new idea and participated in participatory experiment.*

RES 11 also confirmed that “the basis for generating new idea or new way of doing things is the real problem identified.”

Engaging in participatory research approach created extra burden on researchers and it was demotivating for them from engaging in collaborative experiment and contributing

their ideas, knowledge and experience. RES 10 said:

*.. participatory research is burdensome for the researchers since they are responsible to work with farmers and engage them in actual experiment by frequently traveling to their plot throughout the three years experiment period. Multiple rounds of trainings, discussions, field visits, field days, and evaluations are facilitated by researchers.*

RES 08 also indicated that “additional burden on researchers may lead to lack of commitment.”

#### **4.3.7. Degree of Complexity in Knowledge Being Articulated and Shared**

Elicitation and sharing of tacit knowledge can be affected by the degree of complexity or the degree to which knowledge can be communicated, understood and shared among the groups involved in the participatory research. In the context of the study, the findings indicated that the degree of complexity in knowledge depends on 1) the extent of visibility of the benefit of technology or the incidents on which actors articulate and share their tacit knowledge 2) level of sophistication in the new technology or agronomic practice introduced and 3) the extent of scientific and technical issues involved.

##### ***Extent of Visibility***

The possibility of articulating and sharing tacit knowledge can be hampered if one party fails to visualize the benefit of the new technology or agronomic practice introduced. As

RES 03 illustrated:

*We introduced Vitamin A enriched yellow flesh sweet potato developed through breeding. ...Vitamin A is lacking in most of the cereals produced in the area. Despite the benefit of the variety farmers rejected this option since it was less sweet than others and has less market demand. We couldn't convince farmers since it was impossible to visually demonstrate the vitamin content of the variety.*

The above excerpt imply that farmers couldn't visualize the benefits and the group couldn't proceed with further collaborative experiment, evaluation and selection processes which are important triggers for tacit knowledge elicitation and sharing. The invisible nature of causal agents of plant disease makes the transfer of knowledge to farmers about symptoms of the disease more difficult and limits their knowledge contribution in the participatory experiment. As RES 11 recounted:

*... the common symptoms of disease for rice are brown spot and bluish. We wanted farmers to inform us when they observe such symptoms. Communicating these symptoms to farmers and enabling them to visualize it was difficult.*

### ***Level of sophistication in Technology or Agronomic Practice***

Articulation and sharing of tacit knowledge of actors can be also affected by the level of sophistication in the new technology or agronomic practice introduced. As RES 10 said:

*Proper flow of knowledge depends on the type of technology and practice being presented. If it is simple it can be easily presented and farmers can understand it easily. If it is complex it may not be clear for them.*

Regarding the role of simplicity of the new technology or agronomic practice in the sharing of ideas and knowledge, RES 02 said:

*... We developed a technology using very simple techniques and local materials. ... We didn't have much challenge to present our ideas in a way farmers can easily understand and to increase their active involvement in participatory experiment. Farmers were active in contributing their innovative ideas.*

On the contrary the level of sophistication could also be the source of innovative ideas. There could be more room for generating and sharing innovative ideas when the technology or agronomic practice becomes more sophisticated. RES 08 illustrated this fact with tangible experiences.

*If we compare FRG project focused on bean variety selection and production with the one focused on onion storage, the experiment conducted in bean was more sophisticated. It involved many aspects of increasing productivity and using a product including row planting, better land preparation, better planting pattern like intercropping with maize, food preparation, etc. These sophistications and broader scope created more opportunity to generate and share more innovative ideas. But the scope of the onion storage project was not as broad as that of bean and farmers had their own storage mechanisms. We just provided them an option. We didn't have much room to go further in terms of creativity and generation of innovative ideas.*

It is clear from the above excerpts that the lower the level of sophistication, the greater the level of understanding and it is easier to articulate and share innovative ideas. But this is not always true since it is evidenced that the higher the complexity the larger the scope and the greater the opportunity for actors to articulate and share their innovative ideas.

#### ***The extent of technical issues involved***

If the extent of technical issues dominate in the collaborative experiment process it is difficult for researchers to transfer the required knowledge and skill to farmers. Farmers may not understand the technical issues which minimizes their participation and contribution of innovative ideas. As RES 02 said:

*If the experiment involves scientific and technical issues it is difficult to express our ideas to farmers. For instance, if the research is on the impact of chemical fertilizer on the production of a certain crop (e.g. wheat), it is difficult to explain to farmers about the level of Nitrogen and Phosphorus content in different types of chemical fertilizers (e.g. UREA and DAP) and their impact on soil fertility as well as crop productivity.*

RES 09 also added:

*...We may not be able to communicate the exact meaning of the technical term in a way farmers can easily understand.*

Therefore, dominance of scientific and technical issues in the participatory research

means less understanding and less participation on the part of the farmers. This implies less possibility of extracting and integrating farmers' ideas and knowledge into the innovation process.

#### **4.3.8. Model Farmers as Knowledge Intermediaries**

Model farmers are also called innovative farmers and their cognitive capacity is better than others. They are capable of understanding and adopting new ideas and knowledge easily and quickly. DA 02 and RES 03 gave almost similar responses and said:

*We consider farmers as model based on their capacity to easily understand the advantage of the new technology and immediately adopt it. These farmers update themselves by establishing close relationship with the research center and observing new technology releases. They can provide relevant feedbacks on the improvements of the newly introduced technology.*

Regarding the competency of model farmers RES 03 added:

*... Highly experienced model farmers explain the process even more than the researcher using stories, examples, etc.*

RES 10 also recounted that 'there are model farmers who can even understand highly scientific and technical processes. When the sophistication increases it becomes clear not to all farmers but only for clever farmers (model farmers)'.

The existence of model farmers facilitated the transfer of knowledge to other farmers since other farmers build more trust if the new idea or knowledge or technology is accepted by model farmers. As DA 01 said:

*Other farmers were convinced when they were communicated by model farmers who have the capacity to properly explain ideas and influence other farmers....*

Regarding the role of model farmers in knowledge transfer RES 03 added:

*Other members feel confident to accept and implement what the model farmers already accepted. They pay more attention to the model farmer than the researcher. Therefore, we train the model farmers (experimental farmers) first and then, the model farmers train the remaining members of FRG. The training given at these two levels was one way of transferring knowledge and skill. Such approach also contributed to the building of common understanding.*

When DA 02 discussed about the role of model farmers in creating common understanding, he said:

*Those farmers who couldn't understand .... were coupled with model farmers so that they can be assisted until they understand the whole process...*

#### **4.3.9. Resource and Infrastructure Problem**

Major factors identified under resource and infrastructure problems that impacted the generation and sharing of innovative ideas in participatory research include financial, human, logistical, technological and infrastructural constraints. All the stated factors have restricted the implementation of FRG projects in very limited areas. As RES 07 stated:

*In FRG approach, farmers are considered as knowledgeable, they conduct research, and they practice. But this approach couldn't involve large number of farmers and researchers and couldn't cover wide geographical area due to high resource requirement.*

Regarding challenges pertaining to human resource RES 10 described:

*There is high turnover and transfer of extension agents after being trained and worked with farmers and researchers for a long time. Researchers also leave the sector due to further education or other reasons after being involved in so many stages of participatory experiment.*

Financial, logistical, technological and infrastructural constraints had impact on the frequency of interaction among researchers, farmers and extension workers and on the process of eliciting and sharing tacit knowledge. This was evidenced by excerpts from different respondents:

RES 09: *It would have been better to be with farmers for long time in order to extract more ideas from them. But we have limited time of face-to-face communication.*

RES 04: *FRG project requires continuous follow up, monitoring and discussion with farmers. But we have resource and capacity limitation. Being unable to meet with farmers frequently limited the transfer of knowledge.*

RES 05: *I may have innovative ideas in my mind but I may not be able to implement them due to lack of resource and logistics. ...The resource shortage has been an obstacle to organize different experience sharing forums for farmers within the same locality or from other locations. The resource shortage hindered the involvement of multiple stakeholders in discussions, experience sharing and making decisions.*

RES 07: *The distance affected the performance of FRG members represented from two or three villages in a Kebele.*

RES 01: *If the experimental field is very nearby the researcher visits the field very frequently, if it is far, the researcher may not be able to visit frequently. But the basic principle of FRG approach says that the researcher has to go to farmers' field, setup FRG and discuss with farmers whatever is happening.*

DA 02: *... distance and lack of roads and bridges were major barriers to conduct extensive experiment in many high potential areas.*

Table 4.2: Summary of Empirically Supported Determinant Factors

<b>Determinant Factors from Literature</b>	<b>Empirically Supported</b>	<b>Factors from Empirical Finding</b>
<i>Creating Interactive Platform</i>	<b>Y</b>	<i>Degree of Complexity</i>
<i>Cognitive Competence/Knowledge Capability</i>	<b>Y</b>	<i>Model Farmers as Knowledge Intermediaries</i>
<i>Social Capital Factors:</i>		<i>Resource and Infrastructure Problem</i>
○ <i>Structural Capital</i>	<b>Y</b>	
○ <i>Relational Capital</i>	<b>Y</b>	
○ <i>Cognitive Capital</i>	<b>Y</b>	
<i>Communication Skill, Method and Media</i>	<b>Y</b>	
<i>Group Heterogeneity</i>	<b>Y</b>	
<i>Motivational Factors</i>	<b>Y</b>	
<i>Shared Mental Models</i>	<b>N</b>	
<i>Shared Experience</i>	<b>N</b>	

#### 4.4. Summary

The findings indicated that farmers acted as key partners and major sources of rich experiences, indigenous knowledge, best practices, agronomic skills, know-how, etc. in participatory experiment and evaluation process. Experimental/model farmers served as knowledge intermediaries or knowledge brokers between researchers and other farmers. They applied their judgmental knowledge when they set their own criteria, conduct field evaluation, rank different options of technologies based on field performances, justify their preferential ranking and select the best technology or agronomic practice. They also shared their tacit knowledge when they provided their feedbacks during participatory experiment. They took leading role in making presentations and reacting to questions on field visits, field days and exchange visits which allowed them to share their rich experiences, lessons and perspectives on the field experiment they participated in. Experimental farmers mentored non-experimental farmers based on the knowledge, skill, experience, best practice and lessons they acquired from researchers during participatory experiment. Farmers articulated their practical intelligence by way of conducting their own experiments through manipulating treatment and control conditions as well as through manipulating the existing agronomic practices. Based on their experiments they proposed options of achieving better results. Based on their indigenous knowledge, long years of experience and/or practical intelligence they introduced their own innovative ways of treating animal disease, weed prevention, plant positioning, planting and watering, redesigning newly introduced tools, efficient spacing between seeds and efficient space utilization, etc. They depicted maps representing their implicit understanding of their environment and resource endowments. Tacit knowledge transfer

among farmers in peer-to-peer informal discussion and mutual learning process was found very effective.

Researchers applied their insights, expertise, past experiences understanding of the local situations and personal judgments in the development of new agricultural technologies and in the manipulation of scientific recommendations to fit local contexts. They also applied their practical intelligence to come up with better solution through innovative use of abundantly available local resources and improving local practices. They dominantly conduct on-farm controlled experiments to articulate their tacit knowledge.

It was found that the dominant forms of tacit knowledge externalized and shared in participatory research approach fall under medium and low degree of tacitness since the approach focused on experiments (applied research) and practical issues. The specific epitomes of tacit knowledge dominantly shared in participatory research process include judgments, insights, practical intelligence and indigenous knowledge under medium degree of tacitness; and practical skill, lived experiences, expertise and rules-of-thumb under low degree of tacitness.

The study also identified that both farmers and researchers applied mechanisms of externalization including metaphor, storytelling, dialogue, apprenticeship or mentoring, experimentation and evaluation, observation, learning by doing, lessons learnt, modeling technique, asking question, localization and on-farm demonstration. One of the key findings indicated that there is no one-to-one relationship between mechanisms of externalization and degree of tacitness as it was suggested by previous studies. One mechanism may serve articulation of tacit knowledge with different degrees of tacitness.

The study also identified several factors that influenced the process of externalization of different forms of tacit knowledge. These influencing factors include creating interactive platform, disparity in cognitive competence or knowledge capability, social capital factors (structural, relational and cognitive capital), communication skill, method and media, group heterogeneity, motivational factors, degree of complexity/abstraction in knowledge being articulated and shared, distance compounded with poor physical infrastructure and resource constraint.

## **CHAPTER FIVE**

### **FINDINGS AND DISCUSSIONS**

The analysis and discussion, the main focus of this chapter, was guided by the following analytical framework (Fig. 5.1) that constitutes different analytical dimensions and their relationships. The analytical dimensions were directly coined from the research questions and reflected our research framework. The discussions of results or findings were framed by these analytical dimensions. The data analysis done in chapter four was used as an input for the fifth chapter – presentation of findings and discussions. This chapter focused on the first two research questions – identifying taxonomies of tacit knowledge and mechanisms of tacit knowledge externalization and sharing. The findings related to the third research question, the potential of mobile technology, were dealt in the sixth chapter. This chapter constituted three major components. The first component presented a discussion on taxonomies of tacit knowledge that are dominantly articulated and shared in participatory agricultural research process. The second component focused on tacit knowledge externalization mechanisms. The third component presented discussions on the determinant factors that impact tacit knowledge externalization and sharing. Finally, a framework on tacit knowledge externalization and sharing was proposed consisting taxonomies of tacit knowledge, mechanisms, factors and platforms.

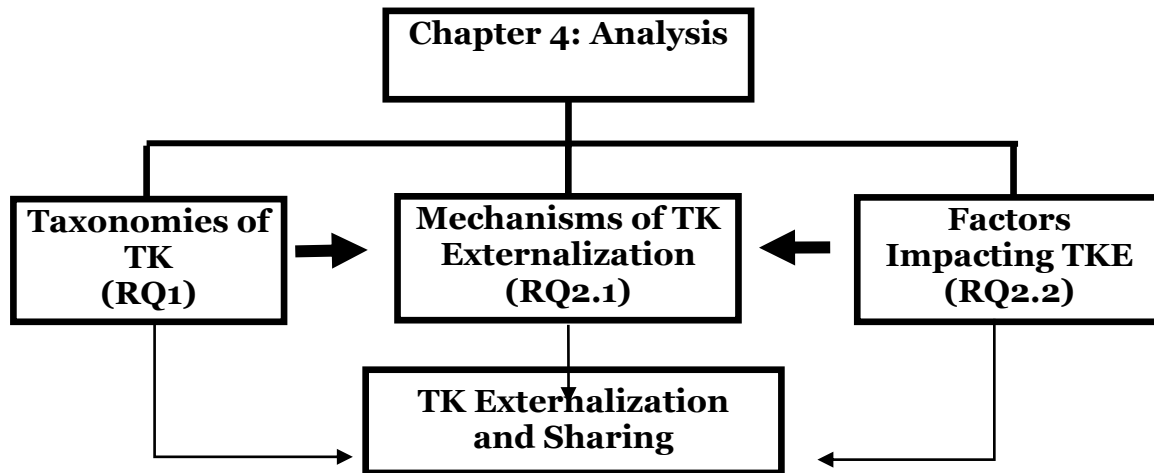


Fig. 5.1: Analytical Framework for Chapter 5

## 5.1. Taxonomies of Tacit Knowledge

McAdam, et al., (2007) argued that identifying types of tacit knowledge is essential for understanding its nature, anticipating appropriate methods for its conversion into explicit knowledge and to inform the design of a system to support articulation and flows of various types of tacit knowledge. Based on this belief they recommended three classifications of tacit knowledge based on high, medium and low degree of tacitness. Our empirical study mainly identified tacit knowledge with medium and low degree of tacitness. This is mainly due to the nature of the experiment, which is dominantly applied research and involves more of practical issues. It was confirmed by respondents that the kind of knowledge being articulated and shared in such practice oriented environment is not as such highly abstract. Therefore, the data didn't show evidence on high degree of tacitness or abstraction and the discussion focused on parts of tacit knowledge under low and medium degree of tacitness.

### **5.1.1. Low Degree of Tacitness**

Evidences from the empirical study demonstrated that under low degree of tacitness practical skill, lived experiences of farmers and rules-of-thumb were the dominant forms of tacit knowledge externalized and shared in the participatory research process.

Although *experience* is classified under low degree of tacitness because of its higher visibility (McAdam, et al., 2007), findings indicated that it was also a basis for developing other forms of tacit knowledge with high, medium or low degree of tacitness. For instance, the application of farmers' judgmental knowledge (medium degree of tacitness - MDT) on whether to accept or reject a particular technology constitutes element of experience. Farmers' ability to apply their practical intelligence (MDT) was also based on experience. Know-how and skills which are classified under low degree of tacitness constitute elements of experience. Farmers applied their rich and lived experiences to introduce different approach or technique and come up with better results. They also used their prior experience to set their own criteria and make judgment while evaluating different technologies. Researchers also applied their expertise and experiences in the process of environmental analysis, identifying farmer's needs, identifying core problems and introducing localized technologies. Therefore, in a participatory agricultural research context experience is the dominant forms of tacit knowledge which is embedded in other forms of tacit knowledge with low, medium and high degree of tacitness.

Farmers' unique *skills* of doing experiments by themselves, their analytical and problem solving skills had contributed a lot in the collaborative experiments. They applied these

skills to conduct cost benefit analysis, make comparisons, make rational judgments and recommend better options.

In the participatory research context farmers' *rules-of-thumb* was commonly used as a control while conducting experiment on the newly proposed technology or agronomic practice. It was also found that farmers applied their rules-of-thumb to influence the implementation of the proposed technology and suggest modifications or adjustments.

McIver, et al. (2012) argued that knowledge with low degree of abstraction can be observed, taught, codified and disaggregated from its context since it is based on principles, rules, heuristics, and stable relationships. Our study also signified that the procedures involved in the practical work made the experiences and skills more visible.

### **5.1.2. Medium Degree of Tacitness**

The study disclosed that in participatory agricultural research context insights, judgment, practical intelligence and indigenous knowledge were the dominant forms of tacit knowledge under medium degree of tacitness.

Farmers and researchers used their *insight* or intuitive perception to evaluate different features of the plant and make comparisons; to assess the local problems from different perspectives and propose relevant solutions; and to manipulate and justify treatment and control variables when they conduct experiments. Researchers applied their creative thinking and insights in the process of reflecting on the strong and weak aspects of farmers' local practices, manipulating the existing practices and extending experiments

by considering additional treatment conditions to come up with locally relevant technology or technique. Researchers with multidisciplinary background were also sharing their insights in the research review meetings regarding FRG projects and they were providing additional inputs to the innovation process.

The primary purpose of participatory approach is conducting collaborative experiment on multiple options of technologies to select the one which can best addresses agricultural problems and farmers' needs. The selection was made based on farmers' *judgment* through the process of evaluation and ranking at different stages of the experiment. Their judgmental knowledge was articulated in the form of setting their own criteria and justifying their selection based on the criteria. Their perspective in the process of setting and justifying their criteria was quite different from the documented scientific criteria. It was also found that farmers came up with their own criteria represented in their own language but having equivalent scientific representations. Without having articulated criteria farmers also made judgment based on their wisdom or accumulated knowledge of life in the sphere of agronomic practices. Therefore, judgment which is classified under medium degree of tacitness by McAdam, et al. (2007) was a dominant form of tacit knowledge observed in the participatory research process.

Sternberg and Hedlund (2000) described *practical intelligence* as knowledge acquired implicitly from everyday experience. McIver, et al. (2012) also acknowledged that such kind of knowledge is built on the unique talent of individuals participating in the practice. In this study it was found that farmers' practical intelligence which has been developed

from their day-to-day agronomic practices was used to generate new ideas, perspectives or methods which have never been explained in any scientific document. Some of the examples of farmers' innovations generated based on their practical intelligence include: using unique criteria to measure crop productivity; introducing efficient techniques through hybrid of scientific and traditional methods; providing innovative and highly localized inputs for redesigning recommended technology; using unique methods of plant breeding; and efficient spacing and space utilization through zigzagged planting. These cases signified that based on their practical intelligence farmers have the potential to suggest better, efficient and context specific methods and technologies. Researchers and farmers validated these articulated tacit knowledge through further experimentations.

Puri (2007) claimed that *indigenous knowledge* is intangible and part of the everyday practices of the members of a community but can be informally expressed in local customs, experience, technology, and wisdom. The study also revealed that farmers applied their indigenous knowledge in various projects related to treatment of animal disease, pest management, handling termite problems, etc. They also applied it to introduce improvements in technology proposed by the research, to come up with innovative solutions that can solve local problems and to provide pertinent inputs to the experiments being conducted under FRG projects. Therefore, it was found that indigenous knowledge was embedded in farmers' practices and customs, developed through trial and error and implemented by farmers without formal expression in words.

## 5.2. Mechanisms of Externalizing Tacit Knowledge

Chennamaneni and Teng (2011) said, certain kinds of tacit knowledge are entirely unconscious and inaccessible for introspection (too deeply ingrained), while others are conscious and are accessible, if triggered properly. As it was indicated in section 5.1 those categories of knowledge with medium and low degree of tacitness/abstraction were commonly articulated and shared in the practice oriented environment of participatory research. Although specific mechanisms were associated to a corresponding degree of tacitness in the literature (e.g., by Chennamaneni and Teng, 2011), our study didn't show a one to one relationship between mechanisms of tacit knowledge externalization and degree of tacitness/abstraction. In the study context one mechanism enabled participants to articulate tacit knowledge with different levels of abstraction. The dominant forms of tacit knowledge externalization mechanisms in the participatory agricultural research context were found to be experimentation and evaluation, apprenticeship or mentoring, metaphor, storytelling, dialogue, asking question, localization, observation, modeling technique, on-farm demonstration, reflection-in-action (non-verbal practices), learning by doing, and lessons learnt. This section analyzes how the stated mechanisms enabled participants of FRG project to articulate their tacit knowledge.

### *Metaphor*

For farmers, metaphorical expressions were used as culturally developed ways of communicating ideas. Metaphorical expression empowered farmers to offer explanation about agronomic phenomenon in a more rational and understandable way. Their metaphorical expression directly matched with the scientific explanation. One typical

example is farmers' logical expression using metaphor of extravagant rich farmer and food abundance in holidays to reflect on the reaction of the plant to the application of fertilizer. The phenomenon was abstract and beyond their capacity to comprehend. But they managed to offer a rational explanation using their own metaphorical expression. Schön (1979) claimed that individuals formulate metaphorical representation to elicit unarticulated perception of similarity between two things derived from experiences. This was clearly observed when farmers make judgments on the experimental results of two different varieties or implements or agronomic practices. Researchers also used metaphor in order to communicate scientific or technical concepts and processes to farmers in a more understandable way. Such expressions enabled farmers to visualize and internalize the scientific representations. Many authors argue that metaphor is used to externalize tacit knowledge with medium degree of abstraction (Nonaka, 1994; Nonaka and Konno, 1998; Ambrosini and Veronique, 2001; He and Li, 2010; Chennamaneni and Teng, 2011). But according to our study findings the use of metaphor was not associated with degree of tacitness but rather more associated to the ability of farmers to understand and express the agronomic phenomenon and processes they observed during participatory experiment process.

### ***Storytelling***

Styhre (2009) and Al-Qdah and Salim (2013) said that storytelling allows participants to frame their experiences in stories and add meaning and context to the ideas and facts. According to the findings of the study farmers used their experiences to reject or accept the solution proposed by researchers and justified their decision using narratives on their previous successful or failed attempts on similar solutions. Storytelling was also used by

researchers to articulate and transfer tacit knowledge embedded in best practices and lessons learned from other similar projects.

### ***Dialogue***

Alwis and Hartmann (2008) claimed that tacit knowledge can be explicated when ideas are exchanged and debated. Nosek (2004) also argue that participants further articulate their tacit knowledge (experiences, feelings) through dialogue, achieve common understanding through collaborative meaning making and generate novel conceptual combinations. Our study also confirmed the same. In the participatory research context conflicting ideas were common when discussions were held among farmers and researchers in the problems identification and solution recommendation process. Both farmers and researchers engage in dialogue for sharing ideas, resolving differences, reaching consensus and choosing better option. It was manifested in the process of providing reasonable explanations and developing unique criteria to justify a choice of technology, in suggesting better approach and timing for conducting experiments, in building shared meaning about the essence of the project and in integrating their ideas towards attaining the required goal. Participants were articulating their tacit knowledge in the process of group sense making, reasoning and mutual co-development of ideas. Hussi (2004) also said that through collective reflection, a shared perception is articulated into words, words develop into phrases and further crystallized into concepts.

### ***Apprenticeship or Mentoring***

Apprenticeship or mentoring was common at the initial stage of participatory research when researchers were transferring their knowledge, experience and skill on the newly

proposed technology and associated agronomic practice to experimental farmers. First, researchers practically demonstrate all the implicit skills involved in the new technology and agronomic practice to experimental farmers. Then, experimental farmers repeat the activity following the researchers. McIver, et al. (2012) referred this as a mechanism of transferring tacit knowledge through recreating and rehearsing the experiences. In order to prove whether farmers internalized the transferred tacit knowledge or not they were dividing themselves into multiple sub-groups, implement the procedure and present to each other. Therefore, farmers acquired tacit skills required to do experiments, evaluation and selection through rehearsing what researchers did. Such method was found superior than the theoretical presentation and enabled farmers to build better understanding about the technology as well as the process of experiment and evaluation. Chennamaneni and Teng (2011) considered apprenticeship and mentoring as the richest media to transfer tacit knowledge with high degree of abstraction. But in our study it was found that they were used to articulate and transfer knowledge with low degree of tacitness which includes tacit skills.

Al-Qdah and Salim (2013) said, mentoring is also a means for transferring tacit knowledge through pairing a more experienced, or more knowledgeable person with less experienced or less knowledgeable person through an ongoing relationship of learning and dialog. Our study also identified that slow learner farmers were coupled with model or innovative farmers to transfer tacit knowledge embedded in the technology or agronomic practice introduced by the research.

### ***Experimentation and Evaluation***

Chennamaneni and Teng (2011) argued that prototyping is a process that involves an iterative evaluation of a proposed technology or a product to be developed and it serves as a mechanism for explicating tacit skills that are inexpressible in words but can be nevertheless be conveyed by pointing. Nonaka (1994) also said that it explicates the products' hidden concept (tacit knowledge) in the form of the prototype's specification (explicit). Similar process was involved in the participatory research in the form of conducting recurrent experiment and evaluation on a particular agricultural technology for subsequent years. Prototyping and experimentation and evaluation are two closely related methods having similar consequences on tacit knowledge externalization process. Both give us some ideas of how the technology might work before it is scaled up or to find out what works and what doesn't with the aim of reducing uncertainties and risks. Both are also used to observe and gather feedback. Both methods target the analysis of alternatives to explore and identify best approaches. Both methods answer to the question using the bare minimum of energy and expense possible. Experiments are also done by creating real-world prototypes and testing them, just like allotting limited plots of land where different agricultural technologies and agronomic practices are experimented and evaluated. From the perspectives of tacit knowledge externalization both support eliciting tacit knowledge by pointing to the results. Significant amount of tacit knowledge which is embedded in the minds of farmers, researchers, extension workers and other pertinent stakeholders were explicated in the process of participatory experimentation and evaluation. Gourlay (2006) also suggested that active exploration and experimentation are the critical mechanisms for externalizing tacit knowledge. Tacit knowledge of farmers

in the form of experiential and indigenous knowledge was externalized through the mechanism of experimentation and evaluation.

Participatory experiment enabled farmers to question the proposed scientific solutions, introduce their own innovative idea into the research process, experiment it and come up with their own recommendations. Farmers assigned a different plot and conducted their own experiment by applying treatment and control conditions different from the one recommended by research in order to elicit and justify their own perspective regarding the technology under experiment. In this process farmers externalized their practical intelligence, experiences and skills when they explain why they introduced their own treatment and conducted their own experiment. Farmers also did experiments when they feel that their existing variety or agronomic practice is better than the one which was recommended by researchers but unable to express the difference in words. Polanyi (1966) also said that some tacit knowledge is governing a certain activity but the person cannot articulate it. But farmers demonstrated their knowledge which they believed as superior through their experiment. HaldinHerrgård (2004) considered this as mechanism of articulation of tacit knowledge through non-verbal practices and experiences. Polanyi (1966) and McAdam, et al. (2007) also considered such tacit knowledge as intangible which can be expressed and appear in a more tangible form in the work outcomes of its application. Farmers were also doing experiment to explicate their tacit knowledge in the form of identifying limitations of the recommended variety and suggesting further research for improvement. Their recommendations that came out of their experiment

were used as an input to enhance the proposed technology or conduct further research. They were providing valid feedbacks relevant to the enhancement of the technology.

According to the results of the study farmers' judgmental knowledge (tacit) was elicited when they came up with their own unique measurement criteria to evaluate the results of the experiments. They have their own interpretations on each criterion from the perspective of their typical context or need. The evaluation and selection process in which farmers engage was a major trigger for them to articulate and share their embedded knowledge. Researchers also considered farmers' criteria as an input and integrated them into the scientific criteria. Farmers' practical intelligence was articulated when they identified problems of agricultural implements or mechanized systems under experiment and suggested innovative ideas needed for their improvement or redesign. Farmers' practical intelligence in the innovation of a new hybrid technique of sowing was articulated through demonstrating their experimental result on the field. Farmers developed experience in how to justify the use of control for an experiment, in conducting actual experiment, measuring performances, comparing the results of the experiment against the control, rationalizing their ranking and selection of best technology. Therefore, farmers elicited their perspectives, practical intelligence, rich experiences, best practices, and judgments through conducting their own experimentation and evaluation. The whole experiment and evaluation processes conducted on farmers' plot therefore, triggered externalization of farmers' tacit knowledge.

The knowledge embedded in the new technology or agronomic practice was also externalized by the researchers' team through practical experimentation and demonstration of the results of the experiment. Researchers' expertise and experiences were externalized in two stages. The first stage was in the selection of a variety which could solve context specific problems. The second stage was in conducting adaptation experiment (to prove resistance to drought and disease as well as suitability of soil). In both stages researchers made personal judgments and that was based on their expertise and experience. In the first stage they used rationalization to externalize their tacit knowledge and in the second stage they used experimentation as a mechanism of externalization.

In general, in participatory research context significant parts of tacit knowledge at different levels of abstraction were articulated in the process of participatory experimentation and evaluation. In this mechanism most of farmers' tacit knowledge was manifested in what farmers did (Tsoukas and Vladimirou, 2001) or it was demonstrated and reflected in its utilization (Sigala and Chalkit, 2007) during the experimentation and evaluation process.

### ***Observation***

von Krogh (2009) and Chennamaneni and Teng (2011) commonly agreed that internal behaviors of individuals can be converted into external behaviors through observing actions of others or how they performed a critical task. Our study also confirmed that observation played a critical role to articulate and share tacit knowledge in the context of FRG approach. This is because it mainly focused on visible actions like practical demonstration, collaborative experimentation and evaluation as well as ranking and

selection of technology based on visible criteria. Farmers supported their decisions or choices with the visual representations of their mental abstraction which is the phenotype of the plant. Farmers articulated their long years of rich and lived experiences when they measure and explain their observation in a way different from the scientific method at the evaluation stage. Farmers are keen to observe the phenotype of the plant or any incident like plant disease and reflect on their observation. Tacit knowledge was therefore, externalized through reflection on observation which was represented in the form of farmers' rationalizations (offering reasonable explanations), judgments, ranking and selection of the best technology. It was evident from the findings that observation applies to the forms of tacit knowledge with medium degrees of tacitness.

### ***Learning-by-Doing***

Al-Qdah and Salim (2013) and Alwis and Hartmann (2008) claimed that tacit knowledge can be activated in the process of learning new production methods and improving existing technology through minor improvements based on learning-by-doing, and based on learning-by-using. Evidences from the study also demonstrated that learning-by-doing enabled farmers to extract and internalize tacit skills embedded in the new technology as well as the principles and procedures associated with the new agronomic practices through practicing its implementation on their own farm plot.

### ***Lessons Learnt***

Al-Qdah and Salim (2013) and Chennamaneni and Teng (2011a) claimed that results pertaining to processes that went well and that need improvements are shared with other team members so that they can learn from experiences of others and come up with

innovative ideas for further improvement of the processes. Our study also traced that tacit knowledge was articulated and shared through identifying and presenting lessons on what went right and what went wrong. Identifying factors affecting the success or to the failure of the experiments was another mechanism for articulating tacit knowledge. Such presentations were made in the field days and exchange visits. Tacit knowledge was commonly articulated when participants were suggesting innovative ideas pertaining to corrective actions or remedies to problems.

### ***Modeling Technique***

According to Ambrosini and Bowman (2001), modeling technique is used to reflect on ones behaviors by representing mental models in graphical format. One of the unique capabilities of farmers was articulating their implicit understanding about their environment through drawing. They were actively involved in the process of resource mapping by drawing boundaries, main road, main water stream, crop fields, common land, houses, forests, market, soil types, soil degradation, source of water (irrigation/domestic), community facilities (schools, dispensary, churches and mosques, market place, shops), etc. This resource mapping activity helped the group to identify resource available in different areas. It also helped farmers to identify constraints and potentials in their farming systems and to demonstrate farmers' ability to convey useful information that were understandable for both literate and illiterate. A map was first drawn on the ground by farmers and transferred to a paper later by the extension worker.



Fig. 5.2: Farmers' Resource Mapping Activity (Bedru, et al., 2009)

Farmers also expressed their ideas about the procedures they learnt through practice by drawing process maps. Researchers also used simulation technique in order to transfer the knowledge embedded in the technical issues.

### *Asking the Right Question*

Al-Qdah and Salim (2013) and Ambrosmi and Bowman (2001) said that asking the right question can force individuals to articulate what they were doing which they never realized, neither do they questioned themselves what they were doing and nobody else ever questioned it either. Ambrosmi and Bowman (2001) also said that tacit knowledge is externalized through reporting and guiding decisions, plans, interventions, improved practices, etc. Our study also confirmed that farmers articulated their experiential knowledge when they were asked to reflect on their existing practices, challenges and possible remedies for their problems. They were also articulating their tacit knowledge when they were asked to reflect on what they did during experiment, how they did it and what results they achieved at the end of the experiment. This was common when they make presentation on field visits and field days. They articulate their perspectives, experiences, the lessons they learnt and the knowledge they internalized in the whole

process of the experiment. Researchers were also articulating the lesson they learnt in the process of participatory research when they were asked the right question. We proved this mechanism of tacit knowledge externalization by asking researchers – what would you do differently if you are given a second chance? Based on their lessons, researchers articulated their feelings in terms of suggesting additional factors that should have been considered, gaps that should have been filled, etc.

### ***Localization***

Evidences from the empirical study demonstrated that localization was one mechanism of externalizing tacit knowledge. Localization enabled participants to attain best results in collaborative experiments by using localized techniques or locally available materials. This effort required innovative thinking of both farmers and researchers to come up with best options. This was observed when researchers applied their expertise and experience to develop a technology with very simple and low cost technique and from locally available materials. A case in point is determining critical application time and optimal mix to develop effective organic fertilizer from abundantly available local natural leaves. Such localized innovations enabled researchers to externalize their tacit knowledge in the form of expertise and experiences. As far as farmers were involved in the participatory research, there was localization of some of the experiment processes – using local tools, methods, practices, etc. This is in order to make the new technology/idea/knowledge/practice more relevant and applicable to the farmers' contexts. Localization technique was a typical tacit knowledge externalization mechanism not suggested by literature but found by this study and relevant to the

participatory agricultural innovation context. We feel that it has potential to externalize tacit knowledge at different levels of abstraction.

### ***On-farm Demonstration***

Practical on-farm demonstration was also a tacit knowledge externalization mechanism which was found typical to participatory agricultural innovation context. Tacit knowledge was articulated and transferred through observing, participating/experiencing, explaining and comparing in on-farm demonstrations. With its multimodal mechanism it has great potential to externalize tacit knowledge at any degrees of abstraction.

To sum up, the following table summarizes the mapping of externalization mechanisms to different degrees of tacitness or abstraction.

Table 5.1: Mapping Externalization Mechanism to Tacit Knowledge with Different Degrees of Tacitness

Tacit K Mechanisms	Medium Degree of Tacitness				Low Degree of Tacitness			
	Insight	Judgment	Practical Intelligence	Indigen. Know.	Skills	Experience	Rules-of-Thumb	Expertise
Experimentation and Evaluation	✓	✓	✓	✓	✓	✓	✓	✓
Apprenticeship/ Mentoring					✓			✓
Metaphor	✓		✓			✓		
Storytelling		✓				✓		
Dialogue	✓	✓						
Asking Question						✓		✓
Localization			✓	✓	✓	✓	✓	✓
Observation		✓	✓			✓		✓
Modeling Technique			✓			✓		✓
On-farm Demonstration		✓	✓	✓	✓	✓	✓	✓
Reflection-in-action		✓	✓	✓	✓	✓	✓	
Learning by Doing					✓	✓	✓	
Lessons Learnt					✓	✓	✓	

### 5.3. Factors that impact Externalization and Sharing of TK

#### 5.3.1. Creating Interactive Platform

Many authors including Nonaka and Konno (1998), Yi (2006), Xu and Chen (2010) and Hussi (2004) emphasized that providing physical or virtual forum ('ba') is a necessary precondition for facilitating articulation and sharing of tacit knowledge. Participatory research provided the physical space including trainings, meetings, participatory field experiments, field visits, field days, field demonstrations, exchange visits, informal farmer-to-farmer interactions, etc. for articulation and sharing of tacit knowledge by researchers, farmers, extension agents and other key stakeholders.

Participatory field experiments, field visits, field days and informal farmer-to-farmer interactions were important forums where farmers actively participate, articulate and share their tacit knowledge. Farmers' presentations on field visits and field days

demonstrated their great potential in transferring the knowledge they acquired from collaborative experiment to other farmers and stakeholders. Researchers also shared their expertise, experiences and tacit skills through trainings, practical demonstrations, actual field experiments and evaluations as well as research review meetings and workshops. Platforms like trainings, meetings, field demonstrations, field experiments and evaluations were most important forums that created strong linkage and social interactions among researchers, farmers and extension workers. This created favorable space for relationship and trust building and provided incentive for stakeholders to engage in collective action and articulation and sharing of tacit knowledge.

As most of the platforms depend on face-to-face interaction they were significantly challenged by distance, lack of physical infrastructure and lack of adequate resources and facilities. The shorter the distance between the research center and location of experimental plots the greater the frequency of interaction and the greater the possibility of articulating and sharing tacit knowledge among actors. The reverse happened in the case of long distance due to the stated challenges. Therefore, it is necessary to devise a mechanism that facilitates close interaction as well as articulation and sharing of tacit knowledge among researchers and farmers that requires ICT based interventions.

Theories argue that externalization occurs in a dialoguing 'ba' (Nonaka et al., 2002) but in the actual field study externalization also involved originating ba where feelings, emotions, experiences and mental models are shared in informal meetings. There were many incidents where the sharing and conversion of tacit knowledge simultaneously occurred. In the participatory research approach tacit knowledge was externalized with the co-occurrence of both the dialoging ba (formal assemblies and meetings) and the

originating ba (informal meetings among farmers). Balestrin, et al. (2008) also confirmed that the existence of formal and informal situations enable stakeholders to share abilities, experiences, emotions and know-how, by means of face-to-face communication which promoted an environment of intense sharing of tacit knowledge.

### **5.3.2. Disparity in Cognitive Competence or Knowledge Capability**

Wu, et al. (2010) stated that externalization and transfer of tacit knowledge depends on the cognitive competence or knowledge capability of both providers and recipients of tacit knowledge. According to the authors the provider has to be competent enough to understand and explain tacit knowledge ingrained in his/her mind using his/her expression media including word, sentence, gesture, body language, etc. The receiver should also be able to absorb, interpret and comprehend the tacit knowledge transferred, which is conceptualized by Sigala and Chalkit (2007) as absorptive capacity – capability to acquire, assimilate, transform and exploit the tacit knowledge articulated and shared. Kalling (2003) said, absorptive capacity has impact not only on knowledge externalization, but also on the ability to use tacit knowledge. Our study confirmed that there was significant variation in cognitive capacity not only between farmers and researchers but also within farmers. Individual farmers differ in their experiences, skills, level of understanding and innovativeness. There were model (innovative) farmers whose cognitive capacity and level of understanding was high. There were also farmers with moderate and low level of understanding. It was difficult to bring all farmers at the same level of understanding and to engage them in the innovation process with full potential of articulating and integrating their tacit knowledge.

One of the big challenges was in the areas of building shared understanding between researchers and farmers on knowledge and tacit skills embedded in the new technology or agronomic practices. It was also difficult for farmers to clearly understand the whole process and purpose of experiments, experiment variables and controls as well as the criteria to be used to evaluate the results of the experiment. Farmers may not go beyond the visible effects of the new technology or a disease and may wrongly conceptualize and judge without assessing or anticipating its invisible and future effects. In this case their judgment could be guided by partial observation and incomplete mental abstraction. This was mainly associated with low level of cognitive competence and absorptive capacity of farmers. The whole purpose of participatory research is involving farmers in the innovation process and integrating their tacit knowledge. If farmers fail to understand the new technology or agronomic practice they resist to accept and participate in the experiment that hampers their contribution in the form of sharing their rich experiences, best practices, skills, know-how, indigenous knowledge, etc. The differences in personal interpretations due to variation in perspective, level of experience and knowledge influenced the take-up of the technology and the idea and knowledge embedded in the artifact/technology.

One unique experience found in the participatory research process was using model (innovative) farmers as knowledge intermediaries. Farmers with prior exposure to new technologies and mechanized farming systems have high level of understanding and they were more innovative than other farmers with no exposure. Researchers involved model farmers as experimental farmers and they transferred the knowledge to them. Then,

model farmers transferred the knowledge, the experience and lessons they acquired from researchers and actual experiment to other farmers with modest and low level of understanding. The level of understanding of the slow learners was therefore, raised by coupling them with model farmers. Model farmers played a key role in bridging the cognitive gap between researchers and other farmers through upgrading the level of understanding of slow learners and establishing equal level of understanding among FRG members. Erden, et al. (2008) also suggested that discrepancy in knowledge capability among group members can be handled through compensating the weaknesses via dynamic coordination and heedful interrelating. Model farmers were capable of convincing and motivating these farmers and increase their participation and contribution. Choudrie and Selamat (2004) also claimed that the competency of insightful individuals (in our case model farmers) in the group enables them to build influencing skills and to cultivate sharing attitudes. Burt (2004) argued that there must be someone who translates the knowledge for the participants of the innovation process, called brokerage. He also said, those with suitable connections and/or skills can act as brokers, bringing together the members of heterogeneous groups. According to Hennala, et al. (2011) such brokers play a key role in transferring best practices. Our study also found that in addition to the extension workers model farmers were serving as knowledge brokers or as knowledge intermediaries between team of researchers and FRG members. The greater the number of model farmers in FRG the higher the quality of communication and the greater the possibility for articulating and transferring tacit knowledge. But the detailed communication and idea sharing among model farmers and

other farmers coupled with them was dominantly informal and there was no system of capturing the new ideas and knowledge shared in these informal forums.

In addition to model farmers as knowledge intermediaries, successful capturing and integration of farmers' tacit knowledge may require improving the cognitive capacity of farmers and enabling them to speak openly and freely. Providing clear, tangible and repeated explanation on trainings; multiple rounds of discussions supported by practical demonstrations and visual presentations; sharing similar experiences or best practices of others; and providing supplementary materials were also suggested as solutions for improving farmers' cognitive competences. Repeating the same experiment for subsequent years also allowed farmers with modest and low level of understanding to become equally competent through gaining more experience. The exchange of ideas and knowledge within group of farmers was also another means that enabled all farmers to build better understanding about the new knowledge or practice introduced. It was believed that these diverse methods make all involved members to achieve the same levels of understanding. All these recommendations have implications to the design and development of ICT based communication system.

### **5.3.3. Social Capital Factors**

#### ***Structural Capital***

Balaram et. al. (2003) said, strong tie or social interaction facilitates the integration of variety of individual tacit knowledge in the form of experiences, interests, aptitudes, commitments, tasks, language, or interpretations that give rise to new ideas and collective knowledge. They added that social interaction enables people to converge in their

divergent views, interests, objectives, values, beliefs, etc., build common knowledge, implement solutions and achieve outcomes. Erden, et al. (2008) and Robert, et al., (2008) also said, tacit knowledge which is inherently rooted in individual members' experience, expertise and cognitions is converted into group level tacit knowledge through social interaction. In participatory research approach there are multiple social interaction forums. The findings confirmed that such wider opportunity of recurrent interaction provided more chance for participants to articulate, share and integrate their tacit knowledge. Zhang, et al. (2012) said, strong ties make the flow of tacit knowledge and innovation easier since it increases the level of trust and creates favorable condition to establish common norms and aims. Our findings also confirmed that collegial relationship between farmers and researchers which was enforced by the recurrent interaction and experimentation, due respect given by researchers to farmers' knowledge, participation in research with open and free expression of ideas as well as tie strength especially among FRG members were typical instances of structural capital in participatory research approach. Strong ties among FRG members and the researchers' team increased the level of mutual trust and facilitated the sharing of their tacit knowledge. It was confirmed by the findings of the study that the more the tie strength between farmers and researchers the greater the engagement of farmers in open discussions and sharing of their tacit knowledge. Natalya (2010) also said that tie strength facilitate knowledge creation through transfer of experience and establishment of group knowledge and group skills.

Büchel et al. (2013) confirmed that the innovation group may benefit most from widely dispersed and diverse knowledge networks with many non-redundant linkages outside the group. Our study also confirmed that FRG projects were successful by involving researchers, farmers and extension agents as primary research group and creating non-redundant linkages with experts from different agricultural bureaus, NGOs, agricultural seed enterprises, etc. Such non-redundant networks provided access to the knowledge of various actors outside the innovation group which was directly involved in FRG project. Therefore, there was no over-embeddedness and the flow of novel innovative ideas into the network was not restricted. Shaoyan (2008) also proposed that a structure that is characterized by a high degree of decentralization facilitates tacit knowledge elicitation and sharing.

### ***Relational Capital***

According to Büchel et al. (2013) and Nahapiet and Ghoshal (1998), higher *trust* implies higher willingness to exchange tacit knowledge through facilitating understanding among individuals and having greater openness. Venkitachalam and Busch (2012) also said, mutual trust among members facilitates articulation of tacit knowledge and process of concept creation. Our finding also indicated that farmers' trust on researchers' ideas and their proposed solution was the primary factor that affected the extent of their commitment to engage in collaborative innovation. Evidences from the study revealed that in participatory research the level of mutual trust increased with close and repeated interaction between researchers and farmers and with the involvement of farmers in multiple rounds of experiments on the same technology (conducting the same experiment for 3 subsequent years). Korgh (1998) argued that in a situation where there is

considerable mutual trust individuals are encouraged to make their tacit knowledge explicit and articulate it using unconventional language, metaphors and analogies; experiment more freely to come up with unconventional solutions; and becoming more confident in their pursuit of knowledge creation process. It was found that with higher mutual trust farmers became more open to share their innovative practices, experiences, skills, know-how and indigenous knowledge. At the initial year of FRG project farmers build more trust when the proposed technology was accepted and presented by experimental/model farmers. Farmers' level of trust on researchers increased when their relationship became stronger in the second and third rounds of the experiment. Their trust also increased after they observed the results of the experiment and integration of their feedbacks and indigenous knowledge into the innovation process.

The empirical evidence also identified *culture* as one factor that influenced the smooth flow of ideas and knowledge among the innovation group. Lack of well developed team culture and farmers' negative attitude to some experimental processes due to their culture had an impact on the commitment of members to generate and share their tacit knowledge. A typical example was harvesting a plant at vegetative stage for the purpose of evaluating dry matter yield which was quite essential to determine the level of performance of the plant. Farmers refused to allow researchers to harvest the plant at vegetative stage since it is culturally unacceptable. Due to the cultural influence the possible flow of knowledge through evaluation of dry matter yield was hampered.

***Reciprocity*** which is a relationship based on mutual exchange of ideas, knowledge, experiences, expertise, etc. was affected by the attitudes of both farmers and researchers. Farmers became less willing to share their knowledge when they were uncertain about the new technology and when they felt that they lose their competitive advantage by sharing their knowledge and experience. Researchers' wrong perception towards farmers also affected reciprocity.

### ***Cognitive Capital***

Lack of shared language, lack of shared interpretations and system of meaning as well as lack of shared understanding were found to be the prominent aspects of cognitive dimension that affected the exchange of tacit knowledge in the process of participatory research.

Grant (2007) said that most of tacit knowledge can be shared between individuals who share a mutually agreed language. Korgh (1998) also argues that the language serving the purpose of exchanging tacit knowledge has to be socially justified and known and accepted by the team members. In the participatory agricultural research context it was found that language variation was common between farmers and researchers. It was difficult to build shared system of meaning and understanding in situations where farmers and researchers didn't share common language and when they used interpreter. There might be loss of knowledge in the process of translation. But the finding indicated that such problem can be minimized if the interpreter is directly involved in the participatory research process and has equivalent expertise or knowledge or experience in the subject of investigation.

Variation in terminologies and pronunciations within the same local language also affected the proper flow of tacit knowledge among participants. The results of the study indicated that farmers use their own linguistic representation when they articulate their tacit knowledge. The terminology may be associated to certain feature of something they observed or analogues to what they had known or experienced before. Such linguistic representations may not be clear or easily understood by researchers. It was suggested that close relationship between farmers and researchers and asking clarification from farmers may solve this problem. But in most cases researchers and farmers are not collocated and it may be difficult to establish close relationship and interaction because of the distance factor.

Researchers also used technical and scientific terms that may not be understood by farmers. Lack of direct translation of scientific and technical terms into local languages was a challenge that impeded the proper flow of knowledge. According to Swan, et al. (2000) such barrier requires negotiation, re-creating and re-constituting the knowledge through interactive group process. Our study also found that presenting technical issues or terms in a simplified manner, using equivalent local terminologies, engaging in two way communication and allowing participants to ask questions for clarification addressed some of the challenges associated with technical/scientific terms in the communication between farmers and researchers. Grant (2007) also argued that internal representation is identified by means of language, and an isomorphism is assumed between the internal representation and the relevant linguistic set of sentences. Therefore, internal

representations can be highly explicit by using adequate and precise linguistic representation which is accepted and shared by all participants in the innovation group. Carlilie (2004) said, shared meanings should be created in order to provide adequate means of sharing and assessing knowledge.

Another finding pertaining to linguistic representation was that some of the vocabularies that farmers used had equivalent scientific names but this became clear when both farmers and researchers explained and practically demonstrated their linguistic representations during participatory experiment and evaluation process. For instance, farmers used the term 'Dasha' to evaluate the productivity of a certain variety. This was the same as 'tillering' in the scientific representation. Farmers used 'wide leave' as an indicator of better productivity which was equivalent to high photosynthesis in scientific representation. Both farmers' representations and that of the scientific one were referring to the same parameter of measuring productivity. Therefore, the criteria derived based on indigenous knowledge which was represented in local language had equivalent scientific term and both mean the same when they were used as evaluation criteria.

Mutually agreed language (Grant, 2007), the use of innovative vocabulary (Lawson and Lorenz, 1998) and developing semantic capacity are required to represent and share newly generated tacit knowledge and build shared system of meaning. Our finding also warrants language standardization, developing ontology (building common vocabulary) or building shared system of meaning in order to address the language related challenges and to build common understanding within the group of key stakeholders involved in the

participatory innovation process. Ontological application should be developed for mapping farmers' terminologies to scientific representations and/or indigenous knowledge to scientific knowledge. Researchers should also give explanations about the scientific concepts in a very simple, localized and understandable way and this requires another representation which needs to be clear to farmers.

It was also found that when a researcher didn't speak the local language it became a challenge for him/her to directly transfer the knowledge and skill to the local farmers and it was also a challenge for farmers to directly explain their tacit knowledge to the researcher. In this case, one of the participants (mostly extension workers) who know both languages served as interpreter.

#### **5.3.4. Communication Skill, Method and Media**

von Krogh (2009) claims that communication skills affect the smooth flow of tacit knowledge. The study also identified researchers' communication skill and use of proper terminology as factors that affected the successful delivery of ideas or knowledge to the farmers. As it was evidenced by the findings of the study, communication skill varied across disciplines of researchers. In this regard, it was found that from members of the research team the socio-economic and agricultural extension experts were found better in terms of interpreting and transferring knowledge embedded in the technology to the farmers and bridging the communication gap between researchers with pure science background and farmers. According to the author, such kind of participatory innovation approach negatively impact the smooth flow of tacit knowledge from the local community to the innovation group and vice versa. Farmers should also have better

communication skill to share their experiential and indigenous knowledge. Most of the time model/experimental farmers were found competent in making presentations on field days, field visits and other similar forums.

Gubbins, et al. (2012) said that the learning formats that each individual prefers affect articulation and sharing of tacit knowledge as some people rely more on images to learn while others learn better from verbal material and some are mixed processors whom can learn from either format. The findings of the study also confirmed that presentation methods and approaches of researchers affected the quality of communication and thus, articulation and sharing of tacit knowledge. Farmers may not understand the whole essence of the project and their contribution could be minimal if ideas or knowledge behind the new technology couldn't be delivered clearly using proper media. The result of the study signified that prior knowledge about farmers and their practices positively contributed to the design of appropriate presentation or demonstration techniques that enabled farmers to easily understand the new technology/idea/knowledge introduced. Evidences from the study also indicated that those presentation methods aligned to the experience and level of understanding of farmers addressed the problem of misunderstanding and facilitated the transfer of knowledge behind the new technology. The method should enable the actor to present the idea or knowledge in a more simplified way so that it is possible to build shared understanding among participants. Verbal communication supported with practical on-farm demonstration and multi-rounds of experimentation were found effective to articulate and share tacit knowledge. Communication tools including pictures, posters, brochures, fliers, extension materials,

etc. significantly supported the stated knowledge transfer mechanisms. Although posters are the most effective communication tools their development was costly.

### **5.3.5. Group Heterogeneity**

Different authors mentioned about the role of heterogeneity in members of the group (education, social status, etc.) to the success of innovation and problem solving (Costa et al., 2008; Hennala, et al., 2011). It allows acquiring “fresh” ideas, insights, and experiences (von Krogh et al. 2000) and it serves as a source of creativity due to the integration of diverse tacit knowledge (Nonaka and von Krogh, 2009). The same fact was realized in our study. Participatory research approach has introduced not only the formation of farmers’ research group with diverse experiences but also the involvement of multi-disciplinary research team with diverse levels of experience and expertise. The purpose of involving selected farmers as a research group was for extracting and integrating untapped tacit knowledge of the rural community into agricultural innovation system. The involvement of multidisciplinary research team was for the purpose of capturing and integrating innovative ideas and multiple perspectives of experts in order to address multidimensional problems of agricultural sector. The heterogeneity had positive impact in terms of generating new ideas from different perspectives. It was found that valuable new perspectives, ideas, knowledge, and skills have been embedded in various interpretations that served as an input for further enhancement of the technology. Therefore, it was claimed that every participant should pay attention to such various interpretations and conduct open discussion to extract valuable inputs.

FRG with more educated and experienced farmers at the leadership position made the group more innovative, capable of generating and sharing new ideas and knowledge. Higher age of farmers was associated with rationalization and wise judgment as well as greater innovativeness because of the rich experiences and practical knowledge they acquired through long years of practice in farming business. It was also found that involving female farmers in FRG had its own contribution in terms of introducing new perspectives and contributing more innovative ideas. In addition, female farmers were found more open and positive to share their knowledge and experiences as compared to male farmers. It was also found that the size of the group had an impact on articulation and sharing of tacit knowledge since optimal size contributed to greater group cohesion and greater size was associated with group conflict.

The identified challenges associated with heterogeneity include variation in personal interpretation, failure to build shared understanding and incompetent assimilation and exploitation of embedded knowledge.

### **5.3.6. Motivational Factors**

If an individual feels that he/she might stand to lose by making their tacit knowledge explicit McAdam, et al. (2007) suggested that explication requires a supportive environment involving trust and appropriate structures. Factors like incentive, perceived benefit (economic value, sustainability and market demand) and extra burden on researchers affected the commitment of farmers and researchers. It was found that there is no incentive mechanism in participatory research approach and it affected farmers' motivation to engage in collaborative experiment on the new technology or agronomic practice introduced. Farmers' commitment to collaborative innovation and sharing of

their tacit knowledge tended to be less when they feel that the new technology or agronomic practice may not generate more economic value, create more market demand and sustainably solve their problems. If the impact is indirect and realized after longer period or cycle, farmers may not be motivated to engage themselves in the experimentation, evaluation, improvement and adoption of the proposed technology or agronomic practice. The typical example is failure of forage project because of the fact that farmers couldn't realize the complete cycle and benefit of allotting their plot to the production of forage instead of maize. Farmers couldn't visualize the immediate impact of the project on their livelihood as compared to maize production. Researchers also faced challenges to demonstrate the benefit to the farmers.

The incident of lack of motivation from farmers' side had two implications from the possibility of extracting and sharing tacit knowledge. First, the incident triggered researchers to reflect on the problem and propose possible solution, like in the case of forage project – demonstrating cost-benefit analysis and market opportunities to farmers so that they can visualize the benefit of forage production over maize production. This is a form of tacit knowledge articulation based on the typical problem faced. Second, presentation of rich content and practical demonstrations may boost the motivation of farmers that will force them to engage in participatory experimentation and evaluation as well as articulation and sharing of their tacit knowledge. Therefore, motivation depends on visualization of the actual benefits and impacts of FRG projects. More visualization implies greater motivation and thus, more opportunity to engage in tacit knowledge externalization and sharing. Once the motivation of farmers is boosted, transferring ideas

or knowledge to farmers and the possibility of getting their inputs in the form of experiential and indigenous knowledge is significant.

In addition, participatory research approach imposed additional burden on researchers and extension workers and this was considered as one of the demotivating factor. They are expected to directly involve from the initial stage of problem identification to the final stages of collaborative experiment, evaluation, selection and adoption of technology. All the processes are carried out with farmers who are selected and trained by researchers. Researchers have to go to farmers' plot to make practical demonstrations on the new technology and the required agronomic practices, conduct the actual experiment together with experimental farmers and monitor the evaluation and selection of technology which is done by farmers. This additional burden which was compounded with distance, poor road infrastructure and poor transportation facility had significantly affected the motivation and effectiveness of researchers in facilitating collaborative innovation and sharing of knowledge and experiences. We believe that some of the burdens may be reduced by designing and deploying ICT supported communication, demonstration, experimentation and monitoring system.

#### **5.3.7. Degree of Complexity**

Simplicity or having no sophistication in the idea/knowledge/technology contributed to ease of communication and establishing mutual understanding. Those participatory experiments that used highly simplified techniques and depended on the use of local materials made the transfer of new ideas or knowledge between researchers and farmers and within farmers so easy. It was found that when farmers easily understand the

technology their participation and contribution of innovative ideas increase. On the other side, the possibility of rejection of the technology and failure of the project became high when the technology involved abstract ideas which were difficult to practically demonstrate to farmers. The degree of sophistication may arise from the nature of the newly introduced technology or agronomic practice. Together with low level of understanding of farmers the sophistication may inhibit effective elicitation and sharing of tacit knowledge. The extent of technical issues involved in FRG project had also similar impact. Therefore, the lesser the understanding of farmers about the new technology or agronomic practice due to complexity, the lesser the contribution of farmers to the generation and sharing of their tacit knowledge.

#### **5.3.8. Resource and Infrastructure Problem**

Creating more linkages by involving farmers from wider geographical area and tapping extensive tacit knowledge in to collaborative innovation was significantly hampered by distance, poor physical infrastructure and resource constraint. These factors resulted in limited face-to-face interaction between farmers and researchers, limited experience sharing forums and limited follow-up and monitoring activities. These factors had their own impact on articulation and sharing of tacit knowledge among team of researchers and group of farmers. Because of the stated factors FRG projects were established in few areas based on geographical proximity which restricted the chance of involving more potential areas and innovative farmers in the project. The ICT intervention strategy may address these problems by providing ICT enabled monitoring mechanism and virtual space for discussion and sharing of new ideas.

From the human resource perspective it was identified that problems pertaining to high turnover and transfer of researchers and extension workers after acquiring skill and experience in FRG approach was so significant. If there is high turnover there is loss of tacit knowledge and this warrants the need for capturing tacit knowledge of participants using ICT.

Based on the discussion on mechanisms of tacit knowledge externalization (section 5.2) and factors impacting externalization process, the following table presented the mapping of determinant factors to specific tacit knowledge externalization mechanisms.

Table 5.2: Mapping determinant factors to different externalization mechanisms

Mechanisms Factors	Experiment and Evaluation	Apprenticeship /Mentoring	Metaphor	Storytelling	Dialogue	Asking Question	Localization	Observation	Modeling Technique	On-farm Demonstration	Learning-by-Doing	Lessons Learnt
Disparity in cognitive competence	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓
Social capital factors	✓	✓			✓	✓				✓		
Communication Quality	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓
Group heterogeneity	✓	✓			✓	✓				✓		
Motivational factors	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Degree of complexity	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Resource and infrastructure problem	✓	✓			✓			✓		✓		

As it is indicated above disparity in cognitive competence, communication quality, motivational factors and degree of complexity are major factors that affect all or almost all mechanisms of tacit knowledge externalization.

#### 5.4. Framework for Tacit Knowledge Externalization

As it was discussed in detail in sections 5.1, 5.2 and 5.3 of this chapter with adequate literature support the study identified taxonomies of tacit knowledge classified by degrees of tacitness, the mechanisms of tacit knowledge externalization and factors that impact the externalization process. Based on these findings we developed a theoretical framework for tacit knowledge externalization in the context of participatory agricultural innovation system which is depicted in the following figure (Fig. 5.3).

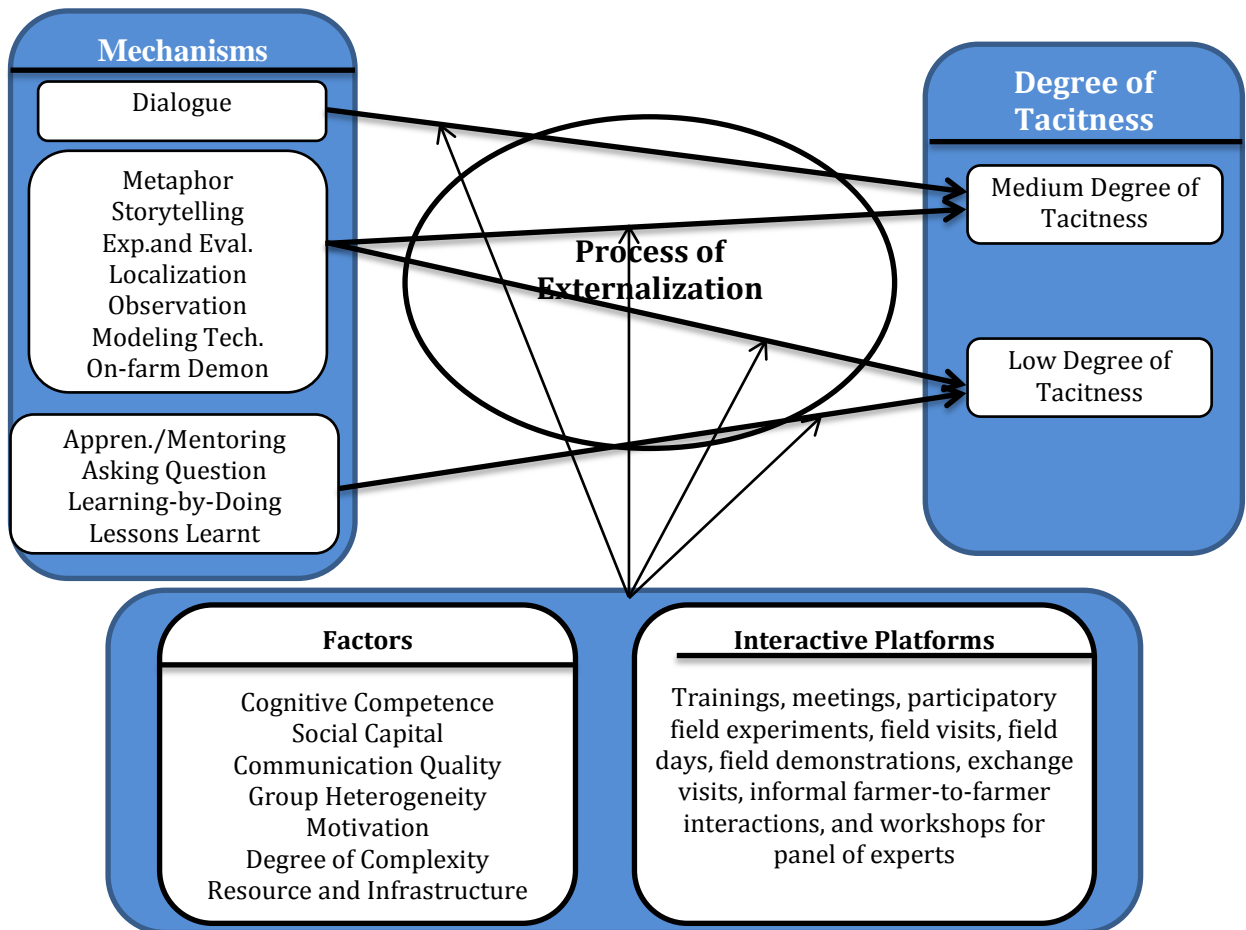


Fig. 5.3: Tacit Knowledge Externalization Framework for Participatory Agricultural Innovation System

The framework represents the relationship among major constructs, mechanisms of tacit knowledge externalization, degree of Tacitness, determinant factors and platforms, interacting together to facilitate the externalization process. As opposed to prior studies that proposed one-to-one mapping between externalization mechanisms and degrees of tacitness, our study confirmed that one mechanism can serve the externalization of tacit knowledge with different degrees of tacitness. As it is indicated in the framework Metaphor, Storytelling, Experiment and Evaluation, Localization, Observation, Modeling Technique and On-farm Demonstration were used to externalize tacit knowledge with medium and low degree of tacitness. In prior studies observation, mentoring and apprenticeship were mapped as externalization mechanisms to high degree of tacitness. But our study confirmed that observation was used to externalize tacit knowledge with medium and low degree of tacitness while mentoring and apprenticeship were used to articulate tacit knowledge with low degree of tacitness (e.g. skill). In prior studies metaphor, storytelling and modeling technique were proposed for externalizing tacit knowledge with medium degree of tacitness. Our study demonstrated that they could also be used to articulate tacit knowledge with low degree of tacitness. In addition to mapping the externalization mechanisms to degree of tacitness the study identified different determinant factors and demonstrated their impact on tacit knowledge externalization process. The impact of each determinant factor was also mapped to each externalization mechanism. None of the prior studies have considered determinant factors and their impacts on externalization mechanisms in particular and the externalization process in general. The role of interactive platforms in facilitating tacit knowledge of different stakeholders was also clearly demonstrated in the study.

# **CHAPTER SIX**

## **SYSTEM ARCHITECTURE FOR MOBILE - MEDIATED TACIT KNOWLEDGE EXTERNALIZATION**

### **6.1. Rationale for Proposing M-Application**

Mobile has become the most powerful communication technology with significant potential for enhancing agricultural and rural development through provision of access to information, markets, finance and governance system (Qiang, et al., 2011). Affordability, its pervasiveness, multimedia communications capability and instant and convenient service delivery are the key advantages of mobile technology (Ibid.). Mobile is considered as a key instrument for leapfrogging for developing countries from fixed-line Internet into mobile broadband.

Large penetration of mobile technology in rural areas has created more opportunity to deploy mobile-based services among small holder farmers (Gichamba, et al., 2015). Mansell (2012) argued that mobile phone networks can play a fundamental role in collaborative learning process and developing countries should exploit the potentials of mobile communication infrastructures to augment collaborations and virtual interactions. Mobile phone is the most appropriate technology for collaborative agricultural innovation system because of its capability in transferring rich media content, its greater knowledge sharing potential and its group video calling feature.

But most of the m-applications focused on improving the supply chain integration and thus, engaged in provision of market information, increasing access to extension services

and facilitating market links (Gichamba, et al., 2015). Qiang et al. (2011) reviewed 92 mobile applications for agricultural and rural development in Africa, Asia, and Latin America and the Caribbean and identified four areas of application: - providing market, climate and disease information; increasing access to extension services and good agricultural practices; facilitating market links - direct links between farmers, suppliers, and buyers; and better access to finance – credit, insurance and payment methods. Gichamba, et al. (2015) also classified all the services of agricultural mobile applications into agriculture advisory information, record keeping, diagnosis services, market information and veterinary services. These facts indicate that the potential of mobile in collaborative research and innovation is less explored and exploited. Most of the m-applications focused on transfer of explicit and codified knowledge. To the knowledge of the researchers, there is no mobile based application designed to support externalization, sharing and capturing of tacit knowledge within the context of participatory agricultural research system. Our study took participatory agricultural research and innovation as a case where farmers are considered as key knowledgeable partners. Evidences from the study proved that the involvement of multiple stakeholders, especially farmers, in the innovation process resulted in articulation, sharing and integration of wealth of tacit knowledge in the form of rich and lived experiences, skills, know-how, expertise, local or indigenous knowledge, best practices, lessons learned, etc. Tacit knowledge articulation and sharing requires technologies that allow free-form communication and collaboration (Panahi, et al., 2012). Therefore, it is necessary to explore the potential of mobile phone in supporting tacit knowledge articulation and sharing in a collaborative research context where illiterate and semi-literate farmers are involved. Mobile technology serves as a

platform where researchers, farmers, extension workers and other pertinent stakeholders can engage in collaborative interaction and articulation and sharing of their tacit knowledge. Therefore, the technological solution that we proposed is called *mPlatform*.

## 6.2. Current Uses of Mobile Phone in Participatory Research

As it was explained by different respondents, mobile phone has been used to facilitate communication among farmers, researchers and extension agents to fulfill different purposes and make most critical information accessible to farmers and researchers. It is also saving resources in terms of effort and time. The excerpts from different respondents on the purpose of use of mobile phone in FRG related projects are summarized using the following table.

Table 6.1: Purpose of Use of Mobile Phone in FRG Related Projects

<b>Excerpts on the use of mobile phone</b>	<b>Respondents</b>
“...to pass important procedural messages to farmers, e.g. how to measure and record plant height, how to handle the occurrence of plant disease, what to do when unexpected rain, flood, weed problems occur, etc.”	RES 10, DA 01, DA 02, RES 03, RES 05, RES 02
“...to alert FRG members for a meeting, training or practical demonstration”	RES 05, RES 02, RES 04
“...to deliver market related information.”	RES 03, RES 07, RES 06
“...for the purpose of establishing experimental site, to follow-up the situation on the experimental farm plot, etc.”	RES 03
“...from the side of farmers – for updating progresses made, for reporting problems or any deviations from recommended practices, for reporting on disease breakout, to inform whether there is rain or not, reminding researchers about the harvesting time, asking researchers what to do when they observe some change or problem on the crop”	RES 08, RES 05, RES 04
“...for gathering pertinent data from farmers”	RES 10

There was one typical FRG project that focused on providing market information to the farmers using mobile phone. Regarding the actual experience about this project RES 05 and RES 07 said:

*Farmers were organized as FRG and each FRG was provided with one mobile phone which was purchased by FRG project fund. Individuals were recruited to gather and provide price related information from different markets. Farmers had access to the price of each commodity in different markets. Based on this information they were selling their product with better price and became highly profitable as the assessment study indicated. Farmers have already understood the benefit of mobile phone and they are using it to assess market situation and commodity prices in different places.*

RES 01 confirmed that the result of this project had a direct impact on farmers' livelihood and they were very much interested.

Different respondents also mentioned their concerns and challenges pertaining to the current use of mobile technology in facilitating communication and sharing knowledge.

*RES 03 ...it is difficult to orally and visually communicate the kind of disease that affected the plant with the mobile technology that farmers have .... it doesn't support visual presentations of the actual problem on the field...there is also network problem and we sometimes fail to access farmers even for setting urgent appointment.*

*RES 06 ... we can't transfer all our ideas and knowledge to the farmers and conduct detailed discussions from different perspective because of high cost....*

*DA 01 ... it is difficult to sense their feelings through mobile communication .... verbal communication of their feelings may not be genuine ... we have to look at their face to judge whether they accepted the idea or not. It is difficult to understand this situation only through voice based communication.*

*RES 11 ... Farmers' capacity to use the modern communication technologies may be hindrance for effective use of mobile based communication system.*

### 6.3. Current Challenges in Capturing of Externalized Tacit Knowledge

As tacit knowledge is considered as a key to innovation, considerable attention has to be devoted to finding ways to “capture” this resource (Kothari, et al., 2011). After it is identified and converted, it has to be captured for dissemination and utilization (Sigala and Chalkit, 2007). Tacit knowledge can be captured as stories, images, videos, audios or any other electronic document (Costa et al., 2008). It is also possible to capture and reuse unique and highly contextual tacit knowledge of different actors.

As the data indicated although wealth of tacit knowledge of multiple stakeholders was articulated in the process of participatory research, its sharing is limited to members involved in the specific FRG project. This was mainly because there was no systematic capturing and dissemination of the articulated knowledge to wider farming and research community. As RES 07 said:

*...farmers in different areas made different experiments in their own way on the same technology recommended by the research. We could have accessed to extensive new knowledge if the results of farmers' experiments were collected and integrated.*

There was limited practice of capturing tacit knowledge in the form of farmers' perceptions, feedbacks, preferences, best practices, etc. and published in the form of reports. The capturing was not adequate due to various challenges. As RES 10, RES 02 and RES 3 explained:

*....most of the innovative ideas shared on different forums have not been captured since our focus was on the end product rather than the processes involved. Only the preference rankings and justifications were commonly recorded. We were interested to capture farmers' innovative ideas using audio, video and pictures*

*and transfer them to non-FRG members but there was lack of appropriate tool. This has been one of the major limitations of FRG approach.*

RES 07 and 04 added:

*...documenting farmers' indigenous knowledge and innovative practices has not been given adequate attention ... and it was due to lack of appropriate system, structures and resources created for this purpose.*

In order to address such problem RES 11 recommended that:

*.... there is a need to develop a system, establish responsible unit and recruit a dedicated professional to coordinate the capturing of different forms of knowledge being transferred in the participatory research process...*

The finding also indicated that capturing was inconsistent, not sustainable and it didn't cover the whole processes and range of interactions and knowledge sharing activities in participatory research. Interactions in collaborative experiments that involved extensive sharing of innovative ideas were not captured. Tacit knowledge capturing mechanisms were not equally applied in all FRG projects. Knowledge sharing among farmers in their informal meetings has not been captured. Researchers' limited effort to capture farmers' innovative ideas and indigenous knowledge due to their bias towards scientific solutions was also another factor contributing to problem of capturing. Those partially documented knowledge were not systematically organized and there is no responsible body to maintain them.

#### **6.4. Requirements for ICT Support**

Respondents also articulated their requirements for modern ICT and infrastructure that can support their interaction and sharing of knowledge and experiences. There is a general feeling that ICT should support the extraction and sharing of farmers' knowledge.

RES 07 said: ... *there should be some mechanism to extract and share farmers' indigenous knowledge so that it becomes explicit, standardized and public and solve situation specific problems.*

There is also a general consensus that mobile phone can play significant role in this regard. RES03 claimed:

*The only technology available in the hands of farmers is mobile phone. Farmers are using this technology for communication. Therefore, this is the kind technology we have to think of for the purpose of sharing ideas and knowledge when participatory research is conducted. It is essential to focus on mobile phone to support sharing of ideas or knowledge.*

RES 04 added:

*The technology that can easily link the three members of FRG – researchers, farmers and extension agents is mobile phone. Mobile apps should be either developed or customized based on the existing systems of communication.*

RES 11 also claimed that:

*Mobile technology is preferred since every farmer has mobile and he/she uses it for communication and idea sharing. I also prefer technology that enables us to share picture supported idea and knowledge since it is powerful.*

The availability of modern technology for communication purpose is very limited even in research center, let alone farmers and extension workers. In such highly constrained environment mobile phone is the most preferred technology to fill the communication gap between researchers, farmers and extension agents.

The following table summarized the specific requirements of respondents towards ICT support, more specifically mobile based system of communication to support interaction and externalization and sharing of tacit knowledge. The requirements revolve around creating linkage, communication, accessibility to content, technology or infrastructure.

Table 6.2: Summary of excerpts on requirements for ICT and Infrastructure

Requirements	Respondents
“...there is a need to have a system relevant to farmers having a direct impact on their livelihood ... that can activate and facilitate communication among different actors...”	RES 01
“...using mobile phone to build a system of communication...that can support farmers to express their ideas freely... that enables researchers and extension workers to support farmers...to share knowledge on new technology to as many farmers as possible with no or minimal cost”	RES 06, RES 07
“...mobile based two-way communication media that can create linkage among researchers, farmers and extension agents and facilitate open discussion or dialogue ... and handle the process of feedback, question-answering session, building consensus and common understanding ...any time and with multiple frequencies”	RES 02, RES 06, RES 08
“...a virtual forum that can create easy access to the knowledge of farmers, extension agents, researchers and other stakeholders”	RES 06
“...a system that can capture best practices and innovative ideas of FRG members and make it accessible to any researcher or farmer.”	RES 11
“... a mobile based system that support wider dissemination of the knowledge generated in participatory experiment conducted in a particular location without geographic and temporal limitation and in multi-media – in audio, image or video format so that farmers in other areas can easily listen, view and understand without requiring special skill...”	RES 02, RES 01
“... a system that allows developing and dissemination of short programs on participatory research supported by audio and video features using local languages...producing documentary films that reflect the process of FRG research from the beginning to the end... that can support practical training and demonstrations...”	RES 01, RES 04
“... a system that support video and audio based presentations, developing picture based content like posters and posting them on common electronic space... provision of a multimedia presentations to farmers that enables them to handle their problems and adopt a new technology and agronomic practice with minimum support from researcher ... through sharing picture and text based descriptions of step-by-step procedures ... through real time presentation of field experiment ... all contents to be delivered in local languages	RES 04, RES 07, RES 09, RES 10
“... a system that allows farmers to easily capture, upload and share their innovative ideas, rich experiences, best practices and indigenous knowledge using voice, image and video...”	RES 01
“... mobile based system should allow follow-up and monitoring of the experimental plots and performances of each experiment remotely on real time basis to be supported by pictures and videos ... enabling to take corrective actions ...”	RES 03
“...focusing on commercial or innovative farmers to begin with implementation of mobile mediated participatory research...”	RES 06

Respondents indicated various constraints from the infrastructure and technology perspective that hinder effective use of mobile for sharing ideas and knowledge in participatory research projects. One is the network problem. RES 03 said “Network availability in all places is very critical in order to communicate with farmers.” From the technological device and connectivity perspective DA 02 said:

*The current mobile device that we are using has limited role in exchanging knowledge, experience, ideas, skills, etc. For this, we need modern mobile phone at least for a group. I also wish to have Internet access at district level.*

RES 06 also expressed:

*The ICT tool should be freely available to farmers including the mobile call fee. Farmers should be able to call freely to the researcher and to the extension workers and have free discussion and get advice. In addition to the mobile phone it is also possible to think in terms of installing other ICT tools at a central location in the village so that farmers and extension workers can use them to interact with researchers.*

Respondents also required additional technological infrastructure in addition to the mobile based communication system.

*RES 08: It is good to have better communication facility like teleconferencing that can facilitate live interaction with farmers and address some of the challenges pertaining to knowledge sharing.*

*RES 02: In the future we need to have Internet to facilitate communication between researchers and extension workers. It is good to have fast Internet connection that can be accessed through mobile phone.*

## **6.5. Design of System Architecture**

As it is stated in the methodology chapter we followed multi-methodological approach to IS research recommended by Nunamaker, et al. (1991) which combined both behavioral and design science approaches. The authors stated that theory building includes

development of new ideas and concepts and construction of conceptual framework. In theory building we conducted a case study to identify mechanisms and factors pertaining to tacit knowledge externalization and sharing and finally came up with a conceptual framework. From the five process steps we focused on the three – *constructing a conceptual framework, developing system architecture and evaluating the architecture*. The first component has been done in the previous chapters and in this chapter we focused on the development of system architecture. According to Nunamaker, et al. (1991) a system architecture provides a road map for the systems building process by identifying system components, specifying system functionalities and defining the structural relationships and dynamic interactions among system components. In this process the constraints /problems/ imposed by the environment must be identified, the objectives of the development efforts must be stated, and the functionalities and the requirements of the resulting system must be defined.

### **6.5.1. Interaction Scenario and Existing Problems**

Based on the recommendations of Alarcon, et al. (2006) and Peffers, et al. (2008) we presented interaction scenarios and associated problems under each concept together since both the problems and communication needs would be addressed by the designed artifact. The roles of researchers, farmers, extension workers and other stakeholders were also embedded in the specifications of scenarios when they are visible. The following table summarized the existing interaction scenarios and associated problems which require the design and implementation of mobile based communication system.

Table 6.3: Interaction Scenarios and Associated Problems in Participatory Agricultural Research System

Concepts	Interaction Scenario	Problems
<b><i>I/ Tacit Knowledge Externalization Mechanisms</i></b>		
Metaphor	Farmers used metaphorical expression to articulate their understanding about their observation or to express the logic behind their judgment. Researchers also used metaphor to present abstract ideas to farmers in a more simplified and understandable ways.	Limited possibility of supporting verbal presentation of metaphors with visualization mechanisms.
Storytelling or Narrative	<ul style="list-style-type: none"> <li>Farmers and researchers uncover and convey tacit knowledge through framing their experiences in stories. This could be in the form of presenting success and failure stories in previous FRG projects.</li> </ul>	Lack of proper capturing and organizing mechanism; limited access to the stories by farmers even within the same FRG members.
Dialogue	<ul style="list-style-type: none"> <li>Researchers, farmers and extension agents articulate, reconcile and integrate their diverse perspectives through dialogues and building shared meanings. The dialogue could be on problem diagnosis and subsequent solution formation, on actual experiment process, on evaluation and ranking of experimental results, etc. Actors articulate new ideas, perspectives, experiences, expertise, etc. through productive dialogue</li> </ul>	Limited frequency of contact among key actors due to distance and resource constraint (time, expertise, financial, logistical, etc.)
Apprenticeship or Mentoring	<ul style="list-style-type: none"> <li>Researchers mentor experimental farmers (members of FRG) and transfer knowledge and skill and then experimental farmers mentor the non-experimental farmers (members of FRG) and transfer the same knowledge and skill plus their experiences, best practices and lessons. The mentoring process involves practical demonstration and observation.</li> </ul>	Lack of adequate mentoring due to resource constraint including limited frequency of contact among researchers and farmers

Concepts	Interaction Scenario	Problems
Experimentation and Exploration	<ul style="list-style-type: none"> <li>• Farmers articulate their practical intelligence by way of conducting their own experiments through manipulating treatment methods and control variables as well as through manipulating the existing agronomic practices. They demonstrate the possibility of achieving better results through such experimentation. Such practical experiment enabled farmers to explicate and share their perspectives/insights, rich experiences, best practices, practical intelligence, indigenous knowledge, skills, know-how, etc. This is not verbally but rather through reflection-in-action, for example, while treating animal disease, preventing weed expansion, setting their own criteria and selecting the best technology based on their preferential rankings, etc. Their criteria and justifications for selection may be articulated based on visual feature of the technology, for example, the phenotype of the plant (wide leaf, deep green leaf, etc.), demonstration of planting and watering technique, physical comparison of traditional and newly introduced tools, etc.</li> <li>• Researchers also apply their insights, expertise, past experiences, understanding of the local situations and personal judgments in the development and experimentation of new agricultural technologies and in the manipulation of scientific recommendations and existing practices. They conduct on-farm controlled experiment to articulate and share their idea or knowledge to the farmers in a way they can easily understand.</li> <li>• Therefore, both farmers and researchers apply experimentation and exploration as a means to articulate, clarify, prove or disprove ideas, perspectives, assumptions and explanations.</li> </ul>	Lack of proper tracking of the process of reflection-in-action; limited possibility of capturing tacit knowledge articulated in farmers' own experimental processes and results; lack of mechanisms to visually present different actions or plant features
Observation	Farmers observe the phenotype of the plant and different agronomic practices and reflect on their observation that represents their internal understanding.	Problem of understanding invisible phenotypic characteristics of plants and wrong interpretations of observations, etc. Lack of mechanisms to capture reflections on observations
Learning-by-doing	Under FRG project the same experiment is done for three subsequent years on farmers' plot. In this process experimental farmers get a chance to learn the tacit skills and knowledge behind the new	Learning-by-doing is limited to the experimental farmers and the tacit knowledge and skills

<b>Concepts</b>	<b>Interaction Scenario</b>	<b>Problems</b>
	technology through direct participation or practicing and self-perfection. They also learn through redoing what they observed on field-demonstration. In the process farmers introduce their own innovative ideas.	learned as well as innovative ideas generated in the process may not be accessible to others. Others do not have equal opportunity to the process of learning-by-doing
Lessons Learnt	Sharing results gained (good or bad) and best practices with other team members and learning from others' experiences through exchange visits and field days.	Limited access to lessons and best practices due to limited resource to organize exchange visits and field days and to capture the lessons and best practices
Modeling Technique	Farmers draw maps to represent their mental models – their understanding about the environment, the resource endowments, boundaries, etc. They also depict process maps to represent their understanding about sequence of activities involved. Researchers also deliver abstract and highly technical issues through simulation.	Limited possibility of capturing the articulated tacit knowledge in the form of visual presentations.
Asking Questions	Tacit knowledge of researchers and farmers can be extracted and captured by asking the right question.	Lack of proper communication channel to enable researchers or farmers to engage in question answering session.
Localization	Researchers provide highly localized solution to local problems based on innovative use of abundantly available resources or materials in the area.	Limited access to information on local resources and local practices that limited the opportunities for exploring innovative ways of applying the local resources.
On-farm Demonstration	Enabled farmers to easily understand the new knowledge embedded in the technology, visualize the difference between traditional farming practices and improved ones and provide their feedbacks and innovative ideas.	Accessible only to FRG members. Limited access by other farmers. There is no mechanism for capturing and sharing innovative ideas generated during practical demo.
<b><i>II/ Factors that Impact Externalization and Sharing of Tacit Knowledge</i></b>		
	<b>Platforms</b> Meetings, training sessions, field demonstrations, participatory field experiment and evaluation, field	Huge disparity in cognitive competence; Extra burden on

Concepts	Interaction Scenario	Problems
Interactive Platform	<p>visits, field days, exchange visits, informal meetings among farmers in coffee ceremonies or other occasions are major platforms where tacit knowledge is externalized and shared.</p> <p><b>Participants and what they share:</b></p> <ul style="list-style-type: none"> <li>• Researchers, farmers, extension workers and other pertinent stakeholders participate.</li> <li>• Farmers are organized under FRG and articulate and share their indigenous knowledge, practical intelligence, skills, know-how, best practices, experiences, etc. They are sub-grouped as experimental (model) and non-experimental farmers. The role of experimental farmers is performing the actual field experiment together with researchers, contributing their own innovative ideas in the experiment process, notifying major changes and incidents to researchers in the experiment process, developing their own selection criteria, conducting evaluation and ranking the results of experiment together with non-experimental farmers, explaining the logic or the justification behind the ranking and selection, training non-experimental farmers and serving as knowledge intermediaries, making presentations, share their experiences, best practices and lessons learned and respond to questions to participants of field days, field visits and exchange visits. The role of non-experimental farmers is observing the whole experiment and evaluation process, acquiring lessons and providing their feedbacks in selection processes.</li> <li>• Multi-disciplinary researchers are also directly involved in participatory research and share their expertise, experiences and perspectives. The roles of multidisciplinary research team include conducting situation analysis and identifying farmer's needs, developing a proposal and improving it based on farmers' feedback, selecting farmers and organizing them as FRG, providing training to members of FRG, conducting practical field demonstrations, conducting field experiment together with experimental farmers, monitoring the experiment process, conducting multiple rounds of meetings with FRG members, coordinating evaluation and selection of the best technology and coordinating field visits, field days and exchange visits.</li> <li>• Private sector, NGOs, experts from agricultural bureaus, associations, and cooperatives also take</li> </ul>	<p>researchers; high cost of transportation and logistics; limited frequencies of communication between researchers' team and FRG members who are dispersed in distant locations; limited guidance, follow-up and monitoring of projects by researchers; application of FRG approach in a very limited area and lack of replication of the projects in different places because of the limited number of researchers as compared to the extensive time, effort and resources required by FRG projects; limited opportunity to harvest the untapped wealth of tacit knowledge from farmers through participatory research approach; lack of proper system of capturing new ideas/knowledge shared in the forums; limited possibilities of accessing innovative ideas shared through informal meetings and discussions among farmers</p>

<b>Concepts</b>	<b>Interaction Scenario</b>	<b>Problems</b>
	part in the interaction process and provide their feedback mostly on field days and field visits.	
Disparity in Cognitive Competence or Knowledge Capability	Farmers are major partners in participatory innovation process who actively participate in collaborative experimentation and knowledge creation and sharing process. They are also sources of cognitive disparity.	Farmers' illiteracy created gap in levels of understanding, conceptualization or interpretation of ideas and observations.
Social Capital Factors	The three dimensions (structural, relational and cognitive capital) are impacting the process of interaction as well as eliciting and sharing of tacit knowledge among actors involved in participatory research process. Strength of linkage, intensity of social interaction, no power distance, more open and participative team discussions, more trusting relationship, collective bonds, group solidarity, reciprocity, shared language, shared interpretations and system of meaning and shared understanding – all have positive impact of tacit knowledge articulation and sharing.	Lack of appropriate tool to facilitate multiple ways of interactions and strengthening linkages; language barrier, challenges in building shared interpretations and system of meaning as well as problem in building mutual understanding
Communication Skill, Method and Media	Communication and communication facilitation skills of researchers as well as the method and media used affect the flow of knowledge.	Lack of communication skill and limited resource to develop and disseminate appropriate method/media of communication
Group Heterogeneity	Farmers Research Group is composed of members with different age group and gender disparities. Participants with older ages have more wisdom and wealth of experiences to share and have better decision making capacity. Women usually come up with more innovative ideas, have better decision making capacity and better knowledge sharing attitude.	Lack of equal access and opportunity for elderly and women farmers to participate and share their tacit knowledge
Motivational Factors	Lack of incentive, perceived benefit and sustainability of the new technology, market demand for the technology, and extra burden on researchers and extension agents are factors that demotivated farmers and researchers.	
Degree of Complexity in Knowledge Articulated and Shared	FRG projects may involve technologies with more sophisticated scientific and technical issues. The benefit of a particular technology or the effect of some agronomic incidents may not be visible.	Difficulty to establish mutual understanding with farmers that limits their participation and contribution of their tacit knowledge
Model Farmers as knowledge intermediaries	They are farmers who have more experience and higher cognitive and absorptive capacity, who can understand and accept new technologies and	Lack of adequate communication media that can support the key

Concepts	Interaction Scenario	Problems
	<p>agronomic practices easily and they are innovators. These model farmers are key members of FRG and mostly become experimental farmers. Model farmers serve as a bridge in the transfer of knowledge from researchers to other farmers and from farmers to researchers. They play key role in facilitating interaction, retraining slow learners and building equal levels of understanding and trust among farmers and increasing technology acceptance and adoption.</p>	<p>role of model farmers as knowledge intermediary</p>
<p>Resource Constraints and Infrastructural Barriers</p>	<p>Group of researchers, farmers and extension agents who are geographically dispersed are engaged in participatory research. This distance barrier impacted the interaction among the group and possibility of articulation and flow of tacit knowledge. FRG projects are highly resource intensive in terms of finance, time and labor. There are also huge barriers of physical infrastructure (road).</p>	<p>Lack of appropriate technology to facilitate linkage and remote communication; High resource requirement, infrastructural problem and shortage of agricultural researchers/experts are major hindrances for replicating FRG projects in wider geographical areas at district and Kebele level. This factor also limited the possibility of expanded participation and the possibility of tapping wealth of experiences and indigenous knowledge from a wide farming community.</p>

### 6.5.2. System Requirement for mPlatform

System requirements were extracted from interaction scenarios and associated problems summarized based on qualitative case study results. They were expressed in the form of how a new artifact is expected to support solutions to problems not hitherto addressed. In general, the mobile based communication system (mPlatform) should support all tacit knowledge articulation and sharing activities of actors involved in the participatory

research. Farmers have built unique, local and situation specific knowledge from the actual agro-economic practices and the challenges they are confronting with. How to capture and link all the knowledge acquired by farmers and integrate them to the scientific knowledge is the key area that needs to be addressed by the mPlatform. The system requirement specification has identified both the functional and non-functional requirements.

**a) Functional Requirements**

The following table summarizes the functional requirements of mPlatform which are developed based on the results of the empirical study.

**Table 6.4: Functional Requirements of mPlatform by Externalization Mechanisms, Degree of Tacitness, Influencing Factors and Media Richness**

<b>Mechanisms</b>	<b>Type of Tacit Knowledge Externalized</b>	<b>Degree of Tacitness</b>	<b>Influencing factors</b>	<b>Required Features</b>
Dialogues	judgment, insight	Medium	Infrastructural & resource challenges, Disparity in cognitive competence, Motivation , Degree of Complexity, Structural & Relational Capital (Trust), Group Heterogeneity	<p style="text-align: center;"><b>High Media Richness</b></p> <ul style="list-style-type: none"> <li>• Real-time video conferencing with supporting images, audios, videos &amp; textual presentations; broadcasting discussions and allowing open participation, question-answering &amp; feedback sessions; (Dialogue, brainstorming sessions, social capital factors, etc.)</li> <li>• Video based interactive coaching (direct interaction with the coach or using SW agent* as a facilitator) - verbal communication and coaching process between researchers and farmers and between model farmers and other farmers in a virtual setting (Apprenticeship/Mentoring, learning-by-doing, Observation, disparity in cognitive competence, degree of complexity, infrastructural &amp; resource constraints, )</li> <li>• Virtual training and on-farm demonstration supported by simulation of new agronomic practices and technologies, as well as digital extension materials, posters and other visualization tools including animations, pictures, drawings, graphical representations, etc. (observation, on-farm demonstration, learning-by-doing, localization, disparity in cognitive competence, degree of complexity,</li> </ul>
Apprenticeship/ Mentoring,	skill, experience, expertise	Low		
On-farm demonstrations	Judgment, Practical Intelligence, Indigen. Knowledge Skills Experience Rules-of-Thumb Expertise	Medium & Low		
Experimentation & Exploration	Insight, Judgment, Practical Intelligence, Indigen. Knowledge Skills Experience Rules-of-Thumb Expertise	Medium & Low		

Mechanisms	Type of Tacit Knowledge Externalized	Degree of Tacitness	Influencing factors	Required Features
Observation	Judgment, practical intelligence, experience, expertise	Medium & Low		infrastructural & resource constraints, ) • Virtual collaboration on field experiments and evaluation – real-time interactive video based presentations, coordinate and follow-up field experiments, facilitating farmers' evaluation and selection processes, supporting presentation of farmers' own experiments with manipulation of inputs, facilitating deliberations, dialogues, QA sessions,... (Experimentation and Exploration, dialogue, localization, disparity in cognitive competence, degree of complexity, infrastructural & resource constraints,) • Real-time video based interactive virtual tour – field visits, field days, exchange visits, actual field experiment and evaluation processes on new agricultural technologies and agronomic practices supported with interactive video and audio presentations, open reflections, discussions and feedback mechanisms (observation, training, Experimentation and Exploration)
Learning-by-doing	Skills, experience, rules-of-thumb	Low		
Metaphor	insight, practical intelligence, experience	Medium & Low	Experience Communication Skill & Media, Disparity in cognitive competence, Degree of complexity	<b>Medium Media Richness</b> • Audio, Narrative, Pictorial/iconic and graphical representation of ideas, metaphors, stories • Live audio conferencing/Phone based conversation system (build stories, metaphorical expressions and their meanings)
Storytelling	Judgment, experience	Medium & Low		
Modeling Technique	practical intelligence, experience, expertise	Medium & Low		
Localization	Practical Intelligence, Indigen. Knowledge Skills, Experience Rules-of-Thumb Expertise	Medium & Low		
Asking the right question	Experience, expertise	Low	Communication Skill & Media, Disparity in cognitive competence, Degree of complexity	<b>Low Media Richness</b> • Live audio conferencing/Phone based conversation system (asking the right question, capture lessons learnt and best practices)
Lessons Learnt	Skills, experience, rules-of-thumb	Low		

### *b) Non-Functional Requirements*

In addition to the above functional requirements the study also identified the non-functional requirements of mobile mediated system of communication (mPlatform). The identified non-functional requirements include:

1. Smart phones are needed for a group of experimental farmers and group of researchers to interact, capture the whole process of experiment and evaluation and share the externalized tacit knowledge. It is needed to handle more complex, multimedia based two-way communication and feedback system. The Smartphone should have platforms with group video calling features equipped with digital camera and capable of playing videos and pictures to support media enriched interaction among actors engaged in participatory research. Basic phones may be used by other farmers to access the knowledge stored in databases, either pulled or pushed.
2. Android should be used as a platform for running the mobile applications.
3. Technologies like SMS, USSD, IVRS and mobile web should be used to develop the mobile application. GSM and CDMA networks with 3G Internet connection may be used to facilitate exchange of multimedia contents.
4. Mobile interface should be developed for farmers to pull and push knowledge in text, audio, video and image format. Both web and mobile interface should be developed for researchers and other experts to interact with farmers and other stakeholders in the same multimedia form.
5. The system should not require high technical skill, it has to be simple and easy to use. It should provide touch tone features (features of voice activated search) to support illiterate farmers to easily retrieve and access multimedia content. In addition, the system should provide voice recognition and text reader functionality to facilitate access to best experiences and innovative practices by illiterate farmers and to involve them in knowledge creation process.

6. The interaction interface should support user multitasking while using the device – walking around the plots, explaining, taking pictures, capturing videos, recording discussions/debates, etc. simultaneously.
7. The system should ensure accessibility by making the service adaptable to different mobile devices, support different languages of the communication and cognition (e.g. screen magnification/zoom, screen rotation, customization colors and brightness).
8. The user interface tier should be optimized for different devices (laptops, desktops, tablet, etc. by creating different presentation layers for each device that can be delivered based on tracing user's browser type.
9. There should be a possibility of casting mobile phone's screen to PC or to a larger screen, like 60-inch HDTV in order to enhance visualization for group of participants.
10. Laptops or PCs should be used as supplements when appropriate since they can be connected to mobile phones to push text and other multimedia content.
11. Regarding battery consumption:
  - a. Solar panels should be provided for re-charging mobile batteries in areas where there is no electricity.
  - b. Since there is limited battery life of mobile devices the software design should consider a battery aware solution.
  - c. The use of extra batteries should be considered in case of extended interaction or activity duration
12. The system should provide an option to allow users to link to a cloud and store the multimedia content.

### **6.5.3. Systems Architecture for mPlatform**

Authors like Taylor (2009), Leonard and Sensiper (1998) and Nonaka (1994) argued that observational and experiential methods of acquiring tacit knowledge without language have more promise for transferring highly inarticulable dimensions of tacit knowledge. Technical part of tacit knowledge - know-how, crafts and skills are also effectively transferred through observational methods. Therefore, the design of mPlatform emphasized multimedia features that enhance observation method of acquiring and transferring tacit knowledge. This is because agriculture is more of practice oriented and enabling actors to observe the skilled activity of other actors is one major means of transferring tacit knowledge. Just by observing the practices of farmers, experts can identify unique experiences, skills, indigenous knowledge, etc. being implemented which is different from the procedures suggested by scientific knowledge. Farmers also do the same when they observe the practice of experts – they realize the differences between their customary practice and the scientific one and easily learn through observation. Therefore, visualization is an important element in the design of the mPlatform and more emphasis is given to transferring tacit knowledge through videos and images of processes and objects as well as through more rich media such as video calls and videoconferencing methods. This approach of articulating and sharing tacit knowledge is also recommended by Panahi, et al. (2012).

The visualization features also support social interactions, discussions, dialogues, feedbacks, trainings, mentoring, demonstrations, experiments, evaluations, field visits, field days, exchange visits, etc. Once the communication between team of researchers

and experimental farmers is supported by rich media (visualization tools – video, picture, simulations, models, etc.) researchers can virtually conduct field demonstrations, train and mentor farmers as well as coordinate and monitor participatory experiment and evaluation, field visits, field days and exchange visits. Such visualization mechanisms enable farmers to learn through observing and repeating others' actions (learning-by-doing). Therefore, supporting the whole interaction and field experiment processes with mobile's visualization features has been considered as major component of the design of mPlatform.

It is believed that such support can pull wealth of tacit knowledge from vast spectrum of stakeholders including the farming community. It also increase participation, create mutual understanding, expand collaboration, enhance reciprocity, facilitate mutual learning and building trusting relationships. The system also considered facilitating mutual learning process through coupling of slow learner farmers with model farmers. Provision of features that support model farmers to provide formalized mobile supported mentoring and apprenticeship activity is also another major area of focus in the design of mPlatform. Visualization mechanisms also play significant role in this respect.

mPlatform also supports the development of ontology and corpus of metaphor with their contextual interpretations and supports language translation in order to build shared language, shared system of meaning and shared understanding.

Storage of multimedia content in different databases and extracting, annotating, indexing and tagging of newly generated tacit knowledge are major activities included in the design of the architecture. The architecture also considered retrieval, access and sharing

of all the captured and stored multimedia content through special features of voice activated search, broadcasting techniques and recommender systems.

The following figure shows the architecture of mPlatform developed for representing mobile mediated externalization of tacit knowledge.

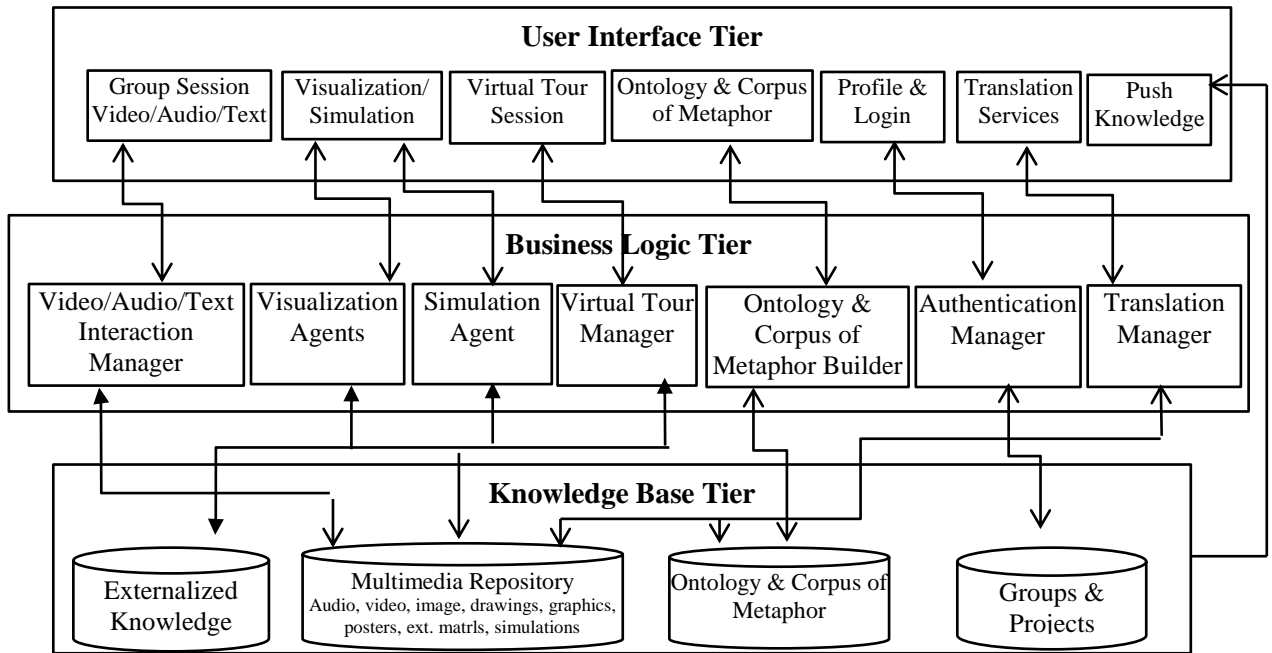


Fig. 6.1: mPlatform Architecture for Tacit Knowledge Externalization (Dialoguing ba)

The proposed system has a three tier architecture. This is because, each logical layer (User Interface layer, the business logic layer and the data layer) should be deployed on a separate machine. The description of each tier is presented as follows:

- **User Interface Tier**
  - In all the components of the user interface the generic functions of retrieving and storing knowledge from or to a knowledge repository are embedded. The **Group Session** user interface manages the collaborative multimedia based live interactions among the group in different forms of dialoguing ba which include dialogues, brainstorming sessions, reflections, question-answering sessions, trainings, coaching, on-farm demonstrations, field experiments, technology evaluation and selection processes, etc. The **Visualization/Simulation** interface enables participants to develop and store visualization and simulation tools as well as retrieve them for supporting live interactions. **Virtual Tour Session** user interface facilitates virtual real time presentation of field visits, field days, exchange visits, actual field experiments and evaluation processes. The **Ontology and Corpus of Metaphor** interface allows participants to store and retrieve descriptions of terminologies and metaphorical representations which are generated during collaborative interactions. **Profile and Login** interface enable participants to establish the profile of each of the participants by entering their details together with username and password. **Translation Service** interface supports interpreters to attach multilingual audio and textual translations to collaborative live interactions. **Push Knowledge** interface is

responsible to retrieve relevant knowledge from different repositories and push it to mobile phones of farmers, researchers and DAs to make them aware of new knowledge, new solutions and best practices, lessons, etc.

- **Business Logic Tier**

- **Video/Audio/Text Interaction Manager** facilitates the process of conducting audio and video conferencing sessions, video recording, speech recognition and recording as well as capturing textual descriptions. This module or application supports the delivery of all real time multimedia content. It facilitates the transfer of tacit knowledge (especially the technical knowhow and skills) through watching and observing other people's practices. In this live interaction manager module the system supports presenters to retrieve and display all supporting content which were previously captured and stored in audio, video, image or textual formats. It also allows participants to integrate multimedia content generated by themselves (e.g. participatory video). It further processes the contents captured in multimedia format during collaborative experiments, evaluations, field days, field visits, discussions, dialogues, etc. The processing involves classification of the text as well as the voice, video and picture clips stored in the database and tagging, extraction of newly formalized tacit knowledge and storing the formalized knowledge

to a separate database of its own. **Visualization Agent** facilitate building and maintain visual tools (pictures, drawings, graphics, posters as well as training modules, extension materials, brochures and fliers enriched by pictures and process flow diagrams). **Simulation Agent** provides features for developing and maintaining simulations on new agronomic practices and process of conducting experiments on new technologies. **Virtual Tour Manager** facilitates the process of conducting audio and video based live tour during field visits, field days, exchange visits, actual field experiments and evaluation processes. It captures the audio and video presentations, process them and stores on appropriate databases. The processes include classifying and tagging the multimedia tour content as well as extracting pertinent knowledge and storing it into a database of formalized knowledge. **Manager Ontology and Corpus of Metaphor Builder** supports participants to build ontology that involves mapping local knowledge representation to the scientific knowledge representation and vice versa, mapping simplified local terminologies for scientific and technical terminologies as well as standardization of local terminologies. It also supports participants to build contextual interpretations of metaphorical expressions. Both ontology and corpus of metaphorical expressions are used for providing formal and explicit specification of shared

conceptualizations. **Authentication Manager** checks whether the user is a member of the group by looking into user's profile in the group database. Then the user shall be authorized to participate in virtual discussions as well as sending and receiving messages. The same authentication procedure is followed to allow the user to create a new group. Only authorized member is allowed to create new group. The new group is assigned a unique identification number (access code) and this number (code) is communicated to each member of the group. **Translation Manager** facilitates the translation of audio, video and textual presentations into several local languages and synchronizes the translations with the each of the presentations.

- **Knowledge Base Tier**

- The knowledge base tier consists four major databases. **Externalized Knowledge** database manage and stores formalized knowledge in the form of new lessons, best practices, experiences, expertise, know-how, skills, indigenous knowledge, etc. sifted from various dialoguing ba or virtual collaborative interactions. **Multimedia Repository** database manage and stores all the multimedia content generated in interaction platforms. **Ontology & Corpus of Metaphor** repository is used to manage and store all terminologies and metaphorical expression with their localized and simplified meanings. **Group & Projects** database stores and

maintains the profiles of all members of the groups and the projects in which they are involved.

In general, a hybrid of centralized and distributed architecture (Kayastha, et al., 2011) is proposed for implementation of mPlatform:

- Centralized client-server architecture is found appropriate for mPlatform where the mobile users are clients who access the centralized server and retrieve or store multimedia content.
- Distributed Architecture – this architecture is needed to facilitate peer-to-peer communication among FRG members, between FRG members and team of researchers and among team of researchers. Farmers can communicate with each other and exchange knowledge, experiences, skills, lessons, etc. using short-range network technologies like Wi-Fi and Bluetooth. A middleware is required for storing the contents of interaction and sharing knowledge (Kayastha, et al., 2011).

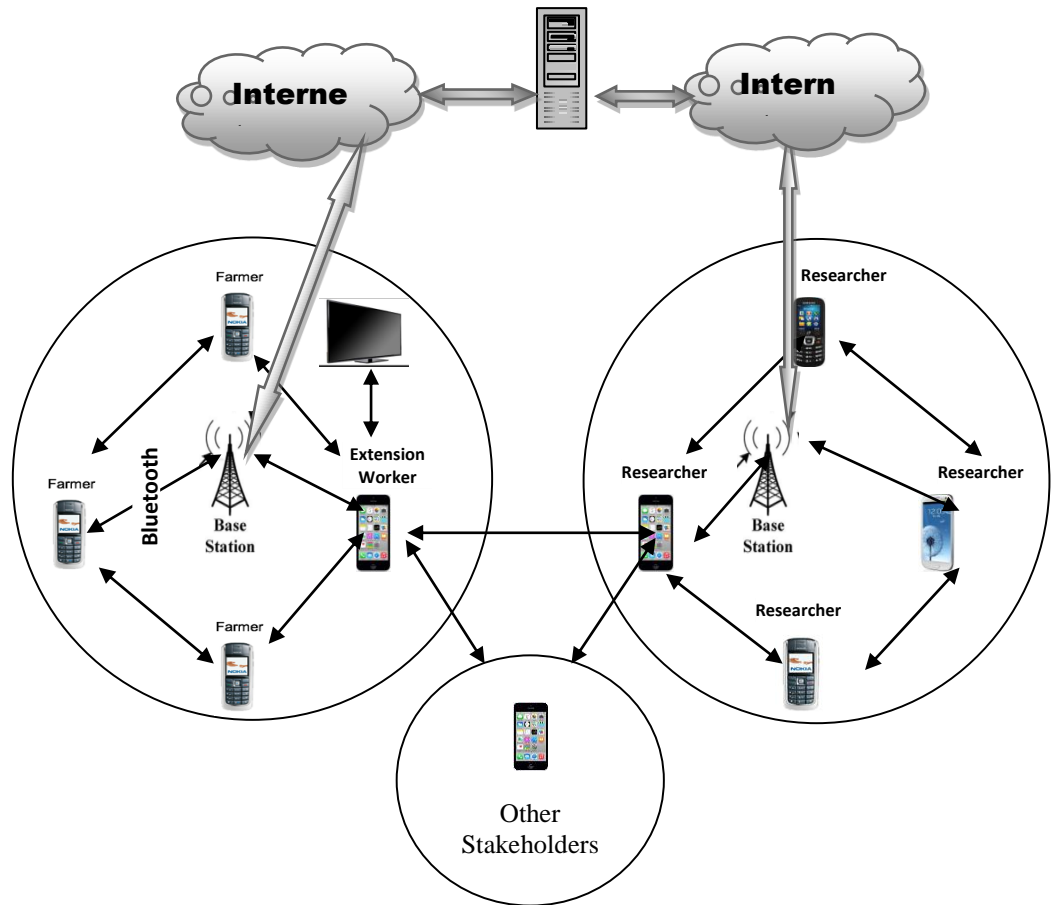


Fig. 6.2: A hybrid of Centralized and Distributed Network Architecture for mPlatform

#### 6.5.4. Implementation strategy

Some of the points proposed as implementation strategies for mPlatform include:

- Expansion of mobile network access to a wider rural community is expected from the government. Ethio Telecom (ET) targeted to boost mobile network access from the current level of 50 million subscribers to 113 million in the second Growth and Transformation Plan (GTP II).
- At the initial stage the mPlatform can be implemented on commercial farmers or model/innovative farmers

- The exchange of knowledge should be handled with no or marginal cost
- The government with possible support from donors should guarantee funding for startup and operating costs and for ensuring long-term sustainability.
- The government should finance the provision of Smartphone for the group of farmers organized under participatory research.
- Extension agents involved in FRG project can assist farmers in textual and other multimedia based communication as well as in communications involving multimedia web applications.
- Extension workers can promote the benefits of the mPlatform and support experimental farmers in using the system.

## 6.6. Validation of Theoretical Framework and Architecture

A letter was written to Ethiopian Agricultural Research Institute to facilitate the arrangement of experts' meeting for the sake of presenting the results of the study and validating the theoretical framework and the architecture. Based on formal request the institute arranged a half-day seminar for the presentation of the results of the study on September 19, 2016 at Holeta Agricultural Research Center. More than 50 agricultural researchers and experts participated in the seminar. An opening remark was made by the Director of the Research Center and invited us to present the results of the study.

The presentation was organized under the following topics – background, motivation and statement of the problem, objective, research framework, research methods, findings, tacit knowledge externalization and sharing framework, system architecture and contribution of the study. After the presentation different comments were given by the participants. The comments are summarized as follows.

1. Most of the participants who gave their comments appreciated the work from the perspective of designing and implementing mobile application for facilitating participatory innovation.
2. Two of the participants commented that the content is much broader and rich than the topic and they feel that there seems to be a mismatch between the topic and the content. But we explained to them that the ultimate goal of the study is proposing the system architecture for mobile mediated tacit knowledge externalization and sharing. But there was no prior theory that could support the development of the system architecture and we started from theory development

by identifying taxonomies of tacit knowledge, mechanisms of externalization and factors affecting the externalization process. We also emphasized that through the qualitative study we were able to extract rich and contextual data and situated knowledge which were used as a critical input for the development of system architecture as it was recommended by Eisenhardt (1989), Mayers (1997) and Lawrence (2010).

3. They also raised their concern about the limited visibility of our original contribution while the findings were presented by aligning to the constructs derived from the prior literature or knowledge. We explained to them that the gap was created due to summarization of the finding using terms derived from literature. We admitted that we should have stated examples from the actual findings as they were presented in the study.
4. One participant asked that why the conceptual framework is being used without being validated through quantitative measures (research). In response to this question we emphasized that the theory building process through qualitative research was not an end by itself and it was mainly used to extract design concepts from rich contextual data or situated knowledge. But the credibility or believability of the results was ensured, one, through sending the translated interview transcript back to the respondents for the verification and gathering of their feedback and secondly, through triangulating the data gathered through interview with extensive review of documents and reports on FRG projects as well as observations. The rigorous analysis involved also made the results more reliable for proposing the conceptual framework that served the extraction of

design concepts and proposing the system architecture. Hypothesizing and testing the conceptual framework using quantitative measures is recommended for further research.

5. One participant raised that the promotion and adoption of agricultural technology varies from one technology to the other. He mentioned the example of eucalyptus tree and how fast it was adopted all over the country when Emperor Majesty Hailesilassie brought it from abroad and given it for planting. But despite the significant benefit of certain technologies and the intensive promotion made for its adoption, farmers may not accept the technology. He asked how this variation in adoption attitude applies to our study findings. We responded that although the technology could be used for promoting agricultural technologies, the ultimate goal of the design of the proposed system is facilitating interaction among multiple key stakeholders in agriculture including farmers and elicitation, capturing, sharing and integration of their tacit knowledge into the innovation or technology adoption process. We added that this mobile assisted wider participation of key stakeholders may contribute to wider adoption of the technology since all stakeholders including farmers participate in experimentation, evaluation and adoption of the new agricultural technology.
6. Two participants raised the issue of feasibility from the perspective of the existing mobile network and the availability of low-end mobile phones in the hands of most of the rural people. Our reflection to this concern was that the government is aggressively investing on the expansion of telecommunication network which provided access to larger parts of the country. Regarding mobile phone devices

we assumed that the government can provide smartphones for a group of 15 – 20 farmers organized under Farmers Research Group either on a cost sharing basis or by covering the full cost. Farmers can participate in virtual multimedia based communication, articulate and share their rich experiences, skills, best practices, etc. It was also mentioned that the mobile phone's screen can be casted to a PC or larger screens to facilitate visibility for all members of the group.

7. One participant asked whether this technology is the only solution and what makes this mobile application different from similar mobile applications developed elsewhere. He also asked what techniques have been used to capture and share tacit knowledge before. Another participant raised a question in similar area – what if we buy an off-the-shelve package that can serve the same purpose? We responded to these questions based on our background on the review of prior works. We explained that to the knowledge of the researchers the existing mobile applications in agriculture focused on improving the supply chain integration and thus, engaged in provision of market information, increasing access to extension and advisory services, facilitating market links, and provision of access to financial services as it was confirmed by Gichamba, et al. (2015). This implies that the applications focused on transfer of explicit and codified knowledge and the potential of mobile phone in facilitating tacit knowledge elicitation and sharing in participatory rural innovation context is not explored before. The context is different since it involves diverse group of stakeholders with diverse cognitive level including the illiterate and semi-literate farmers. It was also explained that we didn't come across prior systems designed for creating virtual

shared space that involves the rural farming community based on rich and situated knowledge about the different forms of tacit knowledge that the rural community has, the externalization mechanisms they apply and the different factors that facilitate or inhibit articulation and sharing of their tacit knowledge. Prior works focused on provision of advanced technologies including groupware, web 2.0, video conferencing, etc. to facilitate social interaction and tacit knowledge elicitation and it was in the context of interactions among employees of high tech industries and multi-national corporations. Even in such contexts we didn't come across systems specifically designed for tacit knowledge externalization and sharing. The stated technologies are inaccessible to rural communities in developing nations due to poor Internet infrastructure.

## **CHAPTER SEVEN**

### **CONCLUSION**

#### **7.1. Summary of Findings**

Ethiopian Agriculture is the leading sector in the economy in terms of its contribution to national gross domestic product (GDP), employment and foreign exchange earning – each accounting for 45%, 85% and 86% respectively. But the sector is characterized by subsistence mixed farming, low productivity of land and labor, natural resource degradation and low use of improved technologies. Enhancing smallholder productivity through sustainable agricultural innovation has become central to the development of the sector in particular and the economy in general.

Knowledge is one of the critical inputs for sustainable agricultural development and food security. But the current agricultural innovation system is significantly dependent on scientific knowledge produced by universities and research institutes, ignoring the wealth of tacit and local knowledge owned by multiple agricultural stakeholders including farmers. Thus, participatory research and technology development approach called Farmers Research Group (FRG) has been introduced since 2004 to cope up with the limitations of the conventional approach. The participatory research approach aimed at strengthening collaborative technology development, verification, transfer and adoption by involving farmers as key knowledge partners. Researchers, farmers and extension agents are the primary actors involved in FRG projects to jointly identify desired outcomes, diagnose problems, conduct experiments on different options, evaluate their impact, and propose improvements. Significant amount of tacit knowledge was

contributed in the form of new ideas and insights, expertise, rich experiences, best practices, skills, attitudes, indigenous knowledge, etc. Intensive joint activities related to experimental practices like that of FRG projects were identified as key processes that are associated with articulation and sharing of tacit knowledge (Vaccaro, et al., 2008).

But the exchange of tacit knowledge among FRG members has been done without either storing it in explicit form or transferring it to other farmers or researchers outside the specific group. This created a huge gap in the level of knowledge gained within members of FRG (among trial and non-trial farmers in the same FRG) and made the knowledge inaccessible to non-FRG farmers within or outside the community (Mume, et. al., 2009). Despite the promising potential of FRG approach, there are challenges in the areas of eliciting, sharing and integrating wealth of tacit knowledge of diverse stakeholders in the agricultural innovation process. Therefore, one of the critical issues to be addressed is exploring the possibility of developing and implementing ICT based solution that can facilitate communication among actors involved in participatory research process and support them in articulation, capturing and sharing their embedded tacit knowledge. This requires deeper understanding of the processes and mechanisms of externalization of tacit knowledge and the potential factors influencing this process.

But tacit knowledge externalization and diffusion and the potential of various mechanisms for externalizing different forms of tacit knowledge is still unexplored and not fully understood. Agricultural sector has rarely been the topic of inquiry in research related to tacit knowledge elicitation. From ICT perspective, how various forms of tacit knowledge can be integrated through appropriate IS design and implementation remains an ongoing challenge for IS researchers. Further studies are recommended on how to

develop a media-enriched system to support externalization of tacit knowledge by local communities (He and Li, 2010). The current mobile applications in agriculture focused on informational and advisory services and have limited capability to support participatory agricultural research which involves the most intensive forms of tacit knowledge sharing and integration (Goyal, 2011). Therefore, this study aimed at identifying taxonomies of tacit knowledge, mechanisms of externalization and sharing together with influencing factors and exploring the potential of mobile technology in supporting the process.

The *first research question* focused on identifying types of tacit knowledge being dominantly shared in participatory agricultural research process. Our study revealed that farmers were the primary sources of tacit knowledge in participatory research approach. They played significant role in the process of generating localized innovative solutions by contributing and embedding their experiences, practical intelligence, skills, and indigenous knowledge. Farmers came up with innovative ideas that served as a basis for further scientific exploration. In addition to farmers, researchers and other stakeholders also generated and shared their tacit knowledge in the form of new perspectives or views, expertise, experiences, etc. It was found that the dominant forms of tacit knowledge externalized and shared in participatory research approach fall under medium and low degree of tacitness. Tacit knowledge with high degree of tacitness or abstraction was not supported since the approach involves more of practical experiments (applied research) and the knowledge shared were not highly abstract or intuitive. Regarding the specific epitomes of tacit knowledge:

- Practical skill, lived experiences of farmers, rules-of-thumb and expertise were identified as the dominant forms of tacit knowledge under *low degree of tacitness (higher degree of visibility)*. Farmers applied their rich and lived experiences to introduce different approach or techniques that complement the scientific recommendations. They applied their agronomic (farming) skills and analytical and problem solving skills to achieve better results. Farmers demonstrated their skill of running their farming enterprises productively, profitably and sustainably during the participatory evaluation and selection process. Farmers' articulated their rules-of-thumb and used it as broad practical guide or principle for doing farming activity or making rational decision. It was also used as a control condition when participatory experiment was conducted. Researchers also articulated and shared their expertise and experiences in conducting environmental analysis, identifying farmer's needs, identifying core problems, manipulating experimental inputs and introducing localized technologies.
- Judgments, insights, practical intelligence and indigenous knowledge were identified as the dominant forms of tacit knowledge *under medium degree of tacitness*. Farmers set their own criteria, evaluated the performance of different technologies/varieties, made judgments and justified their selection. Therefore, judgment was the dominant form of tacit knowledge observed in the participatory research process. Insights were applied to come up with different alternatives of localized solution through manipulating experimental inputs and local practices. Farmers' practical intelligence or the talent they

developed through long years of day-to-day practices enabled them to generate innovative ideas, new methods or technological solutions relevant for addressing their local problems. Farmers' indigenous knowledge was also articulated and applied in the areas of treatment of animal disease, pest management, handling termite problems, developing localized solutions, etc.

The *second research question* focused on identifying mechanisms of tacit knowledge externalization and factors affecting the externalization process. The study revealed a number of tacit knowledge externalization mechanisms under the context of participatory agricultural research context. According to the findings of the study mechanisms include metaphor, storytelling, dialogue, apprenticeship or mentoring, experimentation and evaluation, observation, learning by doing, lessons learnt, modeling technique, asking question, localization and on-farm demonstration. Previous studies assigned specific mechanisms to a particular degree of tacitness. But one of the key findings in this study is that there is no one-to-one relationship between mechanisms of externalization and degree of tacitness. One mechanism may be used for articulation of tacit knowledge with different degrees of tacitness.

- *Metaphor* was used by farmers for articulating their understanding about agronomic phenomenon and in explaining their abstract rationales behind judgments on experimental results. Researchers also used metaphorical expressions to communicate abstract scientific or technical representations to farmers in a more understandable way.

- Farmers built and shared *stories* on their experiences or lessons learnt from their success or failure in implementing technologies or agronomic practices. Researchers also did the same to transfer tacit knowledge behind best practices and lessons in similar projects.
- Researchers and farmers were engaging in *dialogue* in the process of diagnosing problems and proposing alternative solutions as well as evaluating experimental results and justifying their rankings. They analyzed and articulated the content of their mind in the form of innovative ideas, new perspectives and rich experiences.
- Through *apprenticeship or mentoring* researchers transferred their tacit knowledge (practical skills, experiences and expertise) to farmers and farmers rehearsed the same procedure to acquire the tacit knowledge transferred. The same procedure was followed in peer-to-peer mentoring and exchange of tacit knowledge among farmers (model farmers mentoring other farmers).
- Farmers articulated their tacit knowledge through reflecting on their *observation* of the phenotypic characteristics of plants, agronomic incidents, and experimental results.
- *Experiment and evaluation* enabled farmers to articulate their tacit knowledge when they questioned scientific solutions and proposed their own options, improvements or technology redesign ideas. They used experiment and evaluation to prove their belief that the existing local agronomic practice is superior than the one recommended by the research. They articulated their tacit knowledge by formulating their own criteria and justifying their selection during

participatory evaluation. The majority of the stated epitomes of tacit knowledge (insights, practical intelligence, judgment and experience) were articulated in the process of participatory experimentation and evaluation.

- Through *learning-by-doing* farmers extracted tacit skills embedded in the new technology and agronomic practice and implemented them with minor improvements.
- *Lessons learnt* from previous projects or agronomic practices were shared in the form of what went right and what went wrong so that others learned from experiences and came up with innovative ideas for further improvements.
- Farmers actualized their embedded knowledge through *modeling techniques* – e.g. using resource and process mapping as a means to extract their mental models.
- *Asking the right question* enabled farmers to articulate their perspectives, rich and lived experiences, lessons, best practices they acquired from lifelong farming or during collaborative experiment and evaluation process. Researchers also articulated the lessons they learnt from previous experiments and provided their recommendations when they were asked.
- Process of *localization* enabled farmers and researchers to think innovatively and introduce highly localized solutions using the existing local practices or resources. This study identified localization as an effective mechanism of tacit knowledge externalization and it has never been recognized as a mechanism of tacit knowledge externalization in other studies.

- *On-farm demonstration* was one of the most important methods used in participatory research approach to exchange tacit knowledge. It served as a platform for other mechanisms like *apprenticeship, mentoring, learning-by-doing* and *observation* to articulate and transfer tacit knowledge through observing, participating or experiencing, explaining and comparing.

The study also identified factors that affected the process of tacit knowledge externalization and sharing.

- The study identified that all tacit knowledge externalization processes were facilitated by creating different *physical forums (ba)* including trainings, meetings, participatory field demonstrations and experiments, field visits, field days, field demonstrations, exchange visits and forums of informal farmer-to-farmer interactions. Experimental farmers took the leading role in most of the platforms which facilitated articulation, sharing and integration of tacit knowledge of farmers. Limited frequency of interaction among researchers and FRG members affected the effectiveness of the forums in facilitating social interaction, tacit knowledge articulation and sharing.
- The disparity in *cognitive competence* between researchers and farmers and even within farmers had negatively impacted externalization and use of tacit knowledge. It was a challenge to attain the same level of understanding on experimental and evaluation processes as well as scientific and technical features. Lack of shared understanding restricted the possibility of extracting and

integrating tacit knowledge from farmers. Model farmers were used as knowledge intermediaries, bridging the knowledge gap between researchers and other farmers. They facilitated concretization, translation and sharing of tacit skills and abstract ideas. Repeated experiment, multiple rounds of discussions supported by practical demonstrations and visual presentations were also identified as major mechanisms to enhance understanding of farmers.

- Given low cognitive capacity of farmers, the higher the level of *complexity/abstraction* in the newly introduced ideas, knowledge or technology, the lesser the possibility of establishing mutual understanding and vice versa. Limited mutual understanding means limited participation and contribution of innovative ideas by farmers.
- The study identified that *social capital factors* (structural, relational and cognitive capital) either facilitated or deterred social interaction and thus, articulation and sharing of tacit knowledge. The existence of collegial relationship, mutual respect, mutual trust and free and open expression of ideas facilitated externalization, sharing and integration of tacit knowledge. The non-redundant networks of FRG members provided access to the knowledge of various actors outside the core research group (researchers, farmers and extension agents). Weaker team culture and farmers' cultural influence on performing certain experimental activities had negative influence towards engagement of participants in tacit knowledge externalization and sharing. Limited frequencies of interaction between researchers' team and FRG members because of distance and resource constraint restricted the possibility of establishing strong social ties. Lack of

shared language, shared interpretations and system of meaning affected the externalization and sharing of tacit knowledge. Language variation among farmers and researchers and variation in terminologies and pronunciations within the same language were found to be common which hindered the building of shared system of meaning and understanding. Interpreters with adequate knowledge and experience in the subject under experiment were used to minimize the problem. In addition, close relationship between farmers and researchers and asking clarification from farmers partially solved the problems. The use of scientific and technical terms by researchers and lack of equivalent local terminology was also a challenge that impeded the smooth flow of tacit knowledge. It was identified that presenting technical issues or terms in a simplified manner, using equivalent local terminologies, engaging in two way communication and allowing participants to ask questions for clarification addressed some of the challenges. The study also identified that farmers have local terminologies which have equivalent meaning with scientific names or representations.

- Researchers' *communication skill* affected proper delivery of ideas or knowledge to the farmers and triggering them to articulate their tacit knowledge. It was found that researchers should have skill of interpreting and transferring knowledge embedded in the technology in order to bridge the communication gap. Socio-economic and agricultural extension experts were found relevant in this regard. It was also found that model or experimental farmers were competent in making presentations and transferring knowledge to other farmers using local language,

examples, proverbs, etc. It was proved that both researchers and farmers should be supported by communication tools including pictures, posters, brochures, fliers, extension materials, etc. to effectively transfer knowledge.

- The findings of the study also emphasized the need for *heterogeneity* in members of the innovation group in terms of multi-disciplinary background of researchers. This was needed for acquiring new perspectives, innovative ideas, experiences and skills required to address multidimensional agricultural problems. The study also identified that Farmers Research Group composed of highly experienced and knowledgeable model farmers, elderly farmers with capacity of wise judgment and female farmers had significant impact on generation and sharing of innovative ideas.
- From *motivational factors* perspective it was found that lack of incentive and perceived benefit (economic value, sustainability and market demand) affected the commitment of farmers to collaborative innovation and thus, articulation and sharing of their tacit knowledge. Researchers' motivation was also affected by the extra burden they bear in participatory research process.
- *Distance* compounded with *poor physical infrastructure* and *resource constraint* impeded the involvement of farmers from wider geographical areas and tapping of extensive tacit knowledge in to collaborative innovation.

Based on the above empirical findings, a theoretical framework was developed depicting the relationship between four aspects of tacit knowledge externalization and sharing, i.e.,

*degrees of tacitness, externalization mechanisms, influencing factors and the shared space or 'ba'.*

The **third research question** focused on exploring how mobile technology can support externalization and sharing of tacit knowledge within the context of participatory research approach. We chose mobile as the most appropriate technology since it can easily reach millions of rural people and has significant potential for enhancing agricultural and rural development. It can play a fundamental role in collaborative learning and innovation process.

The newly proposed mobile application is expected to serve as a platform where researchers, farmers, extension workers and other pertinent stakeholders can engage in collaborative interaction and articulation and sharing of their tacit knowledge. Therefore, the technological solution that we proposed is called **mPlatform**. We followed multi-methodological approach to IS research recommended by Nunamaker, et al. (1991) to develop system architecture for mobile mediated tacit knowledge externalization and sharing. We integrated the results of the qualitative research with the design of the system architecture based on the guiding principles suggested by Nunamaker, et al. (1991).

We identified problems associated with different interaction scenarios based on respondents' specifications of the existing challenges. Descriptions of interaction scenarios under each mechanism of tacit knowledge externalization and influencing factors indicated users' communication needs for transfer of textual, voice, video and image content. System requirements were also derived from the interaction scenarios, associated problems and respondents' direct specifications of requirements. Both the

challenges and requirement specifications embedded in interaction scenarios have exhaustively covered all mechanisms of tacit knowledge externalization and all factors influencing externalization process. The *mPlatform* is expected to address challenges associated with tacit knowledge articulation and sharing and enhance the integration of farmers' tacit knowledge with the scientific knowledge.

Finally we proposed 3-tier system architecture for the *mPlatform*. The interface tier consisted interaction interface, knowledge sharing interface, mLearning/Mmentoring interface and notification interface. The business logic layer included three major engines – knowledge capturing and processing engine, mLearning/Mmentoring management engine and recommender engine. Knowledge repository tier constituted five repositories – repository of formalized tacit knowledge, repository of explicit knowledge, repository of ontology and corpus of metaphor, repository of learning/mentoring resources, and repository of profile of FRG projects and participants. A hybrid of centralized and distributed architecture was proposed for implementing *mPlatform*.

Validation of the theoretical framework and the architecture was done through presenting the whole dissertation to panel of experts in a half day seminar organized by Ethiopian Agricultural Research Institute in collaboration with Holeta Agricultural Research Center. More than 50 agricultural researchers and experts participated in the seminar, asked questions and gave their valuable comments. The questions and comments raised were related to matching the topic with the content, original contribution in the findings, validation of the conceptual framework with quantitative measure, the relevance of the solution to technology adoption behavior of the farming community, feasibility of the solution from the existing mobile network infrastructure and the low-end devices

perspective, the uniqueness of the proposed mobile architecture and whether it is different the available off-the-shelve packages. We responded to the questions and comments by way of providing clarifications.

## **7.2. Contribution of the Study**

### **7.2.1. Contribution to Theory**

It is argued by Eseryel (2014) that despite the abundance of literature that follows Nonaka and Takeuchi, actual empirical operationalization of their knowledge-creation modes is rather rare. Our study contributed to knowledge creation theory by providing empirical evidence to tacit knowledge externalization construct. The study considered a unique context of agricultural sector where empirical evidence is limited (Gourlay, 2006). The nature of tacit knowledge externalization in agriculture differs since it depended on highly diverse and geographically dispersed stakeholders as compared to the organizational settings where collaborators are co-located with limited diversity (Eseryel, 2014). From team structure perspective – the study incorporated the extreme cases of involving illiterate farmers in the externalization and sharing of tacit knowledge. In addition, the contribution of this study is significant especially from the perspective of addressing the debates over whether or not tacit knowledge can be made explicit.

Previous studies associate specific mechanisms to externalization of a specific epitome of tacit knowledge (degree of tacitness), e.g., Chennamaneni and Teng (2011). Our study revealed that there is no one-to-one relationship between mechanism of tacit knowledge externalization and degree of tacitness/abstraction. It was evidenced by the findings that

one mechanism could be used to articulate tacit knowledge with different degrees of tacitness or abstraction. A mechanism dedicated for high degree of tacitness by previous studies have been used for articulating tacit knowledge with medium and low degree of abstraction in the study context.

The study also proposed an integrated theoretical framework for tacit knowledge externalization that reflects real world situation. This framework is unique because it integrated determinant factors into the model of tacit knowledge externalization on top of mapping degrees of tacitness to mechanisms of tacit knowledge externalization. The framework also incorporated new empirically supported constructs, i.e., experimentation and exploration, practical demonstration and localization, as additional mechanisms of tacit knowledge externalization. Degree of complexity, model farmers as knowledge intermediary and resource and infrastructural problems were also new constructs generated from the data as additional determinant factors. The theoretical framework will be the basis for conducting further studies either to empirically test the framework itself or to investigate issues pertaining to tacit knowledge externalization in different context or from different perspective.

Jakubik (2008) argued that in the knowledge management literature, knowledge creation in a community context is not fully explained and understood and suggested the need for further theoretical and empirical contributions. This study demonstrated how new agricultural knowledge is created through active involvement of wider farming

community in agricultural innovation system and integrating tacit knowledge of members of the community.

Eliciting tacit knowledge can be methodologically challenging given that such knowledge is difficult to articulate and is often embedded in routine practices (Kothari, et al., 2011). Given this feature of tacit knowledge, the tool that we developed for collecting data on tacit knowledge externalization in a distributed multi-stakeholder context is novel and could be used for further investigation of mechanisms of externalizing and integration of tacit knowledge in similar contexts. The analytical dimensions, i.e., the thematic coding and analysis schema, used in the study represent the operationalization of the concept of tacit knowledge and this is also one of the theoretical contributions of the study.

Mansell (2012) claimed that there is a complex challenge in the availability of knowledge essential for developing innovative mobile applications that are responsive to local needs and this challenge is being neglected. In this regard our study has provided knowledge on local practices of and mechanisms for articulating and sharing tacit knowledge which is a basis for proposing architecture to develop mobile based collaborative platform. Special focus on farmers' tacit knowledge and their mechanisms of articulation makes the contribution of the study more relevant from the perspective of proposing innovative mobile application that addresses local needs.

The study also extends the knowledge base by introducing new design constructs that can be used to develop inclusive mobile based communication system which takes into account illiterate farmers as tacit knowledge contributors given their language and vocabulary diversity and disparity of cognitive and absorptive capacity. The problem and

solution representations (Hevener, et al., 2004) are also major contributions. The study also created a linkage between theory building (identifying mechanisms and factors of tacit knowledge externalization) and the design of mobile based communication system (artifact building).

### **7.2.2. Contribution to Practice**

The theoretical framework can provide practitioners with additional insights into how tacit knowledge is externalized and shared in a collaborative agricultural innovation system like FRG consisting researchers, extension agents, farmers and other pertinent stakeholders. An understanding of the type of tacit knowledge of multiple stakeholders can help in making practical decisions as to how to capture tacit knowledge in a formal way or foster an environment where it can be shared informally.

This study has clearly shown the role of model farmers as knowledge brokers or knowledge intermediaries who can bridge the cognitive gap between researchers and other farmers with low cognitive competence. The study also demonstrated how these model farmers play key role in concretizing, translating and transferring the knowledge being shared in the participatory experiment and evaluation process. Therefore, agricultural leaders can recognize and address the significant role played by model or innovative farmers in facilitating agricultural innovation through linking the farming community with the research community and facilitating extraction and integration of felt needs, innovative agronomic practices, rich experiences, indigenous knowledge, etc. Leaders of agricultural research institutions can develop a mechanism that enhances participatory innovation using model farmers as knowledge intermediaries.

The architecture as an artifact is one contribution since it aims at addressing the communication problems of participatory research approach and supporting articulation and sharing of actor's tacit knowledge in the process. The artifact provides design constructs to practitioners that enable them to visualize and understand the features of mobile based communication systems and models to represent and explore the relationship among the design constructs. The system to be developed could be one of its kind in the areas of tacit knowledge externalization and sharing and collaborative rural innovation using ubiquitous mobile phone technology. The architecture also helps policymakers and practitioners to understand how mobile application can facilitate participatory innovation in agriculture and how it supports articulation, sharing and integration of tacit knowledge of multiple stakeholders. Such understanding supports the creation of enabling environments for the development and wider implementation of innovative mobile applications in agriculture.

The mobile based platform (*mPlatform*) can strengthen the capacity of agricultural research institutions to undertake more effective participatory research, monitoring, learning, evaluation and adoption of agricultural technologies virtually. It can also strengthen farmers' participation and feedback mechanisms in the process of technology generation and adoption. *mPlatform* provides as much opportunity to farmers as possible to air their innovative ideas, share their indigenous knowledge and skills, give their feedbacks and support each other through mutual learning. In this line, the system is expected to support informal relationships among farmers and facilitate their interactions. It empowers farmers in the creation and sharing of local and contextually relevant knowledge. It is only in such platform that the untapped wealth of tacit knowledge of

farmers can be easily captured and shared to other farmers and the scientific community. Panahi, et al. (2012) also confirmed that facilitating such interactions is one of the effective ways of transferring tacit knowledge. In general, mPlatform can strengthen peer networks which enhance communication, participation and transfer of tacit knowledge among farmers and research community (Jackson, et al., 2009).

The mPlatform can link geographically dispersed stakeholders in the co-creation, co-capturing and co-dissemination of tacit knowledge. It enhances open and collaborative innovation in agriculture using affordable and less energy-intensive mobile infrastructure. The multimedia capabilities of mobile phone technology can extend the possibilities of involving highly experienced, skilled and practically intelligent farmers in agricultural innovation process.

The finding indicated that one of the factors that demotivated researchers from being engaged in participatory research was its extra burden caused by their full involvement from the initial stage of problem identification to final stages of conducting participatory experiment, evaluation and selection for three subsequent years. They are expected to frequently travel to farmers' plot to provide practical trainings, make field demonstrations, conduct multiple rounds of meetings, facilitate field visits, field days, exchange visits as well as evaluation and selection processes. The resource constraints, distance and infrastructural challenges also affected their effort to effectively implement FRG projects. These extra burdens and challenges can be minimized through mPlatform by providing an electronic forum for handling most of the stated functions without geographical limitations.

The findings of the study also indicated that female farmers have greater potential in generating innovative ideas and making rational decisions together with positive knowledge sharing attitudes. But their limited involvement in different agronomic practices due to over engagement in household chores and the cultural influences negatively affected their participation and presentation of their innovative ideas freely and openly. mPlatform can give more voice to female farmers and create a space for them to openly and freely articulate and share their innovative ideas from wherever they are.

According to Jackson, et al. (2009) farmer led documentation like participatory video can be catalyst for local agricultural innovation. With multimedia capability of the mPlatform experimental farmers can easily capture the whole processes of participatory experiment and evaluation as well as their rich and unique experiences and lessons which can be shared to other farmers. Farmers can transfer their own indigenous and practical knowledge in the form of recorded theatre and storytelling. Therefore, it is possible to engage farmers in mutual or peer-to-peer learning and sharing of experiences and lessons through locally produced and redistributed audio and video content. Technology supported peer-to-peer learning and knowledge sharing process can possibly overcome the limitations of the conventional extension service. This implies that the new knowledge articulated and shared brings significant impact on expansion of local innovation.

### **7.3. Recommendation**

Based on the identified taxonomies of tacit knowledge, externalization mechanisms and factors affecting the externalization process the study proposed a theoretical framework.

All the identified mechanisms and factors and the way they behave in the externalization process were used as design concepts for generating the system architecture. Based on these outputs of the study, the researchers forward the following recommendations.

1. The government should create conducive environment for enhancing participatory research and technology development process through involving farmers and integrating their tacit knowledge into the innovation process. These include:
  - a. Institutionalizing participatory research approach in all agricultural research centers with strong administrative, policy, regulatory and technological support from the government;
  - b. Strengthening the linkage among researchers, farmers, extension workers and other key agricultural stakeholders by strengthening and sustaining interactive platforms (discussion forums, collaborative field experiments, field demonstrations, field-visits, field days, etc.); such platforms should provide extensive opportunity for farmers to articulate their innovative ideas, rich practical experiences, best practices, skills, attitudes, indigenous knowledge, etc. using different mechanisms; the platform should also give more voice to women farmers.
  - c. Providing adequate financial and technological support for farmers to form their own studio and develop their own content in the form of stories, metaphorical expressions, lessons, best practices, indigenous knowledge, etc. using rich multimedia tools;

- d. Supporting model/experimental farmers to share the externalized knowledge in the form of experiences, lessons, best practices, etc. to non-experimental farmers and to scale-up the experimental results (technologies); research centers should effectively use the potential of model/experimental farms as knowledge brokers between researchers and other farmers.
  - e. Raising the cognitive competence and absorptive capacity of farmers through sustained practical trainings supported by field experiments, multiple rounds of discussions supported by practical demonstrations and visual presentations; this brings all farmers at the same level of cognitive competence and understanding.
  - f. Developing incentive mechanism for farmers to increase their engagement in participatory innovation process and enhance their commitment to articulate and share their tacit knowledge.
2. One of the key intervention areas is ICT based solution that can facilitate communication among researchers, farmers, extension agents and other stakeholders and support them in articulating, capturing and sharing their embedded tacit knowledge. ICT based solution can address the challenges of distance barrier, poor physical infrastructure as well as resource constraint and increase intensity of interaction and strengthen social ties. It can also address the challenges of language varieties and lack of shared interpretations and systems of meaning through imbedding different language translation and ontological

features into the system. In order to fulfill such requirements the study proposed architecture for mobile mediated interaction platform (*mPlatform*). For this:

- a. The government/EIAR should invest on full scale development and implementation of the *mPlatform*;
- b. The government/EIAR should provide adequate technological infrastructure including mobile network with a minimum of 3G internet connection for rural areas and smart phones for a group of experimental farmers and researchers with a capacity of handling more complex, multimedia based two-way communication and feedback mechanisms; the government should also provide a minimum of 60-inch HDTV to cast mobile phone's screen on larger screen in order to enhance visualization at the time of group based virtual discussions, trainings, mentoring sessions, field experiments, field visits, exchange visits, other experience sharing sessions, field demonstrations, remotely monitoring field experiments by researchers, etc.;
- c. Solar panels should be provided for re-charging mobile batteries in areas where there is no electricity;
- d. The government with possible support from donors should guarantee funding for startup and operating costs and for ensuring long-term sustainability;
- e. The government should subsidize the cost of communication and the exchange of knowledge among teams involved in participatory research should be handled with no or marginal cost;

- f. Extension agents involved in FRG project should support farmers in textual and other multimedia based communication as well as in communications involving multimedia web applications.
- g. Extension workers should promote the benefits of the *mPlatform* and support experimental farmers in using the system.

#### **7.4. Limitation of the Study**

Research can never be totally value-free or objective since we, as researchers have our own preferences which influences the research processes and results. Yi (2006) said that as far as the researchers collect, interpret and analyze the data, there is an inherent subjectivity and a certain amount of bias might be unavoidable. The selection of research topics, methods and theoretical framework reflect some sort of our personal bias. Therefore, there is an element of personal bias in our exploratory case study research.

Secondly, farmers' voice is limited in qualitative data collection. This is because, from our initial attempt to interview farmers we realized that they consider what they have in the form of tacit knowledge as routine. They don't recognize it as unique contribution when they express it or demonstrate it in practice. They couldn't trace back and tell us about what forms of tacit knowledge they articulated and shared in the participatory research process. The concept of tacit knowledge is difficult to deal with farmers. Language was also another barrier that inhibited us to extensively discuss about such highly abstract concept (tacit knowledge) with farmers. Due to these factors the input that we got from farmers was limited. But much of the data was extracted from researchers and extension workers or development agents. This is mainly because they had access to

both tacit knowledge of farmers and the scientific knowledge during the participatory research process. They can easily recognize innovative ideas contributed by farmers. They were able to trace back and provide us adequate data on what sort of tacit knowledge farmers contributed and how they were articulating it. They were witnessing that farmers' contribution in terms of tacit knowledge was unique. Therefore, we were able to gather not only adequate data on the type of tacit knowledge farmers articulated and the mechanisms they applied but also the approval on the uniqueness and innovativeness of their embedded knowledge as compared to the scientific knowledge.

Thirdly, we used only expert evaluation for validating the proposed conceptual framework and architecture because of the extensive nature of the work and the time and resource limitation.

Fourthly, our study focused on specific context of projects of Farmers Research Group and therefore, the findings may not be extended to other contexts with the same level of certainty.

## **7.5. Future Research**

The proposed theoretical framework was developed for a participatory agricultural research context. As it is stated above the framework may not equally apply in other contexts. Therefore, building on this study further research can be conducted to replicate our study to examine whether all constructs of the framework can be supported in different contexts. In addition, future research can focus on hypothesizing and testing the effects of different forms of tacit knowledge and factors on externalization mechanism using more objective measures.

As it is stated in the limitation of the study the voice of farmers was not as big as it was expected because of the stated reasons. The only possibility that could be recommended for future work in this regard is conducting action research or ethnographic research so that the researcher can get a chance to participate in the process and observe and hear what farmers do or speak.

Our study identified epitomes of tacit knowledge with medium and lower degree of tacit knowledge and found corresponding mechanisms of externalization and factors influencing the process. One can pick a context in which tacit knowledge with high degree of tacitness is shared and explore how mechanisms and factors behave in such context. Action research or ethnographic research methodologies can generate more peculiar epitomes of tacit knowledge and mechanisms of tacit knowledge externalization since researchers can directly involve in the actual participatory research process.

The study identified design concepts or constructs and proposed system architecture for mPlatform. Instantiation is needed to provide a continuing test bed for the design concepts, and the evaluations of the actual system (mPlatform). Therefore, future research can focus on the design, development, testing and implementation of the mobile based communication system.

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## APPENDIX – I: KEY INTERVIEW QUESTIONS FOR RESEARCHERS AND EXTENSION WORKERS

1. Can you tell me a story about one of the most important FRG projects you were involved in?
2. Do you recall any innovative idea/knowledge forwarded by **you** or **your partners** that significantly contributed to the solving of the problem? If so,
  - a. What was that innovative idea/knowledge? (RQ1)
  - b. How did you or your partner obtain this innovative idea/knowledge? (RQ1)
  - c. How was the idea/knowledge presented or communicated to other FRG members? (RQ2)
  - d. Was the new idea/knowledge clear and familiar to all members when it was first presented? (RQ2)
    - If not, why?
    - What was done in order to make the new idea/knowledge clear to others?
  - e. Did you observe variation in personal interpretations when new ideas were presented? (RQ2)
    - If so, what mechanisms were used to resolve conflicts and differences in opinion?
  - f. Had the idea/knowledge been tacit/hidden to you until it was presented in the group session? (RQ1)
  - g. Did you or your partners face problem while presenting new idea/knowledge? If so, (RQ1)
    - What kind of problem was faced?
    - How did you address such problem?
  - h. Is there any mechanism of assessing the validity and usefulness of individual's innovative idea or knowledge? If so, how? (RQ2)
  - i. Do you feel that some of your ideas or knowledge has never been fully presented to your partners? (RQ1)
    - If so, why?
    - What do you think is the best way to present such idea or knowledge?
3. Can you recall any critical incident that you faced in your involvement in FRG project? If yes, (RQ1)
  - a. Did this incident shape your understanding, perception or view? If so, how?
  - b. How did you and your partners react to this critical incident?
  - c. Had your role in the project been central, do you believe that you would handle such critical incident differently? If so,
    - What would have been your approach?
    - How would you communicate and justify your approach?
4. According to your experience, was it documented knowledge (manuals, research outputs) or undocumented knowledge (experience, expertise, skill, know-how, etc.) which was most commonly used in participatory research/FRG project? (RQ1)

5. Do you believe that all types of ideas or knowledge shared and used by FRG members are always clear and understandable to all members? If not: (RQ1 and RQ2)
  - a. What types of ideas or knowledge are mostly difficult to make clear and understandable and why?
  - b. What mechanisms were used to make such ideas or knowledge clear and understandable?
6. How do members of FRG share their experience, skill, know-how, expertise, etc. to their partners? (RQ2)
7. What kinds of ideas or knowledge are shared in forums like workshops, seminars, trainings and field days? (RQ1)
8. Do you feel that language is one of the difficulties in forwarding new ideas/knowledge? If so, how did you and your partners cope up with such challenge? (RQ2)
9. Do you believe that one FRG contributes more new or innovative idea/knowledge than the other FRG? If so, what are the factors? (RQ2)
10. Given the most important project you were involved in: (RQ1)
  - a. What would you do differently if you are given a chance to do it again?
  - b. How do you know that you will be successful?
11. Is there any practice of documenting individuals' experience, skill, know-how, expertise, indigenous knowledge, etc. as well as the findings of your discussion, reflection, observation and interaction? If so, (RQ2)
  - How is it documented?
12. Is the knowledge shared in the FRG project easy to comprehensively document in the form of manuals and reports? If so can you give me sample manual or report? (RQ2)
13. When thinking about sharing your idea or knowledge: (RQ3)
  - a. What communication media would you prefer? Why?
  - b. Have you used ICT (mobile, e-mail, etc.) as a means of communication with members of FRG? If so what do you communicate with them?
14. What are the major challenges of participatory research (FRG) in terms of sharing experiences, skills, know-how, expertise, indigenous knowledge, etc.? (RQ2)
15. Can you think of simple, quick and easy change that can improve the sharing of personal innovative idea/knowledge to bring a big impact? How can ICT contribute in this regard? (RQ3)
16. Who else would you recommend for interview in order to further understand the situation?

## **APPENDIX – II: KEY QUESTIONS FOR FOCUS GROUP DISCUSSION WITH FARMERS**

1. Would you please tell us about the kind of FRG project you were involved in, the processes and achievements of the FRG project?
2. What new lesson did you learn from the FRG experiment and evaluation process?
3. Has anyone of your member contributed new idea which is different from that of researchers in the process of participatory research? If so, what was the source of that idea?
4. How were the new ideas presented by researchers or your members?
5. Were your ideas incorporated in the new project?
6. What challenges did you face in understanding the new project idea presented by researchers or extension workers?
7. Do you still have more idea which you believe can better contribute to the solving of the problem? If so, what is the idea? From where did you get this idea? Why didn't you present it at that time?
8. How did you set criteria to evaluate a technology proposed by research centers? From where did you obtain the criteria?
9. Do you have any challenge in sharing ideas? What should be done?
10. Do you use your mobile to communicate your feedback or new idea to other FRG members?

### **APPENDIX – III: KEY INTERVIEW QUESTIONS FOR HEADS OF OFFICES**

1. What is the functional relationship between research centers and FRGs?
2. Why Adami Tulu and Melkasa Research Centers were selected to implement FRG?
3. How many FRGs have been formed under each research center? Is it possible to get their list?
4. Which of the two research centers performed better in terms of:
  - a. the number of projects implemented?
  - b. the number of new agricultural technologies introduced, evaluated, and implemented?
  - c. the number of researchers, DAs and farmers involved?
  - d. geographical areas covered?
5. Which particular FRGs are known in their strong team work and better performance?
6. Why do you believe that FRG is a preferred strategy to solve agricultural problems?
7. What are the specific benefits of linking the three groups – researchers, DAs and farmers?
8. What sort of knowledge do FRG members share dominantly? How do they share?
9. How can the communication among farmers, DAs, and researchers be enhanced? Can ICT contribute in this regard?
10. Is there any future plan for strengthening the linkage among researchers, farmers and DAs for the purpose of enhancing agricultural innovation?
11. Can I get minutes or recorded videos of discussions, field days or demonstrations conducted by FRGs?

## APPENDIX – IV: DOCUMENTS REVIEWED

Externalization of Tacit Knowledge Backup2.nvp - I

File Home Create External Data Analyze Query Explore Layout View

Go Refresh Open Properties Edit Paste Cut Copy Merge Format Paragraph Styles

Workspace Item Clipboard

Reset Settings

**Sources**

- Internals
  - Documents Reviewed
    - FRG I
      - Guidelines
      - Reports
    - FRG II
      - Guidelines
    - Interview
    - Presentations Audio
    - Web Documents
  - Externals
  - Memos
  - Framework Matrices

**Documents Reviewed**

Name	Nodes	References
FRG Guideline_2009	0	0
Farmer Research Group - Concepts & Practice 2004	0	0
Experiences - FRG	0	0
Gender Seinsitisation Guideline November 2007	0	0
09 Completed Research Reports 2009	0	0
01 FRG Baseline report_main text only	0	0
02 FRG Baseline report December 2005 with data tables	0	0
03 Country Gender Profile December 2006	0	0
04 Market Information in Kenya and Uganda	0	0
05 FRG Completed Research Reports 2007	0	0
06 FRG Research Inventory March 2008	0	0
07 FRG Impact Survey Report Jan 2009	0	0
08 FRG Research Inventory 2009	0	0
Gender Sensitization Session Guideline (2013 09 revised)	0	0
FRG II Pamphlet2013(E)	0	0
FRG Research Inventory (2013)	0	0
FRG Research Inventory (Nov 2012)	0	0
R4F+FRG_No.4(E)_Dec13_2010	0	0
newsletter_No_0	0	0
R4F+FRG_No 8(E)	0	0
R4F+FRG_No.1(E)_July20_2010	0	0
R4F+FRG_No.2(E)_Aug19_2010	0	0
R4F+FRG_No.3(E)_Nov1_2010	0	0
Make your Joint Action Plan More Productive	0	0
FRG guideline	0	0
Make Your Farmer Training More Productive	0	0
Make Your Field Day More Productive	0	0

MR 27 Items

## APPENDIX – V: RESPONDENTS’ PROFILE

Ser. No	Institution	Code	Level of Educ.	Position	Yrs. of Service	Duration of Interview
1	FRG II/EIAR-JICA Cooperation	RES 01	M.Sc.	Chief Advisor for FRGII Project	5	2:02 hrs
2	Wolayita Sodo University	RES 02	PhD Candidate	Principal Investigator for FRG Project; Lecturer and Researcher	6	1:53 hrs
3		DA 01	Diploma	Lab Technical Assistant	3	1:36 hrs
4	Wolayita Zone, Dugna Fango Woreda, Edo Kebele	DA 02	Diploma	Extension Worker (Development Agent)	8	1:30 hrs
5	Adami Tulu	RES 03	M.Sc.	Researcher	12	1:41 hrs
6	Agricultural Research Center	RES04	M.Sc.	Assistant Researcher	6	1:45 hrs
7		RES 05	M.Sc.	Assistant Researcher	8	1:55 hrs
8	Melkasa Agricultural Research Center	RES 06	PhD	Coordinator – Pulse Oil and Fiber Crops Research Program	14	1:20 hrs
9		RES 07	PhD	Agricultural Economics, Extension and Gender Researcher	15	2:08 hrs
10		RES 08	PhD Candidate	Researcher	12	1:33 hrs
11	Oromia Agricultural Research Institute	RES 09	M.Sc.	Rural Development and Agricultural Extension	12	1:10 hrs
12	Mekele University, College of Dry Land Agriculture and Natural Resource	RES 10	M.Sc.	Focal Person for FRG Project; CASCAPE (Netherland’s Project) as a Researcher	4	2:14 hrs
13	Under EIAR - Assosa Agricultural Research Center	RES 11	M.Sc.	Focal Person for FRG Project; Researcher on Rice and Wheat	5	3:18 hrs
14	Holeta Agricultural Research Center	DA 03	12 <sup>th</sup> Complete	Agricultural Economics, Extension and Gender Researcher	38	1:52
<b>Farmers – Welmera Wereda (for Focus Group Discussion)</b>						
1	Under Holeta Agricultural Research Center	FAR 01	7 <sup>th</sup> Grade	Farmer	<b>9 Years of Experience in FRG</b>	1:34 in total
2	>>	FAR 02	None	Farmer		
3	>>	FRR 03	9 <sup>th</sup> Grade	Farmer		
4	>>	FAR 04	8 <sup>th</sup> Grade	Farmer		
5	>>	FAR 05	None	Farmer		
6	>>	FAR 06	None	Farmer		
7	>>	FAR 07	None	Farmer		
8	>>	FAR 08	Basic Literacy	Farmer		

## APPENDIX – VI: MAJOR THEORETICAL CONCEPTS OR ANALYTICAL UNITS

The screenshot displays the NVivo software interface for a project titled "Externalization of Tacit Knowledge Backup2.nvp". The main window shows a list of nodes with columns for Name, Sources, References, Created On, Created By, Modified On, and Modified By. The left sidebar contains navigation options like Nodes, Relationships, Node Matrices, Sources, Classifications, Collections, Queries, Reports, Models, and Folders. The bottom status bar indicates "MR 110 Items".

Name	Sources	References	Created On	Created By	Modified On	Modified By
Factors that Impact TK Externalization	13	269	8/1/2015 2:16 PM	MR	7/17/2016 3:43 AM	MR
Cognitive competence or Knowledge c	12	44	8/1/2015 3:08 PM	MR	8/28/2015 1:46 PM	MR
Communication Quality	12	64	8/1/2015 2:26 PM	MR	8/29/2015 5:33 AM	MR
Creating Interactive Platform	13	29	7/17/2016 3:55 AM	MR	7/17/2016 3:55 AM	MR
Degree of Complexity	8	23	8/1/2015 2:18 PM	MR	8/6/2015 6:27 AM	MR
Group Heterogeneity	11	25	8/1/2015 2:32 PM	MR	7/17/2016 3:48 AM	MR
Motivational Factors	10	23	8/1/2015 3:12 PM	MR	8/6/2015 6:26 AM	MR
Resource & Infrastructure Problems	8	17	8/1/2015 5:36 PM	MR	8/27/2015 1:06 PM	MR
Social Capital Factors	13	44	8/1/2015 2:53 PM	MR	8/6/2015 6:25 AM	MR
Mechanisms of Externalization	14	200	8/1/2015 11:19 AM	MR	7/17/2016 3:43 AM	MR
For High Degree of Tacitness	8	15	8/1/2015 11:21 AM	MR	8/6/2015 6:23 AM	MR
For Low Degree of Tacitness	12	44	8/1/2015 11:22 AM	MR	8/6/2015 6:22 AM	MR
For Medium Degree of Tacitness	12	63	8/1/2015 11:21 AM	MR	8/6/2015 6:22 AM	MR
Process of TK Externalization and Shar	13	78	7/17/2016 3:41 AM	MR	8/1/2015 5:40 PM	MR
Taxonomies of Tacit Knowledge	13	87	8/1/2015 9:53 AM	MR	7/17/2016 3:45 AM	MR
High Degree of Tacitness	1	1	8/1/2015 9:55 AM	MR	8/6/2015 6:29 AM	MR
Low Degree of Tacitness	8	18	8/1/2015 10:02 AM	MR	8/6/2015 6:29 AM	MR
Medium Degree of Tacitness	12	38	8/1/2015 9:59 AM	MR	8/6/2015 6:29 AM	MR
Tacit Knowledge	13	30	8/1/2015 9:47 AM	MR	8/1/2015 9:47 AM	MR
The Existing Use of M and Requirements	13	67	8/1/2015 5:50 PM	MR	7/17/2016 3:43 AM	MR
The Setting	14	71	8/1/2015 6:31 PM	MR	7/17/2016 3:46 AM	MR

**APPENDIX – VII: LETTER OF VERIFICATION FOR  
TRANSLATED and TRANSCRIBED INTERVIEW  
TRANSCRIPT**

To: \_\_\_\_\_

I don't have words to express my gratitude for your willingness and commitment to share your ideas, knowledge, rich experiences and precious time with me for the PhD dissertation research I am engaged in. With your unreserved support I am moving forward towards analyzing the valuable data you provided to me. In this process verification of the accuracy of interviews by respondents is required to ensure credibility (internal validity) of the research. Therefore, I have attached the interview result which is translated and transcribed verbatim based on the interview that we conducted before. This is therefore to request your usual support to verify the correctness of the interview translation and transcription and to give me your feedback and confirmation. You can make corrections on the attached document and resend the same document with your comments and corrections. I would be also very grateful if you provide me responses for questions not responded before. Please find the attached document that consist the translated and transcribed interview.

Thank you again for your willingness and kind support.