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NETWORK OF KNOWLEDGE GENERATION and TRANSFER in SUSTAINABILITY:

Toward an Inclusive System Discovery Approach

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Declaration

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Approval

As principal supervisor, I hereby approve that this thesis entitled *"NETWORK of KNOWLEDGE GENERATION and TRANSFER IN SUSTAINABILITY: TOWARD an INCLUSIVE SYSTEM DISCOVERY APPROACH"* is prepared and submitted by *ABEBE TIGA TENSAY* in partial fulfillment of the requirements for the Master's degree in Sustainability Science.

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Aknowledgement

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Praise God!!!

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Acronym

Eiar/ IAR Ethiopian institute of agricultural research

AU Haramaya (Alemaya) University

MOARD Ministry of Agriculture and rural development

BDARC Bahir Dar agriculture research Center

OARC Oromiya agriculture research Center

NARC/MARC, Nazret/Melkassa agriculture research Center

DARC Debrezeit agriculture research Center

ILRI International livestock research institute

ADET ADET agriculture research Center

AAU Addis Ababa University

CIAT International Center for Tropical Agriculture

NGO Non Governmental Organization

SNNPRSRRC, Southern Nation, nationalities Regional state Research Centre

SNNPRSBA, Southern Nation, nationalities Regional state Bureau of agriculture

WARC Werer agriculture research Center

ICARDA International Centre for Agricultural research for Dry Area

NOAGRIC Norwegian Development Agency

MU Mekele University

DC Degree Centrality

BC Beteeness Centrality

CC Closness Centrality

g number of vertex/Actor

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Abstract

The significance of knowledge and information, and innovation is often said to be premium, and its transfer is vital in a sustainability transformation proces. However, knowledge generation and transfer are underutilized in urban agriculture knowledge and information system due to lack of collaboration of relevant stakeholders, and poor understanding of urban agriculture. Nevertheless, the social capital in rural agriculture knowledge and information system would most likely define structural hole in urban agriculture knowledge and transfer system, and used to construct an inclusive system or model. This research focuses on research, university and (municipal) government pattern of collaboration in agriculture systems in Ethiopia. Apart from the social network analysis software, this research integrates concepts of agriculture innovation system, agriculture knowledge and information system, and soft system methodology. It includes bibliometric analysis, organizational network, and practical case study. The research uses an arc/edge network model, a one mode network model, a process and role-based modeling approach, and a multiple mode network model. Individual/separate analysis in urban agriculture and rural agriculture knowledge system shows that both systems are embded with socio-ecological and socio-economical knowledge that ensures availability of knowledge of sustainability. Addis Ababa and Haramaya universities have the largest proportion of knowledge in urban and rural knowledge and information systems respectively. The bibliometeric joint analysis result shows that the agriculture knowledge and information system involves common vertices of universities and research institutes that show the possibility of important knowledge transfer and inter-exchangeabilty between the two systems. Unlike rural agriculture knowledge and information system, urban agriculture lacks sustainability of knowledge approach that ensures the possibility that the knowledge is shared and applied, however. The organizational network in rural agriculture knowledge and information system, in this case, is found as a sink for knowledge and innovation and it avoids the "source-sink interface". In other words, farmers, the actual users, and expertise have strong linkage in the chain of production scale up/out, for instance soybean technology scaling up/out process in this case. The network affects not only farmers' involvement and gender mainstreaming but also influences technological choice and appropriate cropping and farming system towards sustainability. Hence, maize-based mono-cropping is changed to soybean-based (multiple) rotational farming system. The research develops a new model of an inclusive system. Therefore, a paradigm shift towards multi-functional collaboration within an integrated system is an event/occurrence to embark upon a sustainable agriculture development. This research proposes such a system that includes all relevant vertices and other stakeholders which enhance connectivity, increase diversity of veritices and thier compostion, also increase areas of collaboration and working environment. This requires integration and co-ordination through changing status quo in organizational culture, establishing a continuous feedback loop, and reinforcing entrepreneurship.

Keywords: *Centralization, feedback, panarchy, communication, structural hole, social capital*

1. Introduction

1.1. Background

In this world of 21st century, many cities are characterized by multifaceted challenges of global warming, increasing urbanization, higher population growth rate, financial crises and soaring food price, wide spread of HIV/AIDS and malaria, and limited employment opportunities which in turn become major cause to food insecurity, poverty exacerbation, and increased urban pollution. Consequently, result in heavy socio-economic and ecological pressures on slum dwellers, and harm and damage human, social, economic and environmental sustainability fashionably one after the other. Those conditions often call for a sustainability measure through capitalization/ or creation of new knowledge and diversification of agriculture knowledge and information system and its application in Ethiopia. Knowledge is produced and updated through interaction between action and knowledge, through mutual interaction between the real world and abstract world, and between issues and solutions (Kajikawa, and Komiyama, 2011). Integration of knowledge and action are of paramount importance for sharing and better communication. Knowledge without action cannot change a situation and action without knowledge leads to uncertain results (Kajikawa, and Komiyama, 2011).

According to Norton, Alwang, and Masters(2010), agricultural development today requires an integrated knowledge production system with strong transfer organizational linkage/network, both internal and external, that brings in appropriate technologies, screen, adapt, and produce new technologies and institutions; perform both on-station and on-farm testing. For more effective collaboration in sustainability, organizational and institutional arrangements are necessary (Yarime, 2011). A holistic system building is quite inevitable for bringing about holistic way of resilience. This study investigates to understand and suggest pattern of knowledge generation and transfer on urban agriculture.

To come up with holistic approach, inquiries are multiple perspectives to re-examine the previous scenarios though it is not an easy task that a general and unified methodology specific to sustainability analysis is still on a debate that it depends on priority sector of development in a given country (Yarime, 2009). Institutional analysis and knowledge structuring, which involve a set of processes to access, collect, analyze, assess. Organize and finally represent knowledge based on the structure of knowledge, are important (Kajikawa, 2011; Yarime, 2009) for sustainability analysis of a given knowledge/ or innovation system. Agricultural innovation system (Juma, 2011), agriculture knowledge and information system, and network analysis frameworks (Nooy, Mrvar and Batagelj, 2005) are used for analysis of this research. National research, university and (municipal) government institutions are the research boundaries within the framework. This is because a chain wise building of interlocking institutions and organizations which consist of research and community is at most important to bring about a wholesome effect of sustainability. Interventions that unite research-led and community-based capacity could cost relatively little, add value to existing investments, meet the needs of the poor, and achieve very high returns (Juma, 2011).

This research has five extended themes. Accordingly, the thesis is constructed of introduction, literature review, methodology, result and discussion, conclusion and recommendation. The introduction part explains briefly the research content and summery of the research supported by background information. The literature review has four different topics extensively drawn from

wide range of academic literatures which mainly justify relevance of the research in sustainability science in general and solving problems of the study area in particular. The methodology part explains the study procedure with defined mathematical network formula in detail followed by result and discussion which in turn consists of six different extended sections .The conclusion concludes the research in summery.

For sustainable economic catch-up with a wider recognition of environment sensitivity to agriculture and its related industry, systematic established network of national universities, public research laboratories, and municipal governments are often regarded an impetus and a pillar for successful wholesome development as they are centers for social and physical technologies by providing with reliable and relevant knowledge that is adopted by urban farmers which in turn create bridge for better communication among them.

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*Agriculture knowledge and information system is the persons, networks and institutions, and the interface between them, which engage in or manage the generation, diffusion and utilization of knowledge and information, and which potentially work synergistically to improve the goodness of fit between knowledge and environment, and the technology used in agriculture.

*Agriculture innovation system is defined as a network of organization, enterprise, and individuals for bringing new organization, process, and product into an economic use together with institution and policy that affect their behavior and performance.

1.2. Objective & Research Question

1.2.1. Objective

The ultimate goal is to study pattern of interaction and collaboration among the three key actors in agricultural knowledge and information systems with a major emphasis on drawing a model or an approach for urban agriculture knowledge and information system in Ethiopia through intermediate goals set as follows:

(1) Examine rural agriculture knowledge structure
(2) Examine urban agriculture knowledge structure
(3) Examine potential synergy between urban and rural agriculture knowledge structure
(4) Propose a model to sustainability of urban agriculture

1.2.2. **Research question**

The entire query of this research is eventually looking for and to propose an approach for sustainable agriculture production system through finding answer to a question:

How a sustainable knowledge can be generated and applied in agriculture knowledge and information system, with a particular focus on urban agriculture?

1.3. MAJOR FINDING

Analysis using international science information web of knowledge (ISI), agricultural research and information system (AGRIS), and resource center for urban agriculture and food security (RUAF) data bases reveals that most of knowledge is available at university and research institutes, the same result is found by New Partnership for Africa Development (NEPAD) in its recently released Africa innovation outlook 2010 summery report which is analysed using the scopus database.

The rural agriculture knowledge and information system possesses greater complexity, diversity and complexity due to presence of strong link between knowledge producers and consumers at different level.This indicates that the social capital in rural agriculture knowledge and information system is developed well.

Varoius knowledge transfer mechanism is available in rural agriculture knowledge and information system unlike the case in urban agriculture. Joint planning, joint experimentation/demonstration, joint review and evaluation, joint workshop, joint fielddays, and publications such as books, articles, editorials, meetings, and proceedings are the major knowledge transfer mechanisms in rural agriculture knowledge and information system.However, the majority of the urban agricultural knowledge is embedded with publications although some cases show application of information communication technology (ICT) like video conference for conducting a workshop. The rich experience gained in rural agriculture knowledge and information system interms of promoting joint actions and functions can be adapted to urban agriculture knowledge and information system.

Social capital and organizational network determines knowledge of sustainability and sustainability of knowledge in Ethiopia. The rural agriculture knowledge and information system

bounds knowledge of sustainability and sustainability of that knowledge. In this system, resilience is a factor of availability of different actors, diversity of knowledge of basic, applied, adaptive and testing research, and chain of innovative action to increase resourcefulness of exiting knowledge and robustness by increasing cropping systems, from mono-to multiple, with cross functional activities of supporting food self –sufficiency and food security measures while protecting deforestation, loss of bio-diversity, enhancing human health unlike urban agriculture knowledge and information system. The abscence of link between rural and urban agriculture knowledge and information system is the major constraint in utilizing the available knowledge. Cognizat of this fact, the research defines the structural hole and propose model that enable harness both resources with increasing diversity of knowledge, actor composition, connectivity, and redundancy. Genarally, social capital in a larger system, in this case rural agriculture knowledge and information system, is a structural resilence bridge in defining the potential structural hole in a system of similar function in urban agriculture knowledge and information system.

Availability of knowledge of sustainability does not guarantee for sustainability of that knowledge in the urban agriculture knowledge and information system.unlike urban agriculture system, joint planning, experimentation, demonstaration, workshop and evalution are engines for augmention of shared vision , practice of sustainable development, and for institional policy in rural agriculture knowledge and information system.

Therefore, sustainability science must be regarded as a science of not only knowledge but also highly as a science of time and space of the way information and knowledge is shared and applied on to the ground with an increasing scale of best bet practices. This research found that organizational network is engine of sustainability or sustainable development. However, organization of a new network independently for urban agriculture is not a critical demand albeit a new integrated system. The research also defines this integrated system through defining structural holes in urban and rural agriculture and information systems.

1.4. Contribution of the Study

The study in agriculture knowledge and information system is new. Viewed from sustainability lens, the research employs individual, joint and collective procedures of analysis with some empirical example. Institutions and actors in public sectors with diversity and different level of connectivity and complexity can be integrated together under an inclusive system to create an increasing resilience over food security, drought and human health. Capitalizing a larger system through adding a missing sub-system with potential redundancy and resourcefulness brings an inclusive sytem which is more resilience than the individual systems.

The research combines methodology of different approaches aided by quantitative analysis for justifying scientific characteristics of sustainability.This research has applied the different approach of network analysis, innovation study, and knowledge and information system and softsystem methodology which at same times builds sustainability concepts of multidisiplinarity, interdispilinarity, and transdisciplinarty with some empirical evidence. As a methodology, this research can contribute to the theory of Panarchy, which focuses how collaboration should be structured in sustainability lens.

1.5. Outline of the Thesis

This consists of four sections. The first section embeds three subtopics, namely: First the nature of networks from Bibliometric, second an organizational network as empirical network structure which is operational in rural agriculture and information system, and third a case study on participatory soybean technology development and scaling up/out as a case study supporting a sustainability development approach. Each subtopic has different discussion titles desirable focusing on connectivity, diversity of actors, the pattern of relationship and collaboration. The titles are supported by visualization network results where necessary.

The second section discusses on bibliometeric analysis of the urban agriculture knowledge system in detail. Like in the first section, different issues of network attributes like connectivity, relationship between partitions, diversity, and the nature of embedded knowledge are examined.

The third section mainly examines the network system and behavior of the rural and urban agriculture knowledge and information system combined using Bibliometric cases. This is to see the actors which appear in both cases and the volume of that actor contribution to urban knowledge system.

The last but the not least, the fourth section focuses on combination analysis of the previous cases together. This section explicitly examines results of system combination and its implication for scientific understanding of the characteristics of sustainability science and its practical notions in terms of alleviating poverty, ensuring food security, building and creating new green economic environment, social inclusion and empowerment, and the systems resilience against risks and uncertainties. The entire case is illustrated in the conceptual frameworks.

1.6. Conceptual Framework

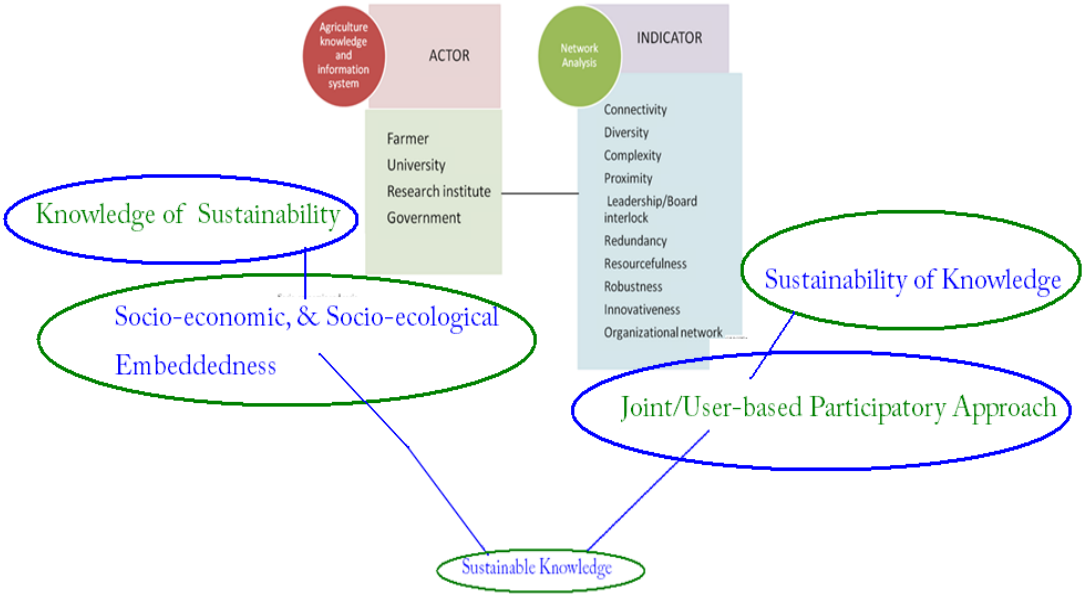


Figure1.Conceptual framework of the research

2. Literature Review

2.1. The nature of knowledge and its importance for sustainability

Knowledge is the only resource today and has no single definition (Ducker, 1999). It is understanding of or information about a subject as (I) expertise, and skills acquired by a person through experience or education as the theoretical or practical understanding of a subject; (ii) what is known in a particular field or in total as facts and information; or (iii) awareness or familiarity gained by experience of a fact or situation (*Oxford English Dictionary*). Such knowledge has different sources that it can be embodied in person embedded in system, embrained in concepts and cognitive abilities, encultured in shared understandings and cultures, and/or encoded in information systems. It can be something that can be built up from interaction with the world, and is organized and stored in each individual's mind, within the minds of employees at organizational levels and in paper and electronic records (*www.digitalstrategy.govt.nz/Resources/Glossary-of-Key-Terms*). Diversity of knowledge sources creates more access to users in different ways.

Knowledge can be analysed as an active process that is mediated, situated, provisional, paragmatic and contested (Venters, Cushman, and cornford, 2002). Knowledge can have different forms. Knowledge can either be tacit that is characterized as a personal, know-how, contextual, experiential, unarticulated, etc asset or resource or explicit that is characterized as something codified, shared, available, formal, systematic, articulated and communicable. Learning from a knowledge system depends on search for a holistic approach that both tacit and explicit knowledge could produce which is capable of solving problems related to economy, environment and society, domains of sustainability or planet, people and profit/benefit (Jorna, 2010). Such a process involves socialization, articulation, combination and internalization, as explained by Nonaka (1997), of a subject matter, in this case knowledge generation and transfer system/mechanism in sustainability with particular emphasis on urban agriculture through examinination of relevant stakeholders, their roles and functions synergistically. Institutional network as such mechanism is a good knowledge management approach because it involves a systematic process that supports a sustainable development of the stakeholders and involves creation, acquisition, gathering, transformation, transfer and application of sustainable knowledge.

Sustainable knowledge can be explained in terms of knowledge domains of sustainability and the extent of transfer and application. According to Jorna (2010) describes knowledge of sustainability (Kos) as organization and innovation processes to examine whether sustaianability concern is planet, people or profit (triple-P) and sustainability of knowledge (Sok) as a communication process to know whether the knowledge is used efficiently, whether it is shared, whether the conditions for innovation creation are sufficient and whether the knowledge has human dimension. Soci-economic and socio-ecological embeddedness in overall development process creates a balance among planet, people and profit resources and the process requires organizational networks of stakeholders from mulidiciplinarity,interdisciplinarity and transdisciplinartiy perspectives(Mobjork,2010; Hadorn,Bradley,Pohl,Rist and wiesman,2006, and Max-neef,2004).

Urban agriculture involves different stakeholders of various professions and experiences. A knowledge that involve collaboration and complexity can be learnt in multidisiplinarity, *interdispilinarity* and transdisciplinartiy manner in way they can combine tacit and explicit knowledge related to urban agriculture and drew a holistic approach ensuring a continuous and sustainable innovation in the knowledge system. Urban agriculture is a sustainable practice with myriads of cross-functional pros related to urban economy, environment and society. The number and composition of stakeholders directly or indirectly involved in urban agriculture differ from city to city, but include different labels of government which consist of local, provincial and national governments, municipal governments and professionals working on urban parks and gardens, health department and inspector, public work, urban planning department, water boards, local leaders and village councils, the private sectors, academic organization and research institutes, non-governmental organizations, social movements, grass roots and religious organizations, male and female urban agriculture practitioners and their organizations (Dubbeling and Merzthal,2006).

Integrated practice of concepts of multidisiplinarity, interdispilinarity, and transdisplinarity can bring about sustainable development. Supplying the demand of ever growing urban population under dynamic urban environment in socialization via multidisiplinarity gives a complete picture of the urban economic, social, built and natural ecosystem, articulation of the perceived environment via *interdispilinarity* suggests possibility of ways how to solve the prevailing problems of employment, pollution, food security, human health, etc and combination and internalization of the knowledge would lead to a holistic approach that will operate as a system.

2.2. Why Network? The nature and importance of network in agricultural knowledge and information system

Network can have various definitions ranging from the very abstract in terms of graph theory to quite practical dimension organizational or social system. According to NOOY, 2005 and Wasserman (1994), a network is defined as a set of actors and a set of lines between pairs of actors with additional information either of the actors or lines. Networking implies linking actions required for ensuring a formal and continuous flow of information, knowledge and resources among the various stakeholders/organizations or their sub-systems with recognized importance of each stakeholder's feedback for sustainable impact (Ethiopian Institute of agricultural research, 2000). Network, therefore, is the system that integrates farmers, university, researchers and extensionists to harness agricultural knowledge and information from various sources for better farming and improved livelihoods. For collective action of farmers, university and research institutes, and social capital is necessary that promotes flow of information and mutual learning between various researchers and groups to oil the wheels of decision making (Komiyama, 2011). Social capital here refers to availability of essential actors and their linkage in knowledge generation and transfer system, and how organizational network affects practice of sustainable agriculture where as Structural hole is a missing subnetwok system of similar function.

Network plays a predominant role in agricultural knowledge system (AKS) which is defined as a system that links farmers and institutions to promote mutual learning and generate, share and utilize agriculture-related technology, knowledge and information. Andersonl, Gundel and Vanni (2010) unveiled types of agricultural research relevant activities prioritized in the African national adaptation programs of action. Accordingly the inquiries are 44 % of knowledge sharing,

36 % of increasing production or infrastructure, 29 % of creating market access or management options, 29 % of developing new farming methods, 18 % of work on biodiversity or soil fertility, 8 % and others (figure2). Urban agriculture is a practical option in bringing about adoption of a new farming system, better communication infrastructure, ways of biodiversity conservation, mechanisms for agricultural production, and climate change mitigation.

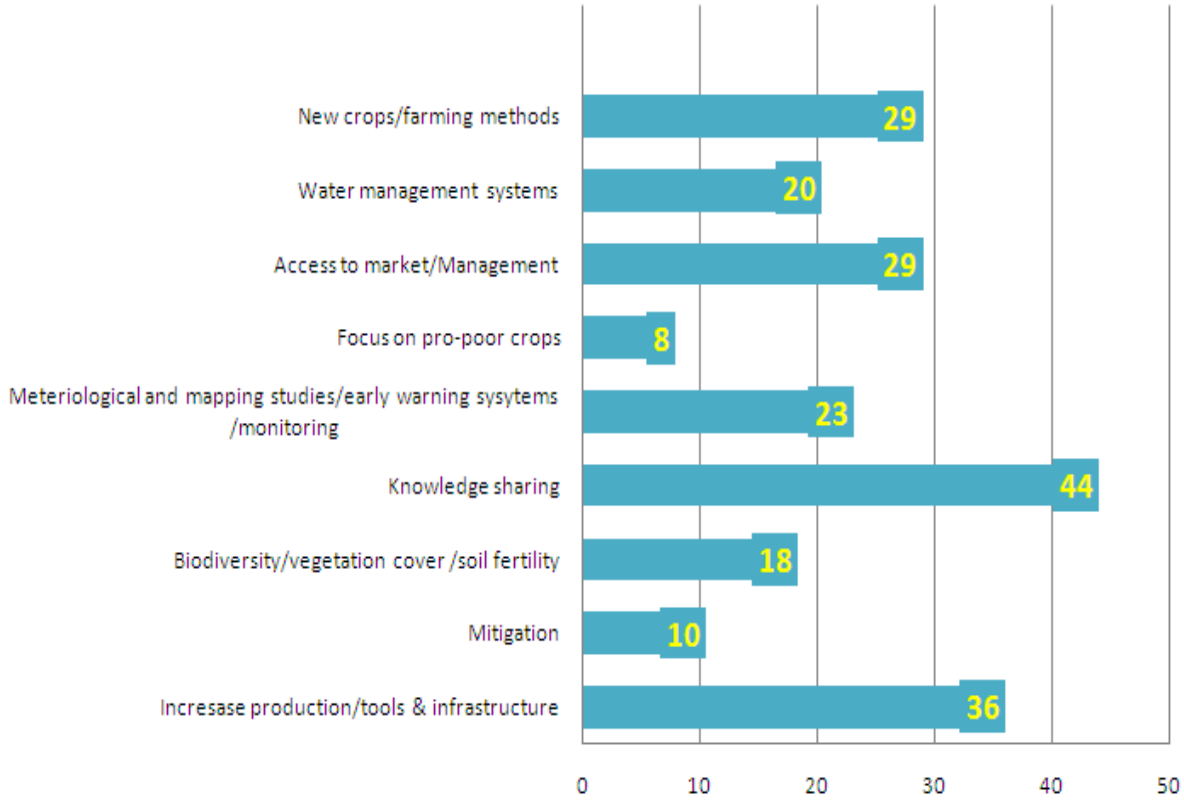


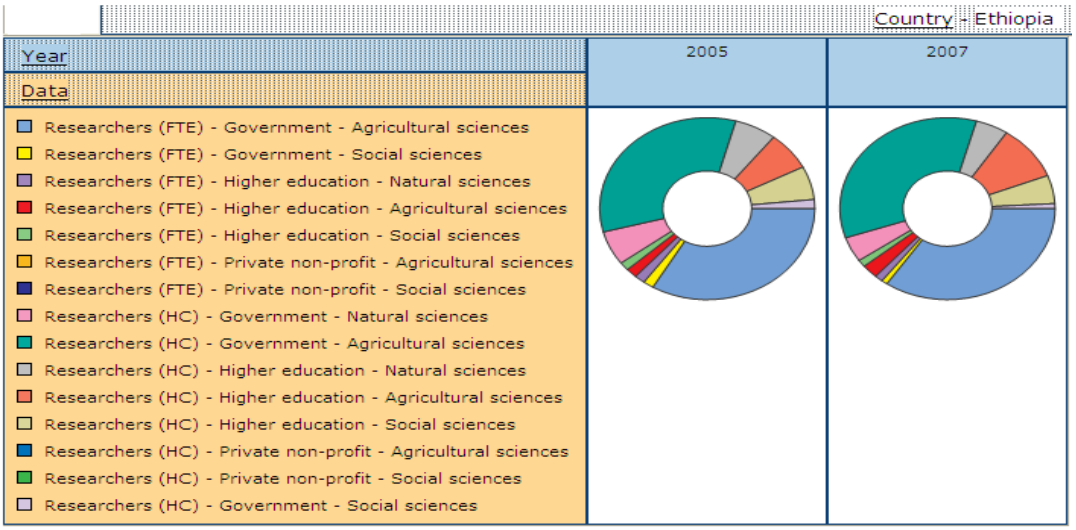
Figure2.Types of agricultural research relevant activities prioritized in the African national Adaptation programs of action (categories presented as percentage of total) Adapted from IIED, 2010

Urban agriculture involves multifaceted activities. Network plays predominant roles integrating different knowledge need, its generation and diffusion among stakeholders of urban agriculture practioners, research, university and urban governments. It is essential for that it strengthens grassroots institutions, addresses needs of urban poor farmers, active participation for better planning and decision making, allows for better feedback and action, creates chain of learning opportunity, allows for faster knowledge generation, transfer and adoption, and allows faster innovation process. Generally a network is basis for knowledge generation, competence building, financial support, provision of regulatory framework and measure, facilitation of information exchange, stimulation of demand and creation of markets, and reduction of uncertainties and resolutions of conflicts.

So as to match the demands of urban growth with activities of high economic, social and environment value, it ought to be included as a multi-functional component in municipal land

use planning, zoning, master plans and neighborhood development plans (Dubbeling, and Merzthal 2006). This helps bringing new factors such as land and labor in urban area into innovative production and sustainable development frontier. In this regard, the position of universities and research centers is of paramount importance for developing environment friendly, economic viable and socially acceptable innovations in time. Owing to higher interface between university and research institutes, where massive agricultural knowledge exists, taking the resources into action remains stagnant.The following table and figure show example of fulltime equivalent (FTE) and head count (HC) of researchers available at universities/higher education and government institutions, and researchers weight by employment during 2005-2007.

Figure3. Researchers by employment in full time equivalent (FTE) and head count (HC)



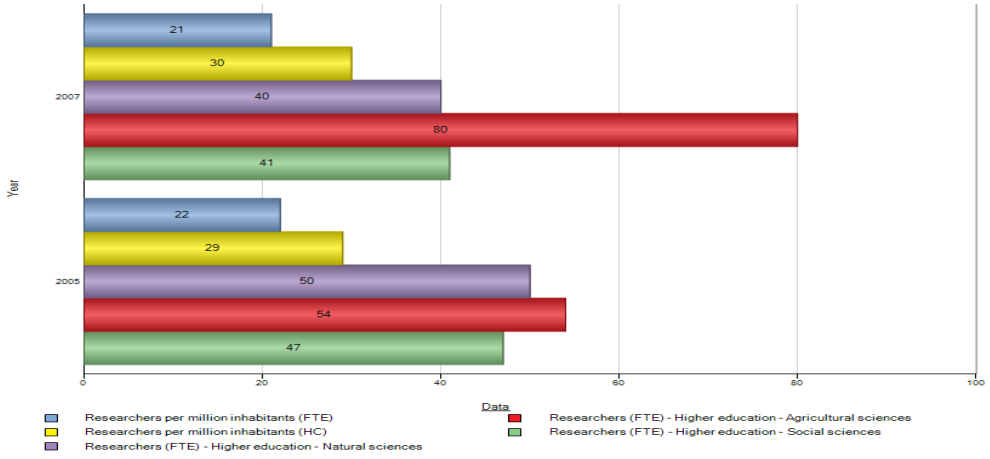


Figure4. Density of researcher and human resources by science category at higher education

2.3. Bibliometric analysis,and its importance

For more realistic and complete picture of the science, technology, and innovation landscape, bibliomtric analysis of science and technology production and knowledge flows are crtical aspects of the state of science, technology, and innovation in Africa (NEPA, 2010). NEPAD (2010) using scopus database found that systemic, institutional and individual forces affect production of knowledge/ science and food security, disease control and industrialization are the major challenges.Strong collaboration is limited. In co-authorship, most African countires have publication network with regional negbouring African countries.For instance, Ethiopia has scientific collaborations with Kenya, Uganda, Tanzania, South Africa and Ghana which represent author of each country (Irikefe, Vaidyanathan, Nordling, Twahirwa, and Monastersky 2011). Ethiopia expends more on research and development relative to its GDP than most other African countries as shown below. Owing to physical and material realities, this scientific knowledge is available at university level where there exits little collaboration for effective transfer, and application.Investment on workshops, libraries and laboratories is where basic solutions lie on in Africa for Africa (Irikefe, Vaidyanathan, Nordling, Twahirwa, and Monastersky, 2011).

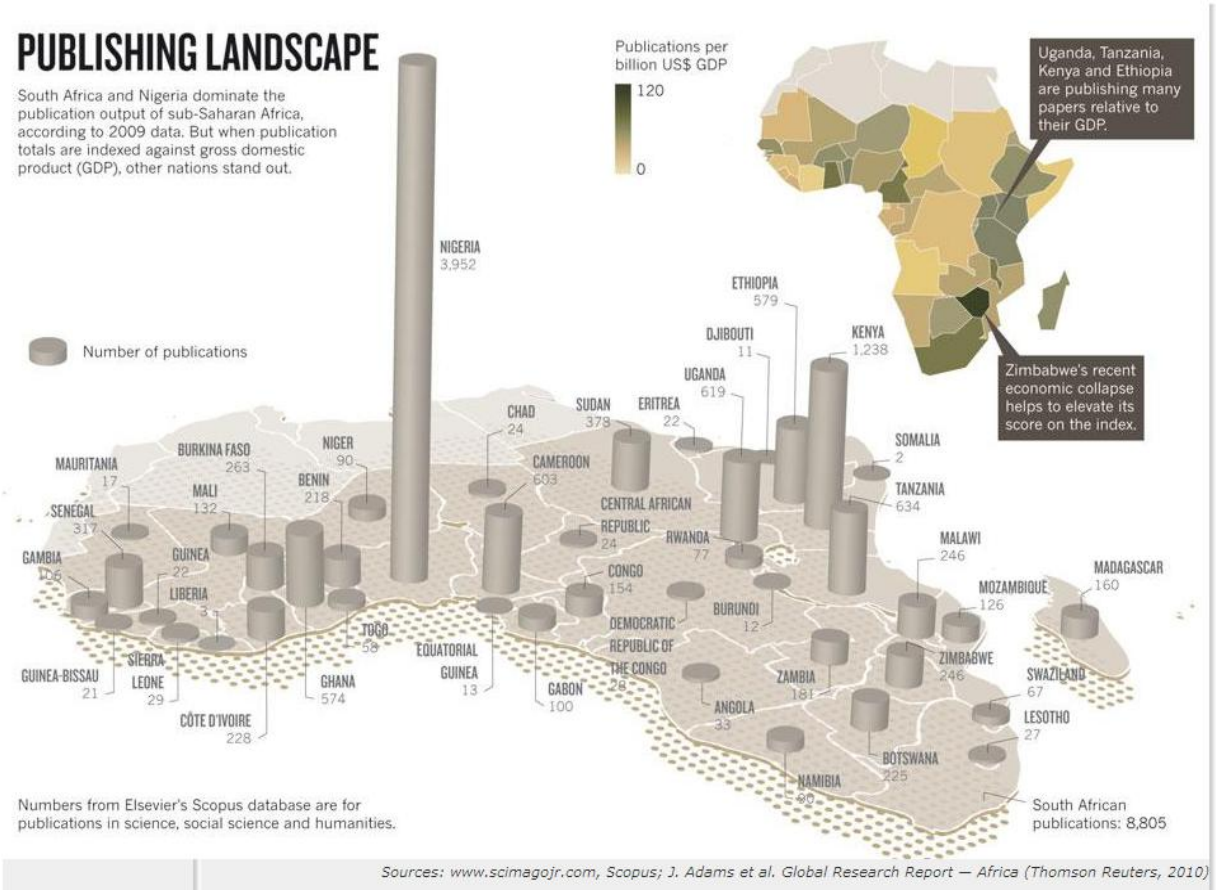


Figure5.Bibliometric analysis in Africa using the scopus database (Adapted from nature, 30June2011)

2.4. Example on type of natural disaster and volume of its aftermath

The agricultural sector suffers from frequent drought and poor cultivation practices. Drought struck late in 2002, leading to a 3.3% decline in GDP in 2003 (CIA, 2010). Between 2000 and 2010, about 32 types of natural disaster were registered of which the flood and drought were the majority. In 2003 only about 12,600,000 people are affected by drought and flood keeping on their aftermath consistent. As agriculture is mainly dependent upon rain water, a change in climate affects many livelihoods adversely unless alternative innovation is developed and properly applied. In urban areas, where many infrastructures like organized water supply system is available, public institutions are crowded with, encouraging urban farming can lesson problems related to environment and health. Drought and flood are the major environmental problems which in turn affect sustainable development in the Ethiopian economy.

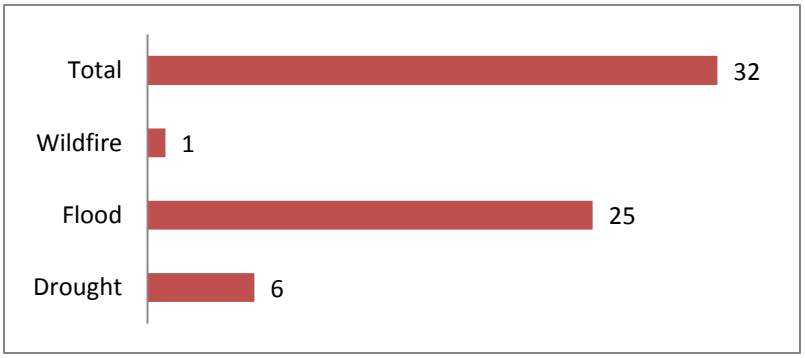


Figure6. Occurrence of natural disasters from 2000-2010

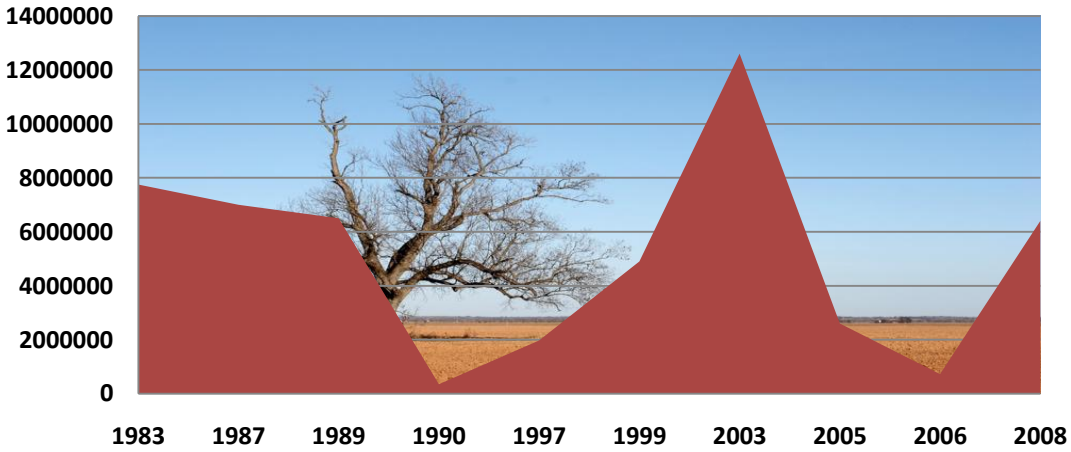


Figure7.Total individuals affected by drought and flood

2.4. Urban Agriculture in Relation to Sustainability

Urban agriculture is an industry encompassing complex activities of production, processing, marketing, and consumptions. This entails that urban agriculture can be integrated into an urban economic, environment and society systems. Addressing the complex nature of urban agriculture requires the coming together of integrated actions among urban agriculture practioners, academic community from research and university, and urban governments. The future habitability, competitiveness, and viability of the cities in developing nations will depend on whether decision makers and urban planners develop and adhere to coherent policies for managing their urban areas (Hoornweg and Munro-Faure 2008).

Urban agriculture is a sustainable practice. It promotes organic production by utilizing organic urban wastes, saves 60-80% of expenditure on food, and reduces energy for transportation purpose by 5 % (Gebreegziabiher, 2004 and Venzhuin, 2000). Hence, urban agriculture prevents pollution, encourages saving, promote public health, creates employment opportunity. It also creates local market such that reduces costs related to transportation, increases consumers satisfaction by creating time and place utility which are very important for risks and uncertainties associated with long distance travel, easily perishability (of agricultural products) and others.

Urban agriculture promotes sustainable development of rural agriculture. According to Veezhuin (2003) urban agriculture contributes to biodiversity and environment management education. Besides, sustainable development of urban fringes, and other untapped areas, it contributes rural environment challenges of soil degradation, water pollution, deforestation and risks of weather fluctuation on agriculture production and productivity. In a micro environment, urban agriculture can be seen as mitigation strategy that it reduces energy consumption for transportation, reduces carbon emission and fuel consumption. It is also important for human health, social inclusion and creation of local market. Environment, economy and society in urban system plays interdependent roles in solving problems through building healthy interaction of among socio-ecological, socio-economical and environment economy and serving as bridge of satisfaction in a variety of ways (figure7).

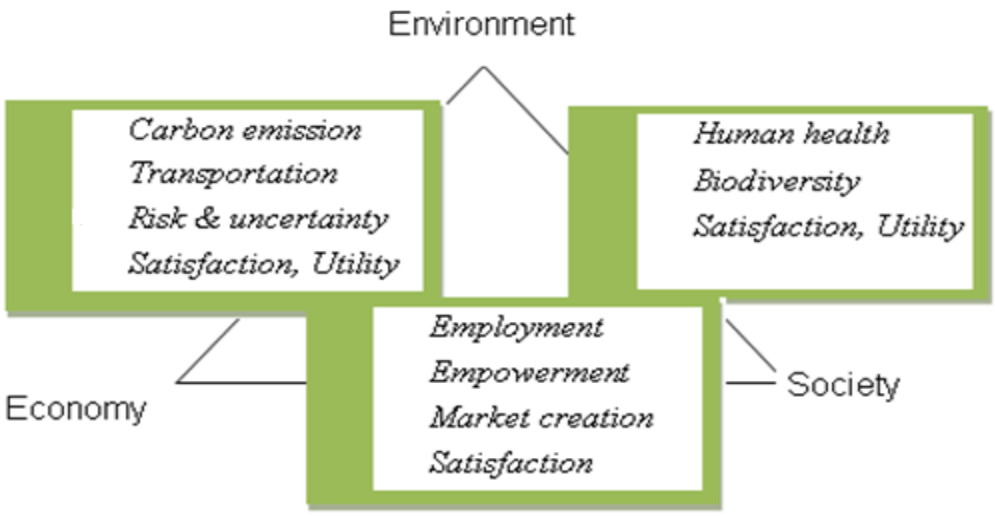


Figure8. Sustainability dimension of urban agriculture

In general, agriculture increases carbon sinks and holds larger potential useful for climate change mitigation.climate change mitigation potential of agriculture estimation is 5.5 to 6 Gt of carbon-equivalent per year by 2030 (United Nations, 2010). This underlines that 89 % carbon from agriculture can be captured via enhancement of agro-ecological agricultural practices that allow carbon sequestration in soils and storing carbon as soil organic matter. Such practice also increases drought resistance of crops as justified in *Ethiopia*, India and Netherlands (United Nations, 2010).

2.5. Problems and Future Directions of Urban Agriculture in Ethiopia

Like many developing countries with dramatic population growth, rapid urbanization, and quickly rising food prices, urban agriculture in Ethiopia is increasingly being recognized as a practice which contributes to development agendas by boosting food and economic security, improving rural-urban environmental management ,and integrating socially marginalized and poor communities(Gultneh and Ness,2009). According to the united nation 2007 world population prospect, urban growth rates for 2010-2015 is 4.37 % which is the fastest growth rate in Sub-Saharan Africa growing at 3.55% per annum. This would lead a transformation of agriculturally arable lands into urban areas which in turn affect food security, loss of biodiversity, increasing soil degradation and production and productivity.

According to Hoornweg and Munro-Faure (2008), though the interest, potential, and risk of urban agriculture are clearly understood, in most cases policy and strategic development and technical guidance are absent or only nascent. Those situations are true features in cities of Ethiopia as well. Various reasons are attributed to the governmental, organizational, sectoral, and economic and other factors, but integration of resources for urban agriculture are a key message by all stakeholders.Furthermore, most researchers are found in research institutes/centres and universities, 50% of government expenditure is spend on research and development fora of agricultural, natural and social sciences , the number of researchers is less, private sectors engagement in research and development is absent, and focus is mainly on rural agriculture(NEPAD,2010;UNESCO, 2007). Absence of interconnectedness between urban and

rural agriculture system not only hampers innovation activities but also limits adoption of existing problem solving approach and urban farmers' productivity under the prevailing inefficient and improper waste utilization and management scheme.

Table1. Situational and gap analysis of urban agriculture

S/	**Stakeholder**	**Constraint**	**Task**	**vision**
1	Water Resource	Degradation & deforestation driven drought Unsecured financial resources Lack of knowledge sharing	Enhanced integrated watershed approach Addoption of appropriate technology Awareness creation Development of clear and practical legistalation	Improved Access to water of appropriate quality
2	Health and Nutrition	Lack of multi-sectoral collaboration Little attention for proper waste disposal management	Expansion of urban gardening Community mobilization Integrated policy development Intensifying the current UA systems Mainstream UA to all health sectors	see a healthy, productive and food secured
3	Livelihood	Limited access to land, water and financial capital Lack of clear and supportive policy Negative perception of UA by residents	Awareness creation Improve cooperation Employ the best and modern technologies Formulation of comprehensive policy Improve market linkage	see an improvement in sustainable living for urban
4	Education	Lack of supportive policy Lack of access to capital, technological and natural resources Poor perception of UA	Change negative perception of UA Addressing the socio-economical and environment benefits UA Creation of future agricultural educators	see the cultivation of the knowledge and skill
5	Land use	Difficulty of using urban land for agricultural practices Poor awareness of UA Limited technical ability to transform land-use planning systems	Awareness creation Integrative policy Demarcating UA zones Making use of unused urban space	See the inclusion of urban agriculture zones in city
6	Environment	Lack of policy Increasing water pollution due to the growing industrial sector Vulnerability of urban riparian zones to different threats	Capacity building of environment managers Formulation of UA policy Integrate waste management system Improve perception of city farming	See clean, green, urban environment rich with biodiversity

Adapted from Gultneh &Ness, 2009(USAID workshop proceedings)

2.6. Hypothesis

An estabilished social capital in rural agriculture knowledge and information system network can be a structural bridge for defining the structural hole in urban agriculture knowledge and information system. In other words, knowledge and information system that is working well in rural agriculture can be switched to function for urban agriculture knowledge and information system.

3. Methodology

Knowledge generation and transfer on subject that could address myriads of cross-functional issues from multidisiplinarity, interdispilinarity, and transdisciplinartiy perspective is a key issue in sustainability science though there is no clear pathway to deal with how it must be addressed, which remained a debate at present (Yarime,2009). Institutional analysis and knowledge structuring, which involve a set of processes to access, collect, analyze, assess, organize and finally represent knowledge based on the structure of knowledge, are important (Kajikawa, 2011; Yarime, 2009) for sustainability analysis of a given knowledge/or innovation system. This research integrates the different concepts of agriculture innovation system (AIS), agriculture knowledge and information system (AKIS), and soft system methodology (SSM).

A subject of research in sustainability science depends from country to country owning to the country's development program and approach. Ethiopia is one of agrarian countries with long history. In this paper urban agriculture is given special focus for that urban agriculture shows similar issues that correspond to sustainability science Vis a-vis addressing multifaceted urban food, health, employment, and environmental problems.

This research employs both qualitative and quantitative approaches. National research, university and (municipal) government institutions are the research boundaries within the framework. Data from international science information (ISI), agriculture research and information system (AGRIS), and resource center for urban agriculture and food security (RUAF) databases are collected. Urban agriculture in Ethiopia, Ethiopia, and agriculture in Ethiopia are used as key words in data collection process. The data consist of 297 bibliometeric, an empirical organizational network of 47 actors, and a case study. This includes the rural agriculture knowledge and information system to understand the difference and draw reliable and relevant lessons and approach for urban agriculture. Publications from each database are analyzed by their respective author-affiliated institutions to examine stakeholders involved or take part, subject type to understand the type and nature of knowledge produced and focus areas by comparing the magnitude of each produced knowledge types.

The research employs network statistics such as centrality and (group) centralization indices, hierarchical clustering, density, mean nodal degree and a collective analysis using Pajek social network analysis software.

The research uses five different model concepts. Accordingly the research employs arc/edge network model, one mode network model, process/role-based network and multiple mode network models. Hence, no dependent and independent variable (Aij=Aji) is used. Pattern of interactions analyzed at individual systems level, joint level and collective level. The networks consist of 46 vertices, 47 vertices, 21 vertices, and 114 vertices each representing an actor with a direct involvement in knowledge generation in urban- and/or rural- agriculture knowledge and information system in Ethiopia, and are connected by lines which each carries values of cumulative frequency of co-occurrence with others in all the cases.

The results of those attributes are used to indicate cohesiveness, leadership, co-collaboration and /or inter-organizational coordination /or integration of a system property (Nooy, Mrvar and Batagelj, 2005), (Hagen, Killinger and Streeter, 1997) and (Wasserman and Faust, 1994). This

suggests strong showcase for a sustainability approach that a system and its sub-systems can be evaluated against efficiency, robustness, redundancy, resourcefulness, and others.

Degree centrality of a vertex is the number of its degree. **Degree centralization** of a network is the variation in the degrees of vertices divided by the maximum degree variation that is possible in a network of the same size. **Degree centrality** is used to measure the extent to which one organization shares knowledge with others which shows the leadership and the frequency of joint contact with others, and equity of knowledge exchange.

$$\text{Centrality} = C'D\ (ni) = d(ni)/g\text{-}1$$

Where, ni= a given actor; d (ni) =number of contact by ni

$$\text{Centralization} = \text{Dc} = \sum_{i=1}^{g} [\frac{[\text{CD}(n*) - \text{CD}(ni)]}{(g-1)(g-2)}$$

n*= most contacting actor to other actors in the network

Betweeness centrality of a vertex is the proportion of all geodesics between pairs of other vertices that include this vertex. **Betweeness centralization** is the variation in the betweeness centrality of vertices divided by the maximum variation in betweeness centrality scores possible in a network of the same size. **Betweeness centrality** is used to show the amount of options an actor can get contact with other actors in a network along with the network path. The more options are available, the more contacts the actor has with others. Such actors higher control over the network activities of knowledge generation and transfer. It can be used as node for decision making with most effective ways that incur little cost.

$$\text{Centrality} = \text{BC}(ni) = \frac{\text{CB}(ni)}{[(g-1)g-2)]}$$

n*= the largest observed value= actors with multiple occurrence in the overall network path

$$\text{Centralization} = \text{CB} = 2\sum_{i=1}^{g} \frac{[\text{CB}(n*) - \text{CB}(ni)}{[(g-1)(g-2)]}$$

Closeness centrality of a vertex is the number of other vertices divided by the sum of all distances between the vertex and all others. **Closeness centralization** is the variation in the closeness centrality of vertices divided by the maximum variation in closeness centrality scores possible in a network of the same size. **Closeness centrality** measures how many an actor's get access to contact with others. Its metrics are used to describe proximity .inclusiveness and cohesiveness. It is important measure of social and economic behaviors of an actor in a network.

$$\text{Centrality} = \text{CC}(ni) = (g-1)\text{Cc}(ni)$$

$$\text{Centralization} = CC = \sum_{i=1}^{g} \frac{[C'c(n*) - C'c(ni)}{\frac{[(g-1)(g-2)]}{2g-3}}$$

n*= the most proximate actors to other actors in the network

g=total number of actor

Structural equivalence measures the degree of co-integration between pairs of actors regardless of their original similarity through hierarchical clustering, and such structure is shown using Dendrogram. This kind of analysis used is to understand individual actors, mutual influence, and extent of co-existence and co-integration. The mathematical description is:

$$dij = \sqrt{\sum_{k=1}^{g} [(Xik - Xjk)^2 + [(Xki - Xkj)^{2]}}$$

Where, I ≠k; j≠ k, Xik=number of contact from actor i to actor k, Xjk=the number of contact from actor j to actor k, Xki=the number of contact from actor k to actor I, and Xkj=the number of contact from actor k to actor j

This determines resilience, robustness or vulnerability which in turn indicates the nature of knowledge firm collaboration pattern in generating and transferring appropriate technology and enhances innovation outside of their respective sub-network system.

Resilence is the ability of social or ecological system to absorb change and disturbance while retaining the samwe basic structure and ways of functioning, the capacity for self-organization and the capacity to adapt to stress and change. For system analysis, resilience is explained via triple- R's (redundancy, resourcefulness and robustness).

Redundancy is the extent to which systems and system elements can satisfy the same functional requirements. A diversity of pathways (or potential for creating a diversity of Pathways) for achieving the same goal

Resoucefullness refers to the ability to diagnose, prioritize and intiate solutions to problems; the capacity for self organization, where internal feed back influences Development; the ability to combine different types of knowledge in order to cope with change and uncertainity

Robustness is the ability of a system to withstand a perturbation without significant loss of performance

The visualizations of network results are structured using Kamada-Kawai (free) and Fruchterman Reingold (2D) algorism functions embedded with pajek software. Bitmap, and encapsulated postscript –clip formats are employed.

4.Result and Discusion

4.1. Analysis of Bibliometric and Emprical Organizational Network of the Rural Agriculture Knowledge and Information System

4.1.1.The actors and the behaviour of their connectivity

46 actors are represented in the knowledge generation and transfer system of which each actors has exchange of knowledge /or scientific information more than once with other counterparts in the system, that is represented by a total of about 190 lines with a denisty of about 0.18.

Table2. The sociogram of connectivity, and density of the rural agricultural knowledge system

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Number of vertices (n): 46

	Arcs	Edges
Number of lines with value=1	0	0
Number of lines with value#1	0	190
Total number of lines	0	190
Number of loops	0	0
Number of multiple lines	0	71

Density = 0.1835749

4.1.2. Componets of the network in the partition system

The rural agricultural knowledge generation and transfer system has three components. Each entities in each component/partition or clustering represents their respective core organization to which they belong. The orange colour (11)are proffesional scientific societies ,the colour 10,represents university clusters of Ministry of Education(MOE),and the blue(9) represents research institutes under an umbrella of ministry of agriculture and rural development(MOARD) which represents about 31 actors

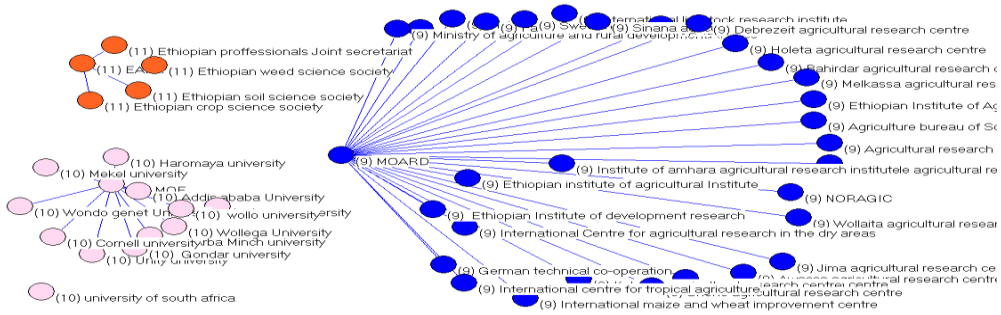


Figure9. Cores and components

4.1.3.Knowledge transfer system

The existence of such kind of ties in joint research, development and diffusion process would leads to an increasing and enhanced understanding of a scientific agricultural environment; both micro- and macro- level, efficiency of resource use and resilience or adaptation in overall sustainable development. To ensure sustainability in a given country, co-existence of human and social capital together with reactive institutions to the challenges of sustainability is an interlocking phenomenon among human wellbeing, and human progress through mainstreamed innovation system that fastens increasing adoption by users, where rejection is due to lack of awareness or knowledge.

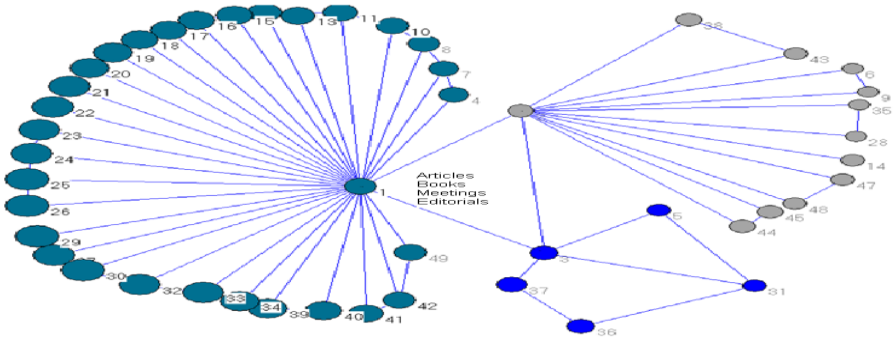


Figure10. Knowledge flow channels between components

4.1.4.Network structural pattern and quantitative behaviour

Organizations like haramaya university, Ethiopian institute of agricultural research,debrezeit agricultural research centre, addis ababa university have 43, 35 ,29, and 22 contacts/ties with the other organizations in the network respectively. In the same order, they also have greater knowledge brokering advatage in the network. Hence, they are spanner of knowledge generation and trasfer network in rural agricultural knowledge system. Haramaya university and Ethiopian institute of agriculture have most proximate position which can be expressed by values of closeness centrality and greater represenativeness explained by maximum number of ties, which is 43 in this case. Despite the single actors nature of influence in the network, the overall values shows a fair knowledge generation and composition(embeddedness), ease of access to share(reachability), options of transferability and equity of leadership in knowledge management (diversity and decentralization). In other words, the network represents greater social capital, mutual embeddness, diversity, and equity in knowledge geration and transfer.

Table3. Centrality and centralization indices in knowledge generation and transfer network

g(46)	Degree	D'C	C'C	C'B
1. Ethiopian institute of Agricultural Research	35	0.7777778	0.5759197	0.164353
2. Ethiopian society of crop science	13	0.2888889	0.4456522	0.0041949
3. Addis Ababa University	22	0.4888889	0.5425331	0.1266972
4. International crops research for semi-arid	8	0.1777778	0.4206155	0.0043769
5. Ministry of Agriculture and rural development	8	0.1777778	0.4068998	0.0011785
6. Haramaya University	43	0.9555556	0.613685	0.2724668
7. Oromiya Institute of Agricultural research	5	0.1111111	0.4352882	0.0040783
8. Farm Africa	13	0.2888889	0.4206155	0.0804438
9. Swedish international Development agency	6	0.1333333	0.3982424	0
10. International livestock research institute	17	0.3777778	0.5058754	0.060624
11. Mekele university	10	0.2222222	0.4565217	0.0885842
12. Adet Agricultural research centre	14	0.3111111	0.4799331	0.0039652
13. Sinana Agricultural research centre	9	0.2	0.4253953	0
14. Debrezeit Agricultural research centre	29	0.6444444	0.5505115	0.1325227
15. Holeta Agricultural research centre	6	0.1333333	0.4253953	0.0007015
16. Bahir dar Agricultural research centre	12	0.2666667	0.4621578	0.0432029
17. Melkassa Agricultural research centre	10	0.2222222	0.4404092	0.0025548
18. Ethiopian institute of development research	5	0.1111111	0.3819876	0
19. Ethiopian Civil service college	5	0.1111111	0.3819876	0
20. Agriculture Bureau of southern	7	0.1555556	0.3819876	0.0086547
21. Agriculture research centre of southern nation,	7	0.1555556	0.3819876	0.0086547
22. Mekele agricultural research centre	4	0.0888889	0.3093784	0
23. NORAGIC (Norwegian development Agency)	4	0.0888889	0.3093784	0
24. Wollaita agricultural research centre	2	0.0444444	0.3706414	0
25. Institute of amhara agricultural research centre	3	0.0666667	0.3634445	0
26. Jima University	8	0.1777778	0.4253953	0.0077726
27. Jima agricultural research centre	4	0.0888889	0.4253953	0
28. Awassa Agricultural research centre	2	0.0444444	0.3781291	0.0011182
29. Ethiopian proffessionals joint secretariat	5	0.1111111	0.3498578	0.0128896
30. Ahri Alert research centre	7	0.1555556	0.4113712	0.0007433
31. Kullumsa agriculture research	1	0.0222222	0.3043478	0
32. Sheno agricultural research centre	2	0.0444444	0.3706414	0
33. wondo genet university	4	0.0888889	0.3781291	0.002573
34. Ethiopian weed science society	0	0.0444444	0	0
35. ethiopian soil science society	0	0.0444444	0	0
36. unity university	0	0.0444444	0	0
37. German technical co-operation	3	0.0666667	0.2971014	0
38. International centre for agricultural research in	15	0.7777778	0.4799331	0.0115849
39. International maize and wheat improvement	9	0.2888889	0.4510215	0.0408626
40. International centre for tropical agriculture	6	0.4888889	0.3119565	0
41. Gondar university	5	0.1777778	0.3982424	0.0137569
42. Arba minch university	0	0.1777778	0	0
43. Cornell university	6	0.9555556	0.4253953	0.0085316
44. University of south Africa	2	0.1111111	0.3565217	0
45. wollega university	2	0.2888889	0.3403162	0.0002652
46. Wollo university	2	0.1333333	0.3565217	0.0007288
Centralization	-	**0.41**	**undefined**	**0.254**

4.1.5. Innovation contributions by university and research institute: size of research and development activities

Both university and research organizations are playing paramount role by generating important knowledge and transferring via a diversity of accessible means for ease of communication. In rural agriculture knowledge system the university generated knowledge outweighs the research institutes. As shown in the figure, university cluster, blue color with different size of circles representing volume of knowledge, have more number of larger circles than the research cluster.

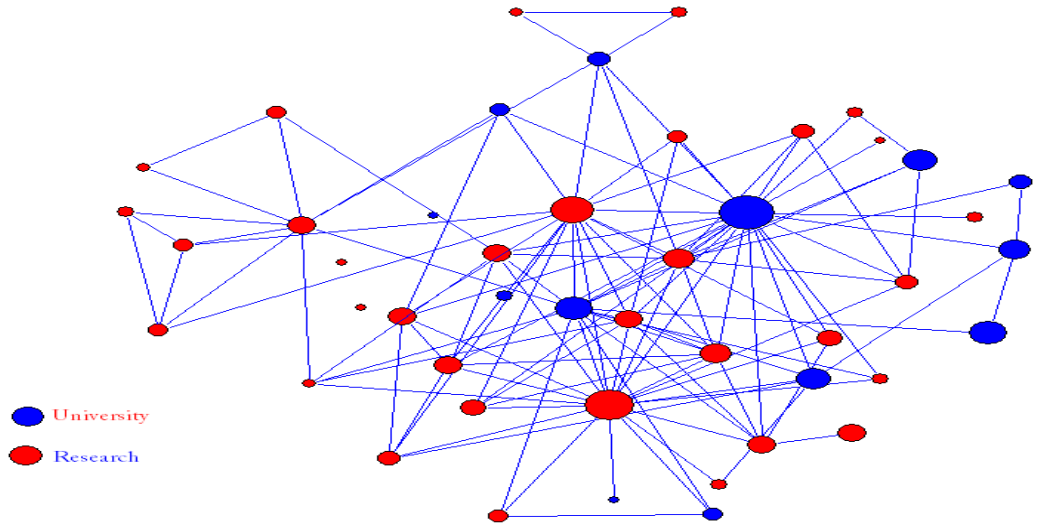


Figure11. Rate of Knowledge by co-authorship

4.1.6. Actors structural equivalence in the network

The following dendrogram shows what the different pairs of actors apart from their sub-network cluster share common behavior. The Institute of amhara agricultural research centre and University of south Africa (25 &44), institute of oromiya agriculture and Jima university(7 &26), international maize and wheat improvement centre and Jima agricultural research centre(39 &27), Awassa agricultural research centre and Wollaita agricultural centre(28 &24), sheno agricultural research centre and Gonder University (32 &41) from top part, Arba minch university and Kullumsa agriculture research centre(42 &31), wollega university and Wollo university(45 &46), wondo genet university and Ethiopian professional joint secretariat (33 & 29), german technical co-operation and mekele agricultural research centre(37 &22) in the middle, and Ministry agriculture and rural development and international Livestock research institute(5&10), Haramaya university and debrezeit agricultural research centre (6 &14), and Ethiopian institute of agricultural research and Addis Ababa university from the bottom are among actors which make the pair wise

structural similarity. The figure shows different hierarchy of differences among the whole structure which is smaller in the periphery than the core, the bottom most part. Most dissimilarity prevails between the middle part and the bottom part.

Apart from similarity of behavior in entities in each sub network system, the hierarchical clustering of rural knowledge system shows overlapping mutual interdependence between the sub network actors which shows co-integration and joint collaboration in the knowledge exchange system. The four actors hold the core position on the structure, namely: Haramaya University, Debrezeit agricultural research centre, Ethiopian institute of agricultural research, and Addis Ababa University.

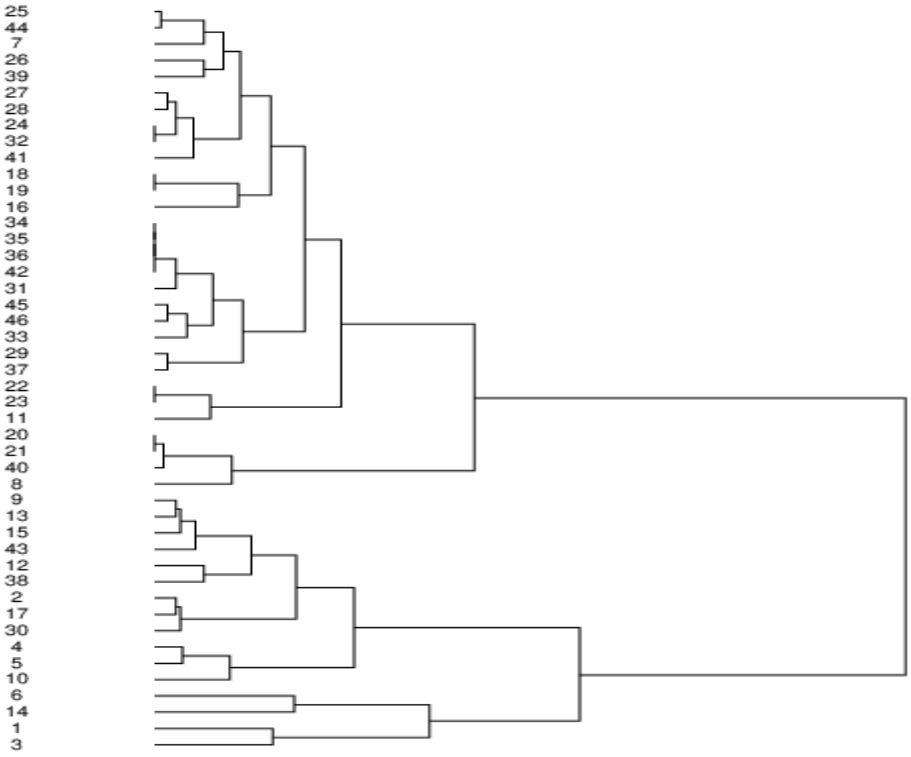


Figure12.Hierarchical Clustering [2]of Actors

[2] Hierarchical clustering is a statistical technique for subdividing units into increasingly more homogeneous subsets.

4.2.Analysis of Emprical Organizational Communication Network Structure[3]

4.2.1. Actors and their connectivity

This network consists of the following different stakeholders operating at local to national levels. 46 stakeholders represent a chain of actors from a district - region-national level. This network has ad-hoc members as well. These are women club, youth club, farmer's research group, and farmer's school. In the network those actors are represented by vertex number ranging from 44-47.The following depicts the network structures and enlists typology of actor. This approach has brought direct contact researchers and farmers; hence progress was made in bringing about integrated problem-solving approaches apart from working with farmers.

Table4. Stakeholders in agricultural technology research and diffusion

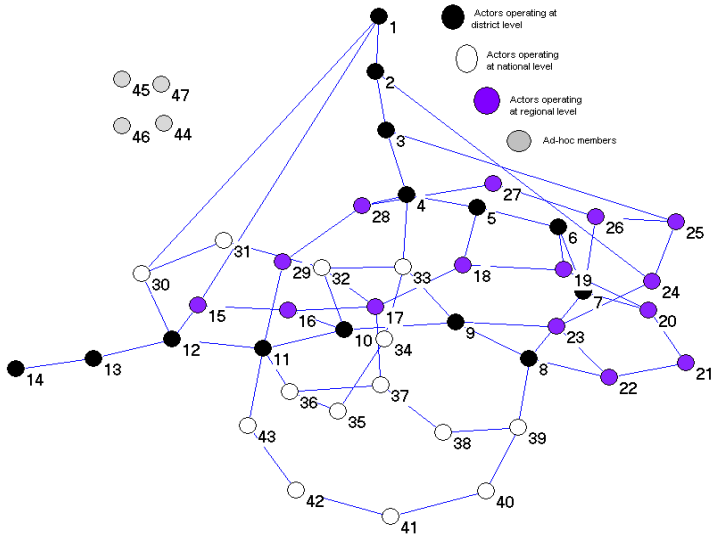


Figure13. Network of the actor

[3] The Data considered in the orgainizational network section are taken from Ethiopian Institute of agricultural research (EIAR).2000.

1. 1 - Head, zonal agriculture development department
2. 1 - Director, federal research center
3. 1 - Director, Regional research centre
4. 1 - Head, research extension division
5. 1 - Male farmer's representatives
6. 1 - Female farmer's representatives
7. 1 - Heads, departments of agricultural universities or college
8. 1 - Representatives, Ethiopian seed enterprise
9. 1 - Representatives, Agricultural input supply agencies
10. 1 - Leader, Zonal extension team
11. 1 - Commodity team leader
12. 1 - Woreda/District agricultural development department
13. 1 - Representatives of development agents
14. 1 - Subject Matter specialists/Technical team
15. 2 - Head, regional Agricultural bureau
16. 2 - Head, Extension department of the region
17. 2 - Co-coordinator, Regional research co-ordination office
18. 2 - Male farmers' representatives
19. 2 - female farmers' representatives
20. 2 - Deans, agricultural colleges/universities
21. 2 - heads, technology multiplication centers
22. 2 - representative, Ethiopian seed enterprise
23. 2 - representative, Agricultural input supply enterprise (AISE)
24. 2 - Directors, federal research centers
25. 2 - Directors, Regional research centers
26. 2 - Directors, research centers of higher learning institutions
27. 2 - Head, federal research-extension division
28. 2 - Head, regional research extension division
29. 2 - Representative, Coffee and Tea authority
30. 3 - Vice minister, Ministry of agriculture
31. 3 - Deputy Director General. Ethiopian institute of agricultural research
32. 3 - Head, Extension department of MOA
33. 3 - Head, Research Co-coordinator of EIAR
34. 3 - Head, Agriculture sector and Environment protection, ESTC
35. 3 - Heads, Regional agricultural bureaus
36. 3 - Head, Coffee and tea development authority
37. 3 - Co-coordinator, Research co-ordination unit, ABS
38. 3 - General Manager, NSIA
39. 3 - general Manager, Ethiopian Seed Enterprise (ESE)
40. 3 - Agricultural input supply enterprise
41. 3 - Vise president for research and development, AUA
42. 3 - Representatives from DBE
43. 3 - General Manager, Coffee and Tea development authority
44. 0 - v44
45. 0 - v45
46. 0 - v46

4.2.2. Joint Collaborations at different organizational levels

Joint collaborations are conducted at local (district), regional and national levels. Actors collaborate to find out farmers' common pressing problem, knowledge development, demonstration and scaling out/up under a given agro-ecological environment. According to the figure bellow, 123 refers local actors participation from local to national levels events.similarly, 213 represents regional actors who participate at all levels in the network. Likewise, joint collaboration exists between local and regional actors like listed as 12 or 21. On the other hand the single digit number represents actors participating either at local (1), regional (2) or national levels (3) only. Female and male framers are active players at local and regional levels. This kind of cluster framework fosters innovation and adoption. The horizontal collaborations between similar actors encourage and enhance communication between actors supported by vertical relation of policy making, monitoring, implementation, and evaluation to scale up/out proven improved technologies with strong shared responsibilities and positive externalities.

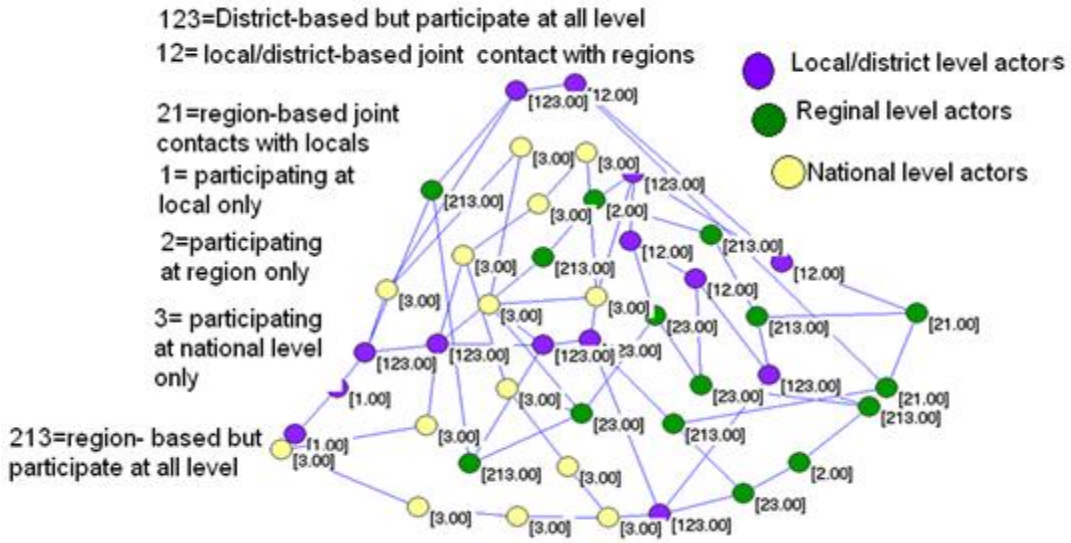


Figure14. Joint information flow among actors of different levels

4.2.3. Structural attributes of each actor and actors

The table depicts the computed attributes of the structural property of the network. Accordingly, no significantly difference is found in each actors importance measured in each column values of degree, closeness, and betweeness centrality values but those values for ad-hoc members. This shows no dominance by few, equity of knowledge generation and transfer; ease of access to knowledge and information and no control over knowledge flow. The shared social capital characterized by fair leadership with fairly distributed ties in the network, creates a better access to information by all relevant actors with multiple of intermediaries or knowledge brokers. The centralization values of 0.05 degree centralization and 0.15 betweeness centralization ensure the existence of strong shared collaboration in the

network. Closeness centralization is found undefined that indicates the presence of very close proximity in the geodesic distance of all actors.

Table5.Structural indices of individual and group actors

	C'D	C'C	C'B
Head, zonal agriculture development department	**0.06522**	**0.24016**	**0.04344**
Director, federal research center	**0.06522**	**0.24475**	**0.04763**
Director, Regional research centre	**0.06522**	**0.25115**	**0.04295**
Head, research extension division	**0.08696**	**0.28463**	**0.09633**
Male farmers representatives	**0.06522**	**0.25963**	**0.0399**
Female farmers representatives	**0.06522**	**0.23867**	**0.02168**
Heads ,departments of agricultural universities or colleges	**0.08696**	**0.265**	**0.08641**
Representatives, Ethiopian seed enterprise	**0.08696**	**0.29333**	**0.14099**
Representatives, Agricultural input supply agencies	**0.08696**	**0.32021**	**0.1432**
Leader, Zonal extension team	**0.08696**	**0.31496**	**0.11442**
Commodity team leader	**0.1087**	**0.30497**	**0.19908**
Woreda/District agricultural development department	**0.08696**	**0.26319**	**0.11451**
Representatives of development agents	**0.04348**	**0.20771**	**0.03961**
Subject Matter specialists/Technical team	**0.02174**	**0.17003**	**0**
Head ,regional Agricultural bureau	**0.06522**	**0.25789**	**0.04466**
Head, Extension department of the region	**0.06522**	**0.27845**	**0.04917**
Co-coordinator, Regional research co-ordination office	**0.08696**	**0.28048**	**0.0924**
Male farmers representatives	**0.06522**	**0.25963**	**0.05853**
female farmers representatives	**0.06522**	**0.23148**	**0.02677**
Deans, agricultural colleges/universities	**0.06522**	**0.22737**	**0.02209**
heads, technology multiplication centers	**0.04348**	**0.20998**	**0.00651**
representative, Ethiopian seed enterprise	**0.06522**	**0.24632**	**0.0389**
representative, AISE	**0.06522**	**0.26871**	**0.05578**
Directors, federal research centers	**0.06522**	**0.2432**	**0.03651**
Directors, Regional research centers	**0.06522**	**0.2343**	**0.02768**
Directors, research centers of higher learning institutions	**0.06522**	**0.24167**	**0.04523**
Head, federal research-extension division	**0.04348**	**0.2372**	**0.01965**
Head, regional research extension division	**0.06522**	**0.265**	**0.06353**
Representative, Coffee and Tea authority	**0.04348**	**0.265**	**0.05217**
Vice minister, Ministry of agriculture	**0.06522**	**0.24167**	**0.02874**
Deputy Director general. Ethiopian institute of agricultural research	**0.04348**	**0.2432**	**0.01715**
Head, Extension department of MOA	**0.08696**	**0.29333**	**0.06767**
Head, Research Co-coordinator of EIAR	**0.08696**	**0.3002**	**0.09429**
Head, Agriculture sector and Environment protection, ESTC	**0.04348**	**0.24475**	**0.01981**

Heads, Regional agricultural bureaus	**0.04348**	**0.23288**	**0.01208**
Head, Coffee and tea development authority	**0.06522**	**0.26319**	**0.05313**
Co-coordinator, Research co-ordination unit, RABS	**0.06522**	**0.26319**	**0.05408**
General Manager, NSIA	**0.04348**	**0.24167**	**0.02618**
general Manager, ESE	**0.06522**	**0.24791**	**0.07892**
Agricultural input supply enterprise	**0.04348**	**0.20883**	**0.03074**
Vise president for research and development, AUA	**0.04348**	**0.19505**	**0.0185**
Representatives from DBE	**0.04348**	**0.20439**	**0.02641**
General manager, Coffee and Tea development authority	**0.04348**	**0.24016**	**0.05235**
v44	**0**	**0**	**0**
v45	**0**	**0**	**0**
v46	**0**	**0**	**0**
v47	**0**	**0**	**0**
Centralization	**0.05266**	**undefined**	**0.15232**

4.2.4. Structural equivalence in the communication network

The Dendrogram given bellow used to show the relative joint co-ordination and mutual interdependence among the different actors in this network. In this hierarchical clustering, male farmers representatives district level(5), female farmers representatives at district level(19), Heads, departments of agricultural universities or colleges(7), Female farmers representatives at regional level(6), male farmers representatives at regional levels(18), and Deans of agricultural colleges/universities (20) are the core actors in the overall network activities. The male and female farmers and agricultural universities at district and regional level hold key positions in the joint planning, implementation, and decision making process. In general the structure shows greater degree of similarity in share of activities and this kind of model can be a good example of bottom up development approach that greater interactive process occurs among the grassroots organizations in all the processes though the structure seldom shows perfect similarity but each level of hierarchy is constructed with declined dissimilarity.

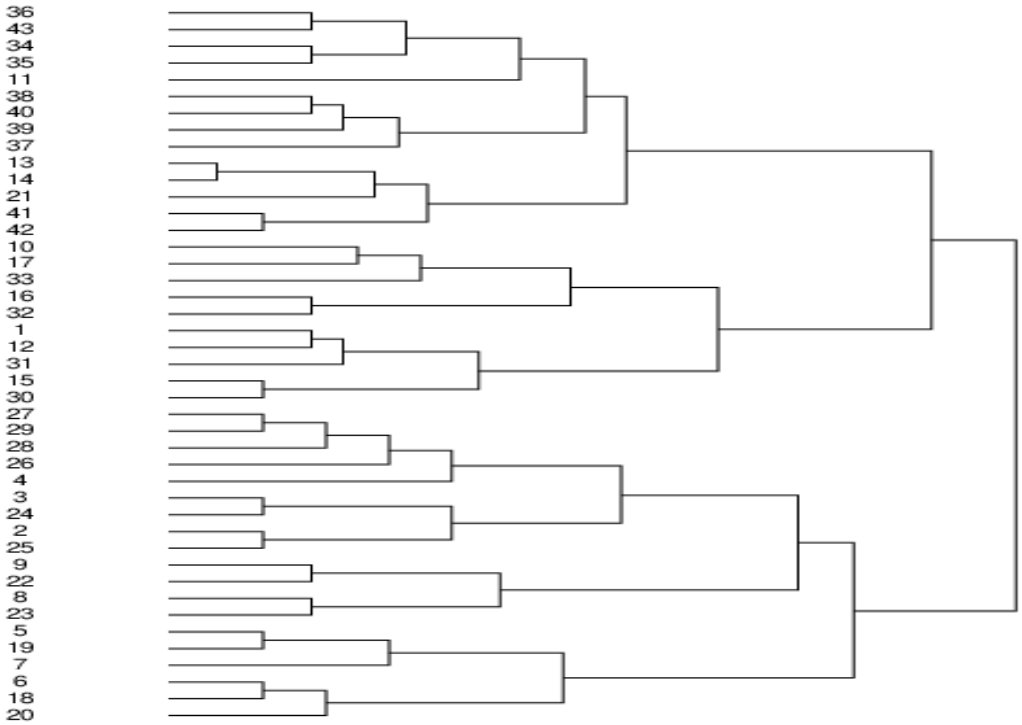


Figure15. Hierarchical clustering of actors in communication process

4.2.5. Role expectations in the clustering of the network

Even though each cluster is meant for generation and transfer of adoptable knowledge required for sustainability, the entire map of the process passes over integrated roles of the different actors involved in the three cluster subsystem of the national agriculture knowledge and innovation system at district, regional and national levels. The following model is used to show those three operational/functional clusters such as district (red), regional (green), and national level (yellow) clusters for joint planning, implementation, decision making, and policy formulation respectively.

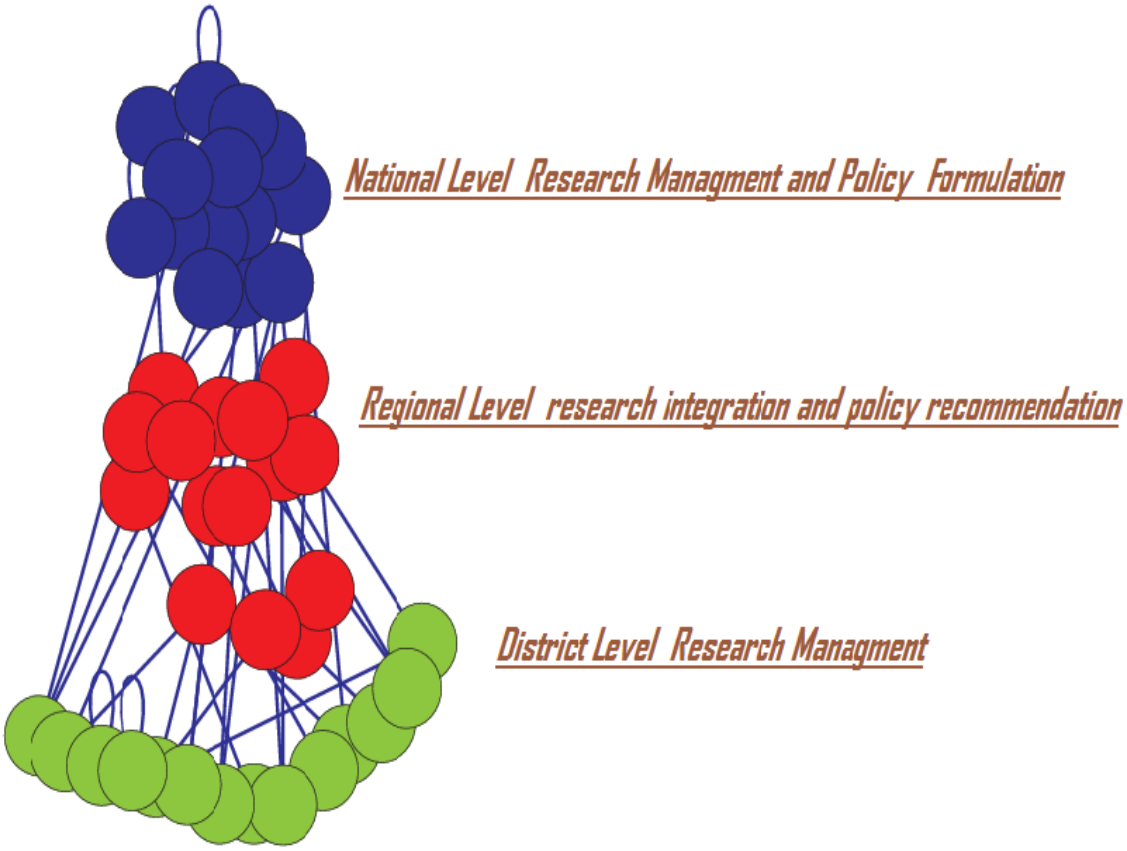


Figure16. Decision making and role integration

4.2.6. Source-Sink relationship in rural knowledge system: Knowledge-innovation trigger

The combined analysis of the bibliometeric and the communication network reveals the presence of driving force for demand for knowledge from users and (knowledge-based) farmers which in turn encourages faster innovation and creation of new knowledge. The following sociogram depicts a total of 93 actors, both involved in knowledge generation and transfer process. The green circle represents 46 actors, from bibliometeric, as a source of basic and applied knowledge and the blue circle represents 47 actors, from the empirical organization structure, as a sink for knowledge which in turn becomes nexus for innovation. The sociogram is based on the two-mode network model that actor-event relationship is explained. In this case, bibliometeric represents actors and the organizational network represents event.

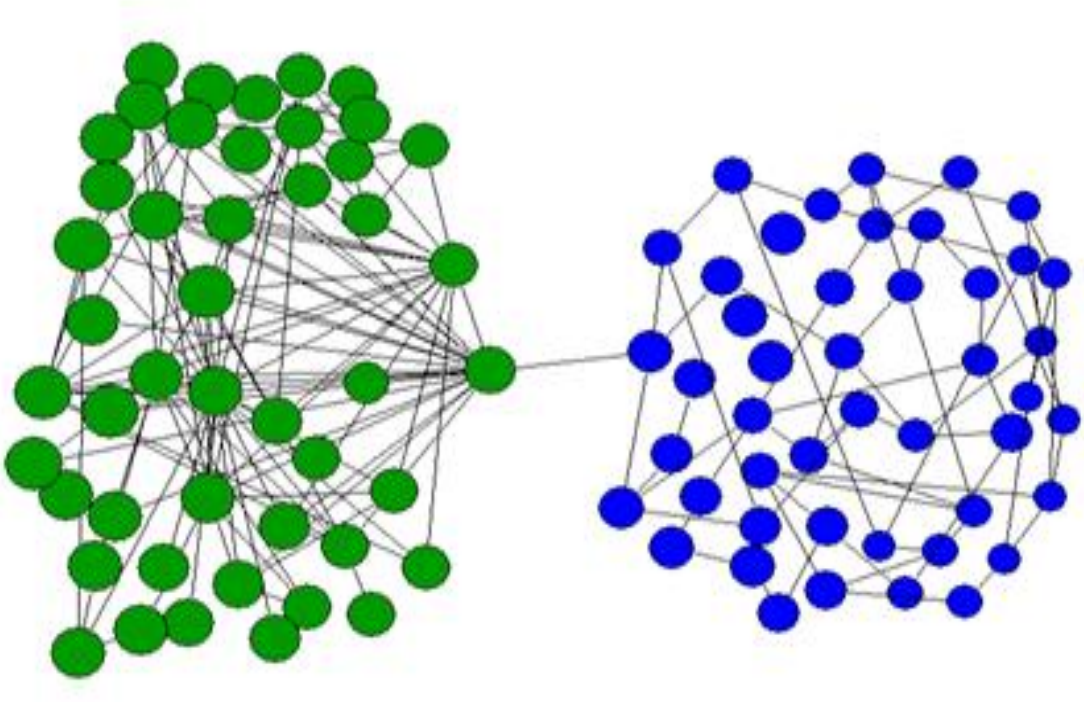


Figure17. Rural knowledge generation, and transfer model

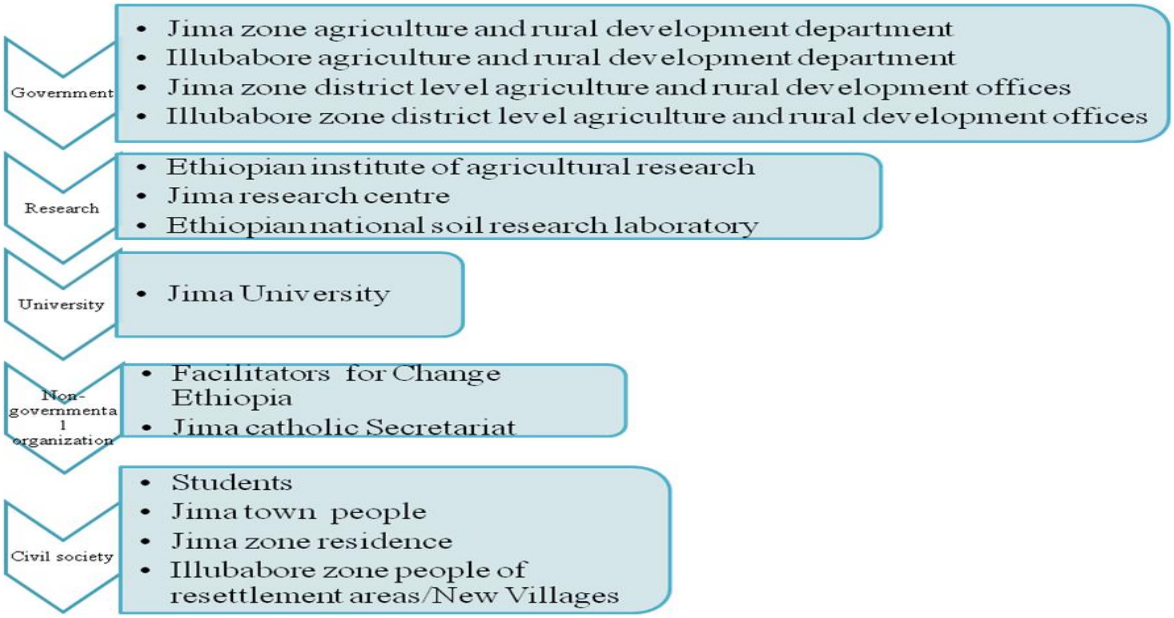
4.3. Participatory Technology Development and Scaling Up/Out: the case of soybean technologies

Legumes in general soybean technologies in particular are examples of sustainable agriculture practices. They both support organic farming system that they fix the natural (atmospheric) nitrogen which in turn adds fertility to soil and maintains the soils micro-environment. Since 2004, selected soybean technologies were generated, developed and scaled up/out. Apart from maintaining the natural environment, it is highly cash and industrial crop for economic source and nutritious diet next to milk. No part of soybean is useless in Ethiopia (Abebe, Derese and Birhanu, 2008). This study includes success stories and importance of collaboration in agriculture technology development and diffusion by involving farmers**.**

4.3.1. Types of Actors and Technology

Two technologies are developed and adopted by farmers. These are Clark63K and Bradyrhizobium japonicum, which is biological and organic fertilizer specific to soybean which increased yield by 27.8 %. Number of adopting farmer increases from 30 (innovators) to 15006 in 2004-2006 in southwestern Ethiopia. Before 2004, attempts were made but failed several times due to the top down approach. This attributes to strong collaboration among different stakeholders with shared roles and responsibility as shown by table below.

Table6. Actors in soybean technology development and diffusion



4.3.2. Knowledge transfer mechanisms and its scaling up/out

Apart from joint workshop,experimental trials, review and evaluation,training, exhibition field days, different publications using English and different local languages and excusrsion are the complimentary mechanisms to create awareness and scale up/out the technologies.Training and exhibition are conducted on soybean production and management, and soybean food preparation respectivly. The publications include application and utilization of bio-fertilizer, nutrition and food preparation, and production and management.

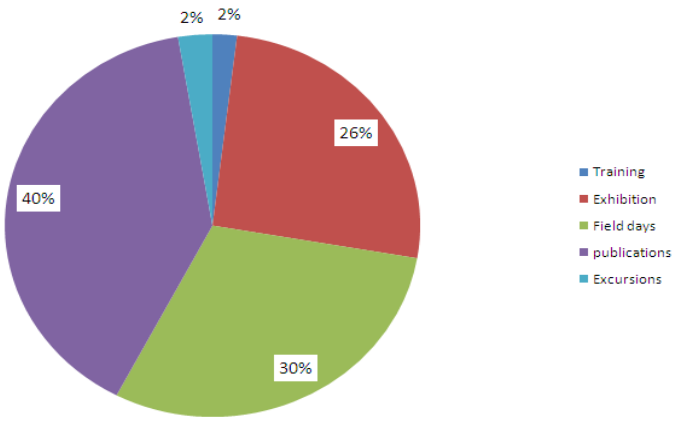


Figure18. Communication mechanisms

4.3.3. Impacts of the Participatory Action

Apart from breaking a long lasted technological laggard, the collaboration had brought about many positive outcomes. Farmers turned from maize-based monocropping to intercropping which has tremendous positive impact on household income, soil fertility, drought and biodiversity. Farmers become soybean basic seed suppliers to other farmers and contribute to supply to soybean processing industry or their agents through local level established cereal banks.

The crop heavily supports food security programs in Ethiopia especially in newly established villages in southwestern Ethiopia. It helps farmers of the area lead sedentary form of living. The training on food preparation not only enhances awareness on importance of soy food but also increased social capital and become gender sensitive in the whole process. At present, those technologies are scaling out in all regions of similar agro-ecological environment in Ethiopia under similar approach.

In general, the aggregate impact of such practices contribute to mitigation of global warming and spur national economic development via mainstreaming knowledge commons global concern, the vertical arrows on the bottom left into the national concern, the horizontal arrow on the bottom right, of overall development with premium objective of reducing carbon emission and spurring an increasingly growing economy respectively.

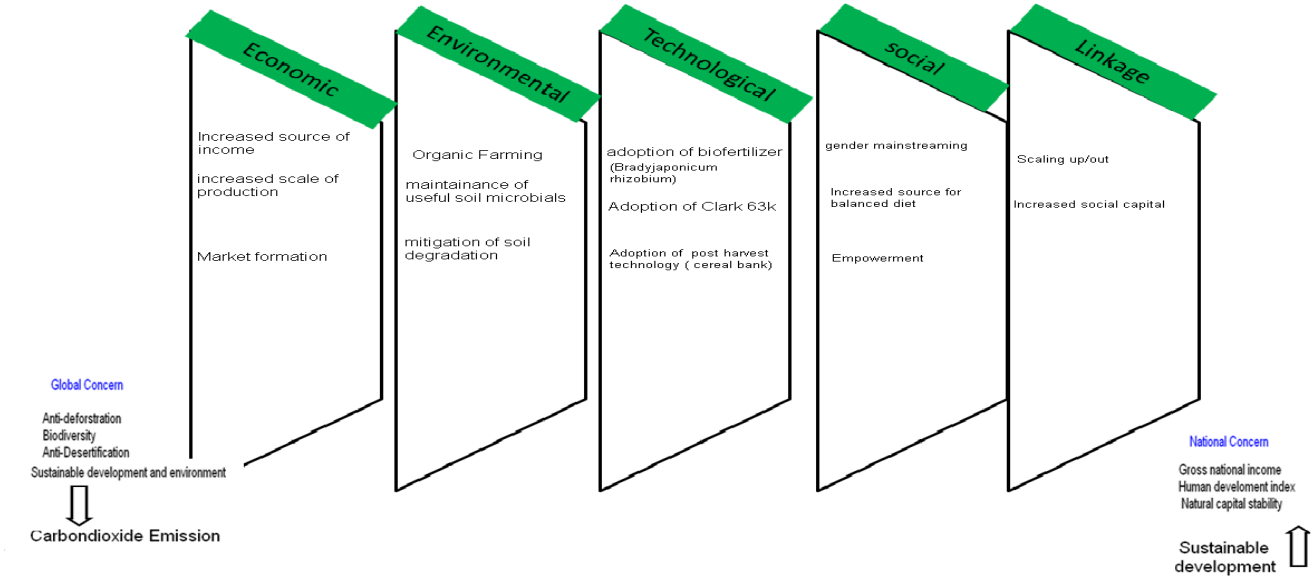


Figure19. Impacts of soybean technology

4.4.Bibliometric Analysis of the Urban Agricultural Knowledge System

4.4.1. Scientific Composition, Diversity and Complexity

Urban agriculture consists of diverse knowledge systems, both natural and social, with verifiable characteristics. Most of the available knowledge are results of individual scholars self initiative; not from the specially designed framework of institutional responsibility & accountability. When we examine the type of knowledge, each data base represents different type in scientific scale of research category. Knowledge found in ISI system mainly represents basic research focusing different academic disciplines, AGRIS system an applied research that represent adaptation of the knowledge system on the ground and RUAF system represents action research focusing and describing what urban agriculture practioners had been doing. ISI system category represents knowledge like agriculture, business economics, environmental science, & ecology, biodiversity and conservation, etc. The AGRIS category represents specific areas of what ISI represents such as agricultural economics and policy, labor and employment, etc where as RUAF category represents practical demonstrations of crop and animal production focusing and addressing different urban issues of finance and credit, food security and nutrition, reuse of wastes and waste water, and gender mainstreaming. The urban agriculture knowledge is embedded with information communication and technology system and embrained with researchers at university and research institutes.

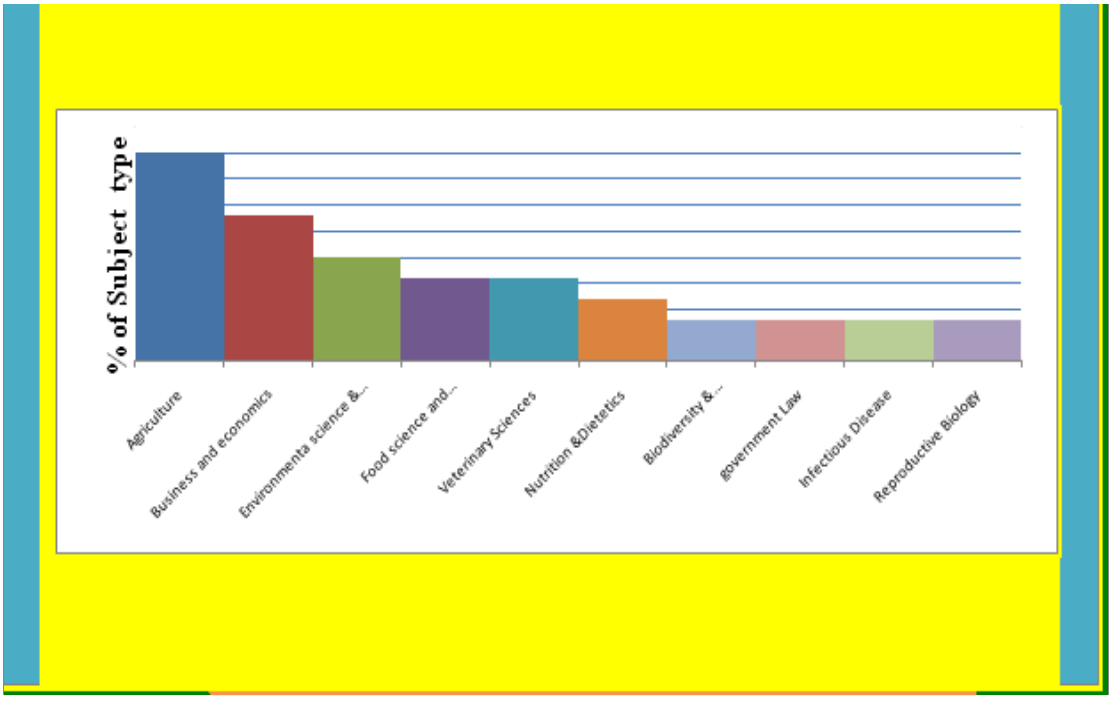


Figure20. Stock of knowledge subject to study in relation to urban agriculture by ISI Category

Figure21. Applied knowledge of urban agriculture (Agris)

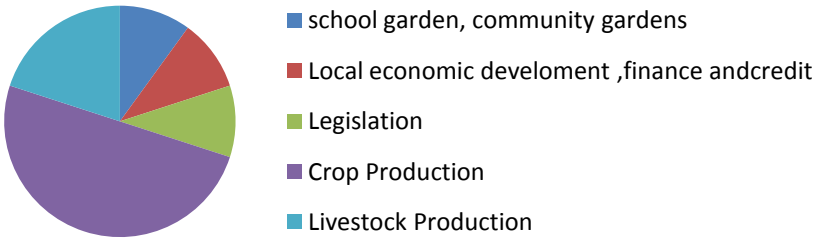


Figure22. Focus areas of knowledge produced by RUAF Category

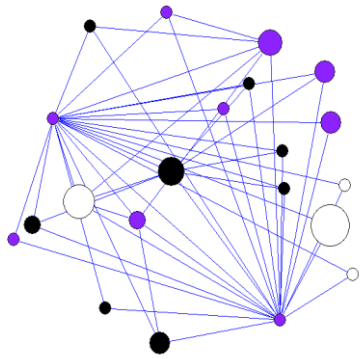
4.4.2.Actors and their connectivity

This network of urban agriculture consists of 21 nodes of actors from university, agriculture organizations, municiplity governments ,and others which have direct link to urban agriculture research and developemnt in Ethiopia for instance,prolinnova-ethiopia and farm africa-Ethiopia. The network has 54 lines, density of 0.26 and the 53 lines have values other than one. The network includes no loops and three multiple lines. Most of the lines are bidirectional/non-directional to each other with interlocking reciprocate behviour among stackholders which ensures greater connectivity and inclusiveness. This presence of interconnectivity and inclusivness creates better exchange and flow of knowledge as knowledge is a result of social interaction. Sustainable knowledge production and transfer process,however depends upon the diversity of stakeholders involved .

Table7.The network and its connectivity

Number of vertices (n): 21

	Arcs	Edges
Number of lines with value=1	0	1
Number of lines with value#1	0	53
Total number of lines	0	54
Number of loops	0	0
Number of multiple lines	0	3



Density= 0.2571429

4.4.3. Structural patterns of the network and between entities of ech sub- networks

The urban agriculture network has made to hold three partitions of Municipality governments cluster, C [1] (8), research institutes cluster, C [2] (9), and Universities cluster, C [3] (4). The first cluster includes eight municipal government organizations, the second nine research organizations and the third four university organizations. The first cluster demonstrates the strong mutual collaboration. Cluster1 alone represents 38% of the total clusters which together contributes 80.9 % cumulative frequency with cluster2.

Table8.Partition clusters and frequency distribution of cluster numbers

Rank	Vertex	Cluster	Id
1	6	3	Haramaya university
2	12	3	Jima university
3	11	3	Addis Ababa university
4	17	3	Ethiopian civil service college
5	18	2	Oromiya Bureau of agriculture
6	7	2	ministry of agriculture and rural development
7	15	2	Hawasa Agricultural research centre
8	14	2	Melkassa agricultural research centre
9	13	2	Ethiopian institute of agriculture
10	20	2	Ethiopian professional joint secretariat
11	9	2	Deberezeit agricultural research centre
12	19	2	Holeta Agricultural research centre
13	16	2	Ethiopian society of animal production
14	1	1	Urban agriculture Bureau
15	3	1	Prolinnova_Ethiopia
16	4	1	Farm africa-ethiopia
17	21	1	Addis Ababa City administration
18	10	1	National urban planning institute
19	5	1	Government of Ethiopia
20	8	1	central statistical agency
21	2	1	Institute of sustainable development Ethiopia

Frequency distribution of cluster numbers:

Cluster	Freq	Freq%	CumFreq	CumFreq%	Representative
1	8	38.0952	8	38.0952	Urban agriculture Bureau
2	9	42.8571	17	80.9524	ministry of agriculture and rural development
3	4	19.0476	21	100.0000	Haramaya university

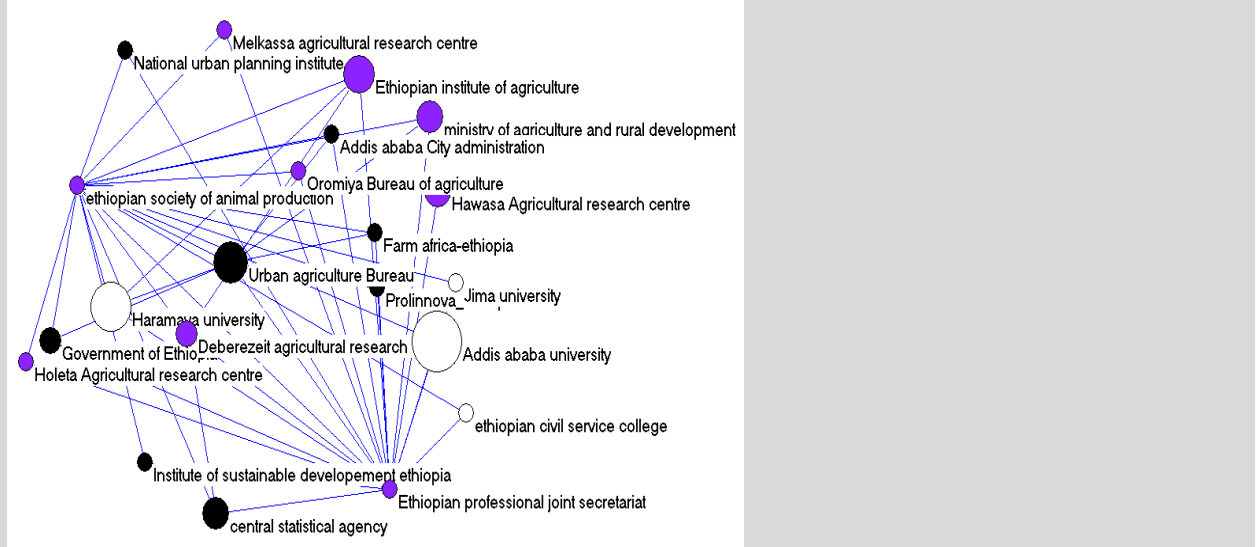


Figure23. The visualization of organization network

4.2.4. Actors and their property in each of the sub-networks

The table below shows the members of each sub-network in partition. In the first cluster urban agriculture bureau, Ethiopian proffessionals joint secretariat and Ethiopian society of animal production has 5, 13, and 13 neighbors of direct relationship in information exchange. The latter two define the leadership position in the network. Their ties directly influence their mutual contact and communication within themselves. The higher the contact, greater will be the importance of produced knowledge in satisfying expectations which leads to a central position in the entire network system.

Table9. Clusters and number of contacts in each entity of the sub-networks

Cluster1	Cluster2	Cluster3
5 - Urban agriculture Bureau	4 - Ministry of agriculture and rural development	0 - Haramaya University
2 - Institute of sustainable development Ethiopia	3 - Deberezeit agricultural research centre	2 - Addis Ababa University
1 - Prolinnova_Ethiopia	4 - Ethiopian institute of agriculture research	2 – Jima University
1 - Farm africa-ethiopia	3 - Melkassa agricultural research centre	2 - Ethiopian Civil Service College
2 - Government of Ethiopia	2 - Hawasa Agricultural research centre	
2 - Central statistical agency	13 - Ethiopian society of animal production	
0 - National urban planning institute	4 - Oromiya Bureau of agriculture	
3 - Addis Ababa City administration	4 - Holeta Agricultural research centre	
	13 - Ethiopian professional joint secretariat	

4.2.5. Centralty indices of the sub-networks

The sub-group centrality indices analysis result depicts cluster1 exhibits a closeness centralization of 0.87 and betweeness centralization of 0.37. Unlike the group centralization values, the individual actor's centrality shows more difference. In the case of cluster two, two actors have degree and centrality values equal to 1.This depicts heavily centralized system in the two clusters. Though Ethiopian institute of agricultural research, Debrezeit agricultural research centre, and Melkassa agricultural research centre in research clusters have more ties than others

in the cluster newtork, the Ethiopian society of animal production, and Ethiopian Joint professional secretariats overtake the maximum position for that they have more individual sources, access and many brokerage place in the two clusters system. However, more knowledge brokerage nodes are available in the research cluster. This ensures that research institutes are most important knowledge and transfer centers.

Table10.Cenrallity indices of partitions cluster1 &2(left to right)

	DC	**CC**	**BC**
	0.571429	0.625	0.2857143
	0	0	0
	0.142857	0.3571	0
	0.142857	0.357143	0
	0.142857	0.357143	0
	0	0	0
	0	0	0
	0.142857	0.357143	0
centralization	**0.84**	**0.87**	**0.38**

	DC	CC	BC
	0.25	0.571429	0
	0.375	0.615385	0
	0.5	0.666667	0.0119048
	0.375	0.615385	0
	0.25	0.571429	0
	1	1	0.3333333
	0.25	0.571429	0
	0.25	0.571429	0
	1	1	0.3333333
Centralization	0.83684	0.88626	0.37539

More importantly, the figures below show more difference in the structure between the municipal and research stakeholders. The intra-connectivity is higher in research stakeholders. This entails a need to strengthen and empower intra-communication within urban agriculture stakeholder cluster apart from the need of communication with research stakeholders.

Figure24. Network structure of cluster1 (left) and cluster (2)

4.2.6. Individual and Group Structural Indices

Table11.Centrality indices of the actors

	g=21		
	D'c	**C'c**	**B'c**
Urban agriculture Bureau	0.45	0.625	0.0284211
Institute of sustainable development Ethiopia	0.2	0.5263158	0
Prolinnova_Ethiopia	0.2	0.5405405	0
Farm africa-ethiopia	0.15	0.5405405	0
Government of Ethiopia	0.2	0.5405405	0
Haramaya University	0.25	0.5714286	0.0035088
Ministry of agriculture and rural development	0.25	0.5405405	0
Central statistical agency	0.25	0.5405405	0
Deberezeit agricultural research centre	0.25	0.5714286	0.0035088
National urban planning institute	0.15	0.5405405	0
Addis Ababa University	0.2	0.5263158	0
Jima University	0.2	0.5263158	0
Ethiopian institute of agriculture	0.3	0.5882353	0.0087719
Melkassa agricultural research centre	0.15	0.5405405	0
Hawasa Agricultural research centre	0.1	0.5263158	0
Ethiopian society of animal production	1.3	1	0.41
Ethiopian civil service college	0.2	0.5263158	0
Oromiya Bureau of agriculture	0.2	0.5263158	0
Holeta Agricultural research centre	0.2	0.5263158	0
Ethiopian professional joint secretariat	1.25	1	0.3826316
Addis Ababa City administration	0.25	0.5405405	0
Centralization	**0.41**	**0.89**	**0.39**

Urban agriculture bureau holds 8 neighbors and 0.45 closeness centrality. Urban agriculture plays as the second hub in this network. Ethiopian institute of agricultural research and Debrezeit agricultural research centre, Haramya University, Addis Ababa University, and Jima University hold the periphery position in the network. Similarly, closeness centrality of all the actors in the network is within the degree of reachability though the Ethiopian society of animal production and the Ethiopian professional joint secretariat are also the most reachable followed by the urban agriculture bureau. They have closeness centrality of 1 and 0.625 respectively. With the same token, they play the decisive role for continuous flow of information in the network that the betweeness centrality of Ethiopian society of animal production and Ethiopian professional joint secretariat are 0.41 and 0.38 respectively. In the network it is observable that group centralization is the highest in the case of closeness centrality which do not insures strong flow of information of knowledge that all to play a game of access to and control over knowledge seems the minimum. That is, in all the actors centralization, the groups centrality exhibit degree centrality of 0.84, closeness centrality of 0.89 and 0.38 of betweeness centrality. In the network, professional societies and bureau of urban agriculture are the first and the second central to the network. Ethiopian society of animal production and Ethiopian professional joint secretariat possess 20 neighbors which scores 1 point each in closeness centrality.

4.2.7. Application of geodesics

The geodesic distances of all actors in the network from urban agriculture bureau shows that they are either 1 or 2 point far of urban agriculture. The institutions with geodesics 1 are those actors with lesser or least produced knowledge and have lesser degree .This can be learnt that important actors in the knowledge production cluster such as universities and research institutes are loosely connected. This can also be learnt as less connectivity between /among different stakeholders which could affect the important role play in joint planning-implementation continuum, and their feedback loop system.

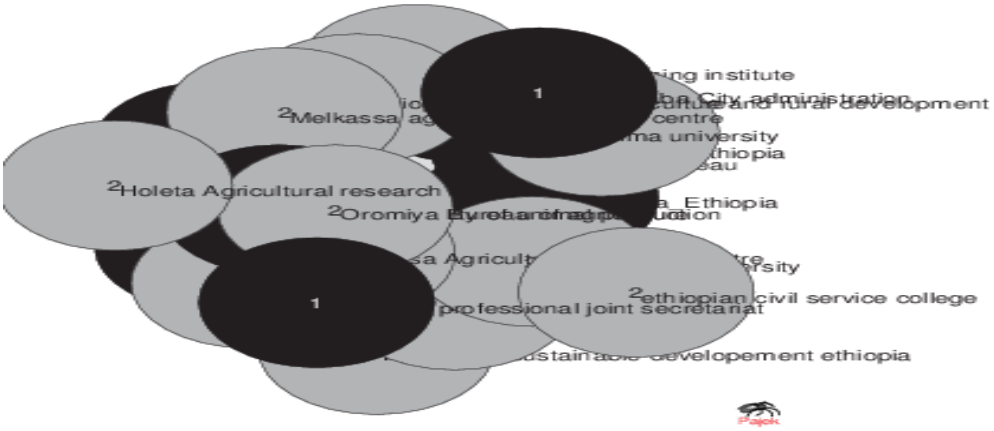


Figure25.All neighbors of urban agriculture bureau

4.2.8. Rate of knowledge and transfer by each actor

The following sociogram shows different size of the circles which represent the magnitude of knowledge generation. The line values represent the size of contact within the network. The number in bracket represent amount of publication records in the respective institution beneath it. In this case of knowledge generation, the universities are the premium, however. Addis Ababa University is the leading followed by the Haramaya university.

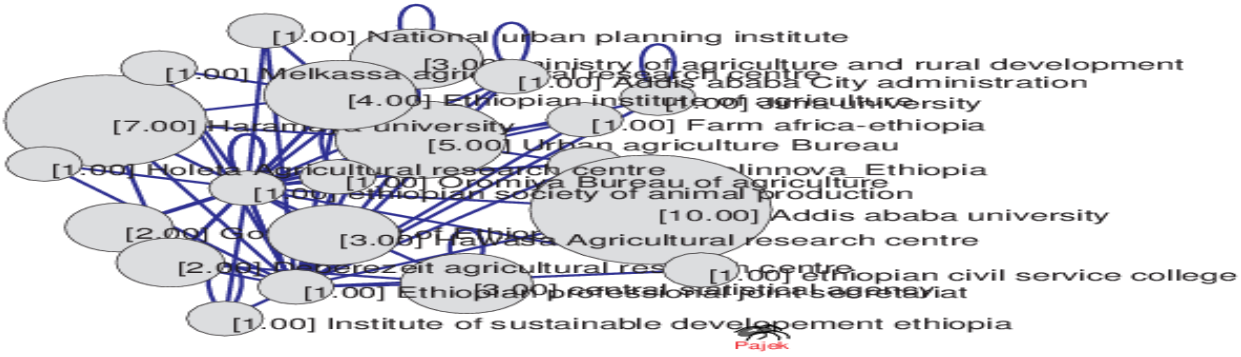


Figure26.Knowledge generation and transfer network

The network in the urban agricultural research system in Ethiopia represents 21 nodes of different stakeholders which consist of mainly national universities, research institutes and municipal government. The number in the parenthesis indicated is the size of knowledge record that actor embedded with.

4.4.9. Structural equivalence in a network

Roles, making contacts, are very important in network in a given position. The Dendrogram below show how similar are pairs of actors and represents hierarchical clustering. The hierarchical clustering in the urban agriculture knowledge system consists of pairs of vertices like national urban planning institute and Melkassa agricultural center (10 & 14), Prolinnova-Ethiopia and farm Africa-Ethiopia(3 &4), Institute of sustainable development Ethiopia and Addis Ababa university(2 & 11), Jima university and Ethiopian civil service college(12 &17), Ethiopian society of animal production and Holeta agricultural research centre(16 & 19), ministry of agriculture and rural development and Addis Ababa City administration(7 & 21),and Ethiopian professional joint secretariat and Ethiopian society of animal production(20 and 16). Groups of vertices like Institute of sustainable Developpement Ethiopia, Addis Ababa university, Jima university, Ethiopian civil service college, Oromiya Bureau of agriculture & Holeta agricultural research centre have similar positions, in this case less number of ties, that make them structural equivalence that they have the same number of ties within each pairs but show greater structural difference with ties Ethiopian professional joint secretariat and Ethiopian

society of animal production (20 and 16). Vertex pairs, 16 and 20 are considered core or major role players as being epicenter for knowledge exchange as they have the most maximum ties in this hierarchical clustering. However, the hierarchy has hardly shown the existence of strong collaboration with other third party, actors out of the domain in the sub-network cluster. This can be taken as panacea for bringing about sustainable development. The Dendrogram is generated using dissimilarity indices using dissimilarity scores of the vector partition in the network using pajek tools (appendix).

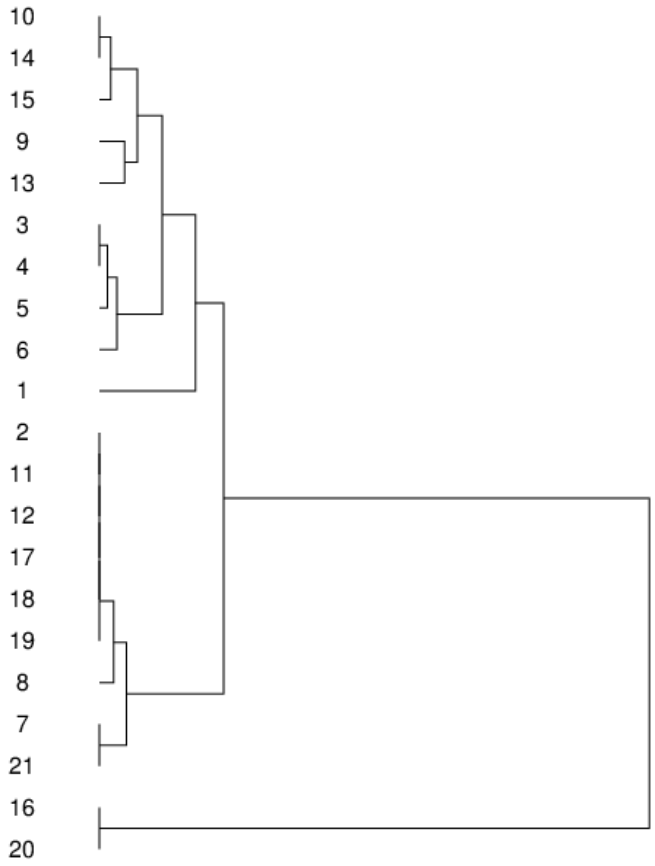


Figure27. Dendrogram of actor

4.5. Joint Analysis of the Bibliometerics Knowledge System

4.5.1. Diversity and redundancy

The joint network of the bibliometeric analysis represents 67 actors connected by 298 non-directed lines. The average distribution of line between each line is about 0.13. Unlike the separate analysis, this joint analysis depicts increased diversity of actors and complexity of their interaction. Such diversity and connectivity are useful in addressing sustainability issues.

Table12. Size, diversity and connectivity in the joint network

	Arcs	Edges
Number of vertices (g): 67		
Number of lines with value=1	0	2
Number of lines with value#1	0	296
Total number of lines	0	298
Number of loops	0	0
Number of multiple lines	0	93

Density = 0.1347806

Different actors had participated though same actors had appeared in both knowledge systems. As they represent a new knowledge each time they appeared taken independently. The actors in rural agriculture outweigh urban agriculture knowledge system. From a total of 67 actors, 21 are in urban agriculture knowledge system.

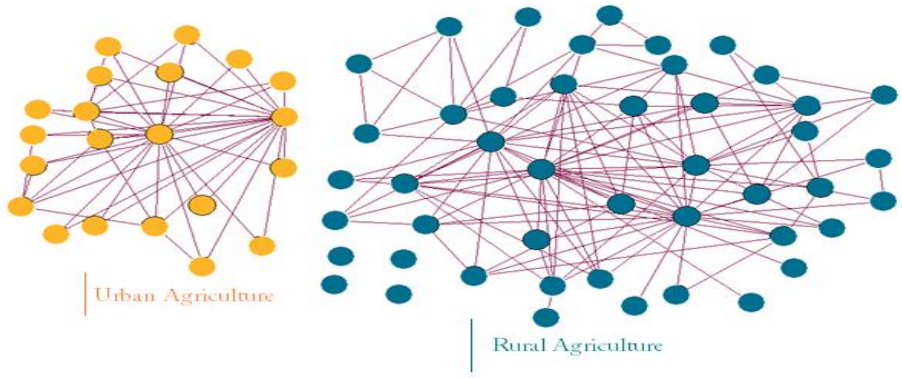


Figure28.Knowledge capital (redundancy)

4.5.2. Degree of Innovation, transferability and /or inter-exchangeability

Despite the difference in size of knowledge generated, universities in both systems correspond to the highest volume. Haramaya University and Addis Ababa University scored highest records in rural and urban agriculture knowledge system respectively. This might be the fact that their focus and proximity affect the difference. Generally it is learnt that more than research institutes, take the premium position in keeping on the knowledge/innovation process. In the figure below, the size of circles with green in colors represent universities corresponding to the degree of knowledge each produced. They also had direct link to the international research organization which contribute to technology transfer despite more participation in this regard is more in rural agriculture.

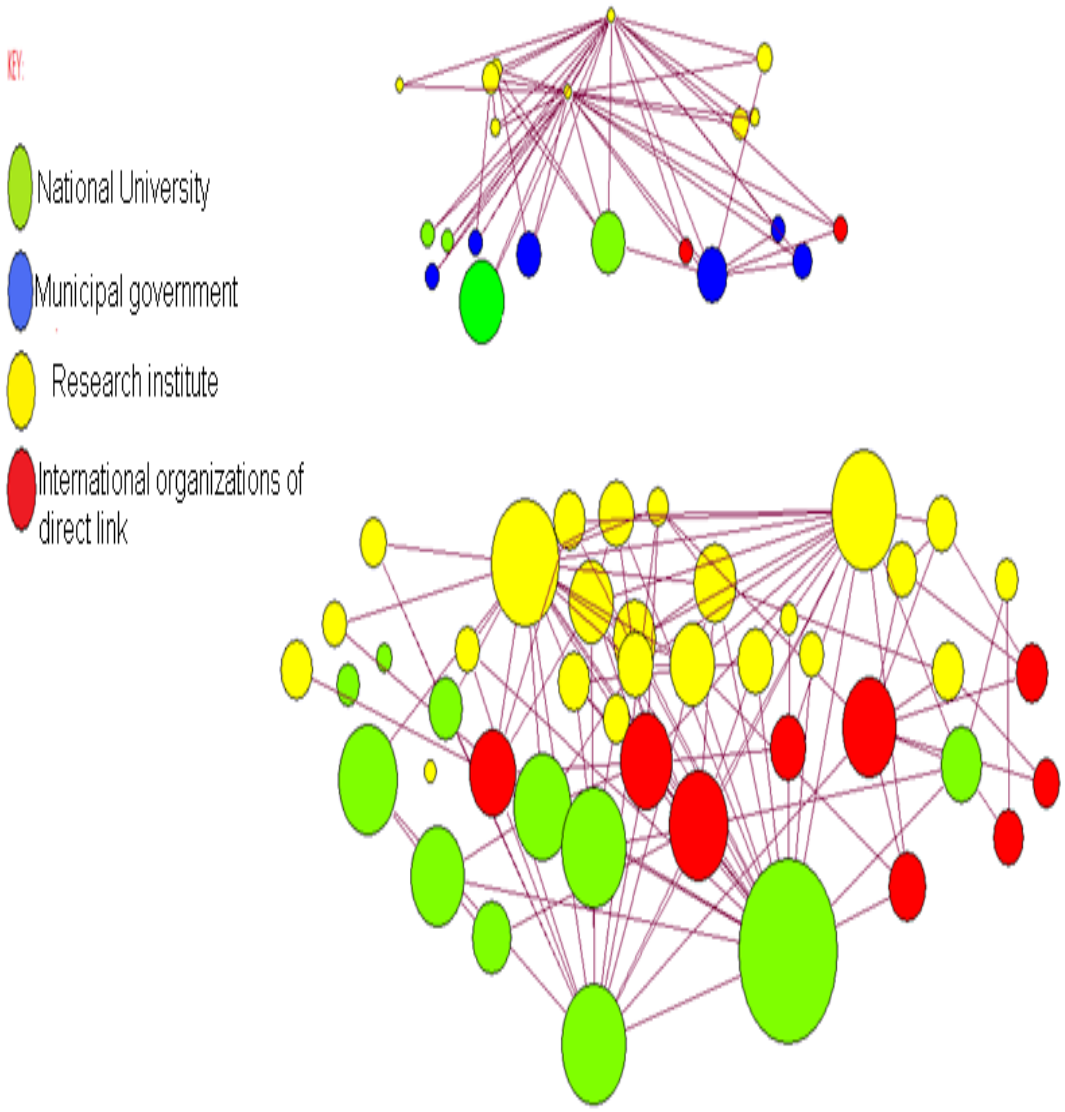


Figure29. Rate of knowledge generation and transfer in agricultural knowledge system

4.5.3. Positive knowledge and innovation externality

In spite of the fact that the two systems are working independently; there exists some university and research stakeholders operating in both systems. This will have a positive impact on the user side provided that they have an easy access to knowledge. Nevertheless, utilization of such positive externalities requires a strong link to the direct users such as urban farmers and their need like the case discussed for rural agriculture. The presence of same actors in the both urban and rural agriculture knowledge system ensures the possibility of knowledge transferability or exchange while discovering important innovation opportunities to urban agriculture knowledge and information system where minimum research and development exist in this sector though it does hardly ensure accessibility to urban farmers. This only ensures availability of knowledge of sustainability. Getting the required knowledge and skill transferred to farmers not only shows effective adoption of important sustainable agricultural technologies but also plays a great role for its scaling up/out and continuity as farmer to farmer technology extension is very important. Hence, it can be taken as an issue of sustainability. The next section explores the possibility of sustainability of knowledge defining the structural hole through collective analysis of the both systems.

4.6. Collective Analysis: All in one; all for one case

4.6.1. Connectivity, diversity, and complexity

Union of the individual system components, both vertices and lines, of rural agriculture, rural organizational network, and urban agriculture could produce a general network with 114 actors of different knowledge which are connected by 307 lines. This type of system is essential for designing a sustainable knowledge which can solve different problems of food security, employment, health, risk and uncertaininty. Adopting appropriate knowledge to urban agriculture from rural agriculture knowledge system builds redundant system which provides supplementary food resources by creating urban food landscape. Creating such landscape in turn creates access to utilization of organic wastes which are in many cases hazardous to human health, avoids loss of income due to travel and /or damage.

Table13. Connectivity and complexity of the network

Number of vertices (g): 114

	Arcs	Edges
Number of lines with value=1	0	60
Number of lines with value#1	0	247
Total number of lines	0	307
Number of loops	0	0
Number of multiple lines	0	74

Density [no loops allowed] = 0.047663

4.6.2. The Social capital and organizational network

Centrality and centralizations values reflect different, yet complimentary characteristics between single actor entities, its sub network and among networks. As demonstrated in the table below, actors like Haramaya university, Ethiopian institute of agricultural research, Deberezeit agricultural research centre, Addis Ababa university, Ethiopian society of animal production and Ethiopian professionals joint secretariat enjoy greater leadership role. They have degree values of 43, 35, 29, 22, 22 and 21 which show their extent of interaction with other network actors. Unlike the individual network analysis, those actors in this case increased the network as they have relatively higher score of degree and betweeness centrality values.

Table14.centrality and centralization indices

Actor[4]	Degree	D'C	C'C	B'C
Ethiopian institute of agricultural Research	35	0.309735	0.232389	0.025713
Ethiopian crop science society	13	0.115044	0.179825	0.000656
Addis Ababa university	22	0.19469	0.218917	0.019822
International crops research for semi-arid tropics	8	0.070797	0.169722	0.000685
Ministry agriculture and rural development	8	0.070797	0.164188	0.000184
Haramaya university	43	0.380531	0.247627	0.042627
Institute of Oromiya agriculture	5	0.044248	0.175643	0.000638
Farm Africa	13	0.115044	0.169722	0.012585
Swedish international development agency	6	0.053097	0.160694	0
international Livestock research institute	17	0.150443	0.204125	0.009485
Mekele university	10	0.088496	0.184211	0.013859
Adet agricultural research centre	14	0.123894	0.193657	0.00062
Sinana agricultural research centre	9	0.079646	0.171651	0
Debrezeit agricultural research centre	29	0.256637	0.222136	0.020733
Holeta agricultural research centre	6	0.053097	0.171651	0.00011
Bahir dar agricultural research centre	12	0.106195	0.186485	0.006759
Melkassa agricultural research centre	10	0.088496	0.177709	0.0004
Ethiopian institute of development research	5	0.044248	0.154135	0
Ethiopian Civil service college	5	0.044248	0.154135	0
agriculture Bureau of southern nation ,nationalities and regional people state	7	0.061947	0.154135	0.001354
Agriculture research centre of southern nation, nationalities and regional people state	7	0.061947	0.154135	0.001354
Mekele agricultural research centre	4	0.035398	0.124837	0
NORAGIC	4	0.035398	0.124837	0
Wollaita agricultural research centre	2	0.017699	0.149557	0
Institute of amhara agricultural research centre	3	0.026549	0.146653	0
Jima university	8	0.070797	0.171651	0.001216
Jima agricultural research centre	4	0.035398	0.171651	0
Awassa agricultural research centre	2	0.017699	0.152578	0.000175

[4] Appearance of same vertex more than one time refers to the vertex that has different knowledge contents either in rural or urban agricultural knowledge and information system.

Ethiopian professionals joint secretariat	5	0.044248	0.141171	0.002017
Ahri Alert research centre	7	0.061947	0.165992	0.000116
Kullumsa agriculture research centre	1	0.00885	0.122807	0
Sheno agricultural research centre	2	0.017699	0.149557	0
wondo genet university	4	0.035398	0.152578	0.000403
Ethiopian weed science society	0	0	0	0
Ethiopian soil science society	0	0	0	0
unity university	0	0	0	0
German technical co-operation	3	0.026549	0.119883	0
International centre for agricultural research in the dry areas	15	0.132743	0.193657	0.001812
International maize and wheat improvement centre	9	0.079646	0.181991	0.006393
International centre for tropical agriculture	6	0.053097	0.125877	0
Gondar university	5	0.044248	0.160694	0.002152
Arba minch university	0	0	0	0
Cornell university	6	0.053097	0.171651	0.001335
University of south Africa	2	0.017699	0.14386	0
wollega university	2	0.017699	0.137321	4.15E-05
Wollo university	2	0.017699	0.14386	0.000114
Urban agriculture Bureau	9	0.079646	0.115132	0.000853
Institute of sustainable Developpement Ethiopia	2	0.017699	0.096953	0
Prolinnova_Ethiopia	4	0.035398	0.099573	0
Farm 52Africa-ethiopia	3	0.026549	0.099573	0
Government of Ethiopia	4	0.035398	0.099573	0
Haramaya university	5	0.044248	0.105263	0.000105
ministry of agriculture and rural development	3	0.026549	0.099573	0
central statistical agency	3	0.026549	0.099573	0
Deberezeit agricultural research centre	5	0.044248	0.105263	0.000105
National urban planning institute	3	0.026549	0.099573	0
Addis Ababa university	2	0.017699	0.096953	0
Jima university	2	0.017699	0.096953	0
Ethiopian institute of agriculture	6	0.053097	0.108359	0.000263
Melkassa agricultural research centre	3	0.026549	0.099573	0
Hawasa Agricultural research centre	2	0.017699	0.096953	0
Ethiopian society of animal production	22	0.19469	0.184211	0.01231
Ethiopian civil service college	2	0.017699	0.096953	0
Oromiya Bureau of agriculture	2	0.017699	0.096953	0
Holeta Agricultural research centre	2	0.017699	0.096953	0
Ethiopian professional joint secretariat	21	0.185841	0.184211	0.011489
Addis Ababa City administration	3	0.026549	0.099573	0
Head, zonal agriculture development department	3	0.026549	0.099013	0.007105

Director, federal research center	3	0.026549	0.100905	0.00779
Director, Regional research centre	3	0.026549	0.103543	0.007024
Head, research extension division	4	0.035398	0.117349	0.015755
Male farmers representatives	3	0.026549	0.107041	0.006527
Female farmers representatives	3	0.026549	0.098398	0.003545
Heads ,departments of agricultural universities or colleges	4	0.035398	0.109256	0.014133
Representatives, Ethiopian seed enterprise	4	0.035398	0.120932	0.023059
Representatives, Agricultural input supply agencies	4	0.035398	0.132018	0.023422
Leader, Zonal extension team	4	0.035398	0.129853	0.018715
Commodity team leader	5	0.044248	0.125731	0.032561
Woreda/District agricultural development department	4	0.035398	0.108508	0.018729
Representatives of development agents	2	0.017699	0.085633	0.006479
Subject Matter specialists/Technical team	1	0.00885	0.070098	0
Head ,regional Agricultural bureau	3	0.026549	0.106323	0.007305
Head, Extension department of the region	3	0.026549	0.114798	0.008041
Co-coordinator, Regional research co-ordination office	4	0.035398	0.115636	0.015114
Male farmers representatives	3	0.026549	0.107041	0.009573
female farmers representatives	3	0.026549	0.095434	0.004379
Deans, agricultural colleges/universities	3	0.026549	0.09374	0.003612
Heads, technology multiplication centers	2	0.017699	0.086569	0.001065
Representative, Ethiopian seed enterprise	3	0.026549	0.101552	0.006362
Representative, AISE	3	0.026549	0.110784	0.009123
Directors, federal research centers	3	0.026549	0.100267	0.005971
Directors, Regional research centers	3	0.026549	0.096598	0.004528
Directors, research centers of higher learning institutions	3	0.026549	0.099636	0.007398
Head, federal research-extension division	2	0.017699	0.097791	0.003213
Head, regional research extension division	3	0.026549	0.109256	0.01039
Representative, Coffee and Tea authority	2	0.017699	0.109256	0.008534
Vice minister, Ministry of agriculture	3	0.026549	0.099636	0.004701
Deputy Director general, Ethiopian institute of agricultural research	2	0.017699	0.100267	0.002805
Head, Extension department of MOA	4	0.035398	0.120932	0.011068
Head, Research Co-coordinator of EIAR	4	0.035398	0.123766	0.015422
Head, Agriculture sector and Environment Protection, ESTC	2	0.017699	0.100905	0.00324
Heads, Regional agricultural bureaus	2	0.017699	0.096013	0.001975
Head, Coffee and tea development	3	0.026549	0.108508	0.00869

authority					
Co-coordinator, Research co-ordination unit, ABS	3		0.026549	0.108508	0.008846
General Manager, NSIA	2		0.017699	0.099636	0.004282
general Manager, ESE	3		0.026549	0.102207	0.012907
Agricultural input supply enterprise	2		0.017699	0.086098	0.005028
Vice president for research and development, AUA	2		0.017699	0.080417	0.003026
Representatives from DBE	2		0.017699	0.084267	0.004319
General manager, Coffee and Tea development authority	2		0.017699	0.099013	0.008563
v44	0		0	0	0
v45	0		0	0	0
v46	0		0	0	0
v47	0		0	0	0
Centralization		**-**	**0.17035**	**undefined**	**0.38866**

The network is composed of stakeholder's expertise from basic and applied science of natural and social sciences to practioners. The centralization values show fair composition of actors with proximate to each other, degree centralization and closeness centralization, and diversity of access to knowledge, betweeness centralization. This kind of network is not only useful to generate adoptable knowledge based on users demand and addresses the context of its utilization to solve local problems like food security and poverty but also play important roles on transferring new ideas of development while sustaining the socio-ecological environments particularly to farmers.

4.6.3. The status of knowledge composition and exchange

The following dendrogram shows the overlapping positions based on knowledge transferring role of the stakeholders in the overall network. Unlike the different individual and joint analysis done before, this structure narrower difference of knowledge exchange potential integration of the different system actors. It represents little dissimilarity between pairs but increasing in the different hierarchy. Actors like 12, 38,1,3,6 and 4 are core actors that they greater ties that build greater relation in the network to exploit knowledge. This entails that network organization strengthens innovation and adoption process because such system increases diversity and composition of actors, which in turn pay for effective transfer of knowledge. Such system shows greater resilience that the different actors involved are embedded with different knowledge of sustainability that at same time augments the robustness of sustainability of the knowledge. In another word, the structure shows how socio-ecological and socio-economical environment can be integrated that the system represents basic research from the university, applied and adaptive knowledge from the research institutes and practical knowledge of experience from the practioners or farmers with high possibility of integrating the different knowledge contents.

Unlike in the individual case, the collective analysis shows increasing level of integration among actors in the different system category. This can be a good showcase for production of integrated

knowledge addressing socio-ecological and socio-economic environments or knowledge of sustainability and knowledge transfer among different actors of different systems ensuring sustainability of the knowledge. Increasing size of interconnectedness implies increasing resourcefulness, diversity of actor's creativity or innovativeness of an integrated problem solving approach or preventive mechanisms. This structure depicts that knowledge exchange, and addresses issues of the different farmer needs in time and space under different agro- ecological conditions of Ethiopia.

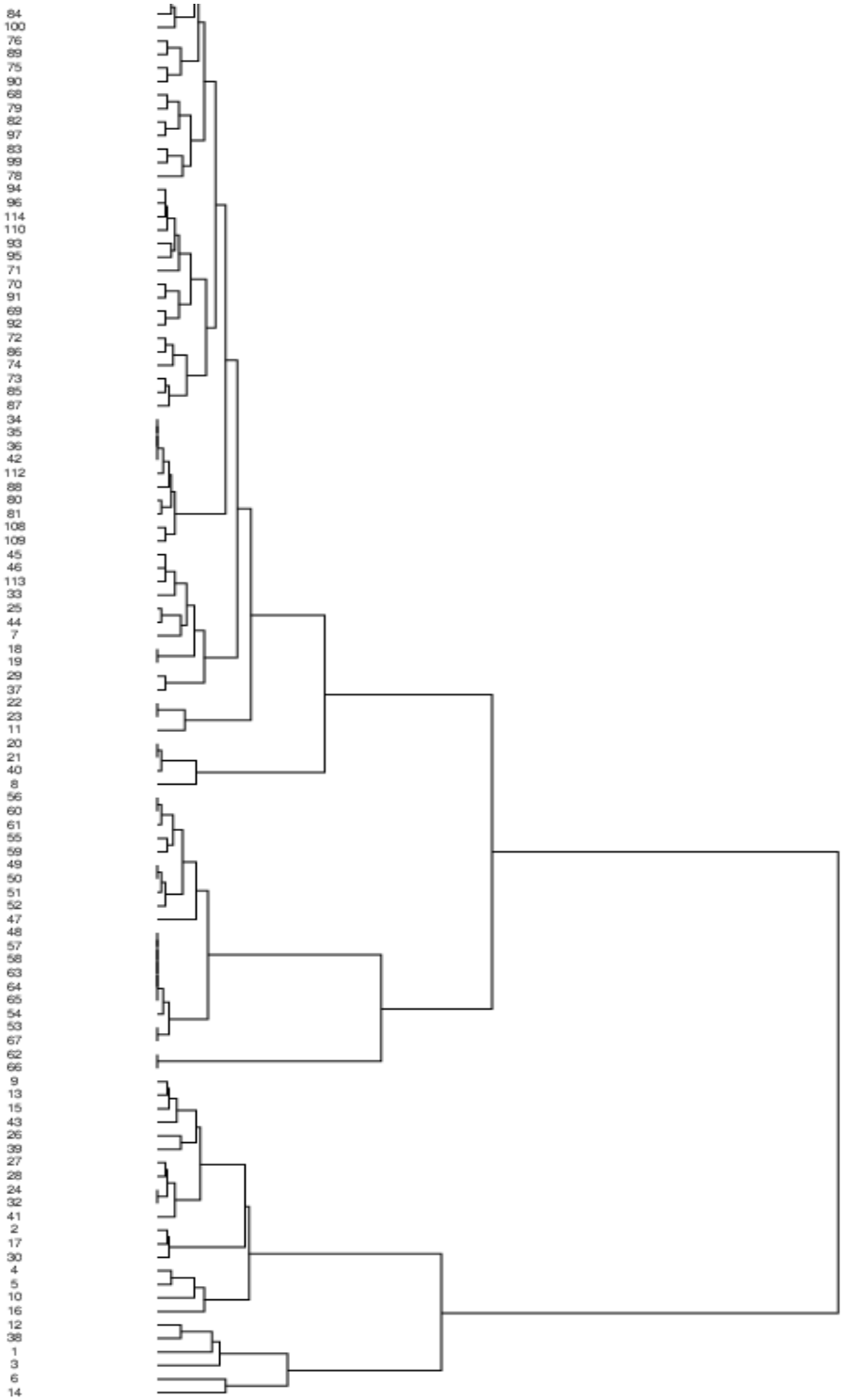


Figure30 .Hierarchical clustering of all actors'integration

4.6.4. Definition of an inclusive System: Advantage of the rural agricultural social capital over defining structural hole in urban agriculture system

Combination of theoretical knowledge and transforming it into practice in agriculture is most important measure to bring about overall sustainability in fighting drought, soil degradation, poverty, and enhancing health condition in Ethiopia. Apart from need of different and diversified stakeholders, strengthening their social capital is an important approach to positive reinforcement of solutions. Unlike in rural agriculture knowledge and information system, a linkage between knowledge source and user is rarely found.

For this combination of the rural knowledge system network, the rural organization network and the urban agriculture system network achieves several cross-functional pros in favor of mitigating multifaceted problems of food security, unemployment, soaring food price, risks and uncertainties over the rain-fed agriculture system of Ethiopia by advancing innovation system, particularly urban agriculture food landscape.

The following network analysis shows, such combination increases system resilience which can be explained by robustness over drought prone problems via utilization of urban organic wastes and waste water, resourcefulness of knowledge integration and redundancy by building the same system of similar function ,and establishing inter-firm alliance of urban and rural stakeholders over the existing agricultural system. The rural organization network illustrates important actor are embedded with proper interlocks of knowledge sources and knowledge users by which farmers needs are addressed with government policy support for wider dissemination of technology and related knowledge of successful results.

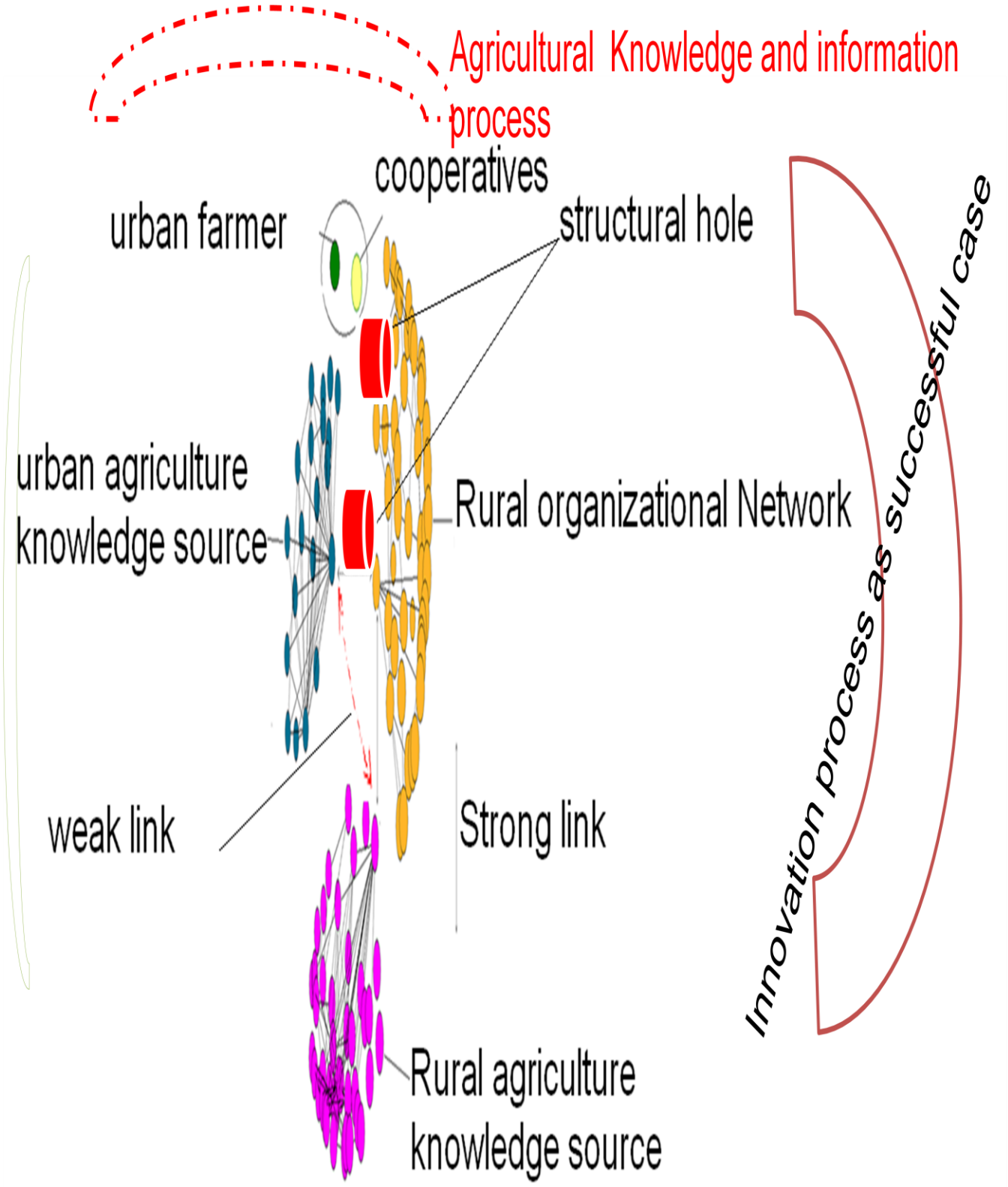


Figure31. Social capital and structural hole

Generally bringing the missing system into a larger part of working of functional agricultural knowledge, and information system methodologically suggests increasing knowledge of sustainability and sustainability of that knowledge. The empirical example in the case of soybean value chain illustrates that production phase that begins with diversity of actors of multidisiplinarity nature with mutual connectivity of cohesive stake holders of socio-economic and socio-ecological embeddedness and relevance to the poor (pro-poor crops) indicated continuous and increasing production by increasing adopting farmers with better post harvest technology (cereal bank), which serves double purpose as quality control and concentration centre for marketing which the scheme become very successful and scaled up/out across regions of similar agro-ecology of Ethiopia. This demonstrates what knowledge of sustainability and sustainability of knowledge are, and how organizational network reinforces the social capital, actor's interdependence and innovativeness and the approach is applicable to urban agriculture knowledge and information system.

5. Conclusion and Recommendation

5. 1.Conclusion

Analysis of the ISI, AGRIS and RUAF sources of bibliometeric analysis reveals that most of knowledge is available at university and research institutes, the same result is found by New Partnership for Africa Development (NEPAD) in its recently released Africa innovation outlook 2010 summery report using the scopus database.

Unlike in the rural agriculture knowledge system, the analysis result in urban agriculture suggests that there is little collaboration among the stakeholders, and few actors like agricultural professional society and urban agriculture bureau influence knowledge generation and transfer in the network. The rural agriculture knowledge and information system possesses greater complexity, diversity, and complexity due to presence of link between knowledge producers and consumers at different level. This indicates that the social capital in rural agriculture knowledge and information system is well utilized.

Varoius knowledge transfer mechanism is available in rural agriculture knowledge and information system unlike the case in urban agriculture. Joint planning, joint experimentation/demonstration, joint review and evaluation, joint workshop, joint fielddays, and publications such as books, articles, editorials, meetings, proceedings, booklets, leaflets and posters are the major knowledge transfer mechanisms in rural agriculture knowledge and information system. However, the majority of the urban agricultural knowledge is embedded with publications although some cases show application of information communication technology (ICT) like video conference for conducting a workshop. The rich experience gained in rural agriculture knowledge and information system interms of promoting joint actions and functions can be adapted to urban agriculture knowledge and information system.

Universities and research institutes are central for knowledge generation and transfers in agricultural, natural and social sciences. The rural agriculture knowledge and information system is characterized by higher rate of knowledge content and knowledge type, joint collaboration with expert, joint experimentation, joint workshop, and joint organizational network than the urban agricultural knowledge system. The availability of knowledge source and knowledge sink in rural agriculture system ensures availability of structured network of knowledge generation and transfer with active participation of both men and women farmers in the process of problem identification, priority setting and review systems. This kind of social capital/ a chain of multiple networks influence a sustainable technological choice, faster adoption, and increasing innovation with faster growing technology scaling up/out which in turn ensures increasing productivity and higher scale of production. Stakeholders in rural agriculture knowledge and information system embeds knowledge of urban agriculture though there exists no linkage that ensures transformation of the knowledge into action by direct users/or farmers.

The network analysis shows important role players and their connectivity to others. As per knowledge generation and transfer is concerned, bidirectional contact, the two way communication plays important role in sustainability. Interdependency and cohesiveness are social dimensions that could be considered whenever there is an inception of network construction.

Determination of structural pattern of a network is the most useful part that enables to quantitative analysis of the network which intern helps better understand what is considered. In this network analysis centrality indices are a good tool whether network can answer economic questions. Whenever important produced knowledge is placed in geodesics and end users are within this network system provided that the knowledge is made to answer sustainable problems. A measure of closeness centrality can be a good index economic analysis and make better decision. Degree centrality together with closeness centrality and betweeness centrality can be used to discuss issues related to society, and economics as they are a measure of participation, distance and decision making or policy formulation.

The empirics of this research ensure that sustainable development of socio-economic and socio-ecological environment builds resilience over drought, degradation, health and income. The scaling up/out of the sustainable and successful research results not only influences mitigating climate change impacts at national level but also contributes to the global level as well.

Urban agriculture consists of different areas of scientific knowledge such as basic agriculture, business and economics, evironmental science and ecology, food science and technology,veterinary science, nutrition and dietetics, biodiversity and conservation, government Law, infectoous disease, reproductive biology and others, and different scientific channels of different publications, meeting and video conferencing.

5.2. Recommendation

In public goods and services, bottom-up knowledge production and skill transfer is a good bridge for sustainable development. Academic understanding integrated with rich experience of other stakeholders in real life situations with diversity can be a key to bring resilient solutions in this changing world of increasing adverse effects. Sustainability in this regard therefore is a question of inclusion and a speed upon which immediate action deemed for adaption and mitigation mechanism is structured or newly created and applied. Hence, new structure of organizational network for knowledge management is essential to furnish and sustain every sector of development. In agriculture world, the poor are the most vulnerable part of society in which their capability and capacity are limited in search of relevant knowledge and acting upon it desirably. Participatory knowledge generation with inclusion of the vulnerable society not only, therefore, enables to actors in the agricultural knowledge and information system generates demand–pull technologies that are economically viable and environment friendly.

Actor's participation within agriculture knowledge and information system brings about multiples of relevant solutions that tune with the need of farmers with diversity of advantages which in turn bring sustainability in the overall farmer's environment in particular in national and regional environment and beyond though it requires restless effort of building a sustainable society. Creation of all inclusive bottom-up development approach is important to design and implement a knowledge-based strategy to curb climate change adverse effects as objectively and systemically as possible.Coordination and integration are key solutions in Africa, and other developing world whenever the following situation exits.

> Many labs are poorly equipped, and science students get little practical research training because research centres are often separate from universities. Financial and logistical support for science is typically divided between many ministries with little coordination, and some states rely too much on intermittent foreign funding. Even when research is successful, it is hard to push developments to the marketplace (Irikefe, Vaidyanathan, Nordling, Twahirwa, and Monastersky, Nature30June2011.p556.)

Action lens seems very limited in scrutinizing and looking for adaptive mechanism in agriculture innovation system. Focus need to be given to conventional agriculture with proper management options to increase productivity and strengthen urban agriculture as a tool to avoid food insecurity or enrich nourishment, alleviate poverty, fight desertification, soil degradation and others as a save and grow strategy, emerging issue against green revolution coined by world food and agriculture organization(FAO).

Sustainability science is a science of integrating a family of knowledge system and a family of approach in natural and social environments. In this regard pooling social resources such as knowledge and mechanisms for application/or implementation requires social networks through which a sustainable knowledge is generated and transferred to end users. In other word, network integrates knowledge and information system, and enhances innovation which ensures knowledge of sustainability and sustainability of that knowledge. However, availability of knowledge of sustainability is not guarantee for sustainability of knowledge unless it is innovated, integrated to existing development agenda with strong participation of grassroots particularly urban farmers within agriculture enterprise value chain of problem identification ,

implementation, evaluation and scaling up/out of best bet sustainable agriculture practices. Unlike the rural agriculture system, urban agriculture system involves large interface between knowledge source and knowledge sink that entails high wastage of knowledge.

The possibility of utilization of ICT technologies like video, mobile phone, video conference, internet, posters and others is greater for urban agriculture knowledge and information system than rural system for that there exits better infrastructure and high level of literacy that make ease of knowledge accessibility and utilization.Empoerwment of municipal level extension officers on delivering important message through right method/ channel at right time will be indispensable.

Network application could be an important tool to understand learning the problem situations, and find out possible wholesome solutions. Sustainability and network is a nexus of linking knowledge and practices and keeps on reviewing over time envisioning better knowledge and innovation in time and space.

Urban agriculture network for collaboration to improve the knowledge base on urban food security in Africa; to build African human resource capacity and expertise in food security policy and management; to develop and advocate policy options to improve the environment within which households make decisions about food security; and to grow the capacity of community change agents to plan, implement and evaluate food security projects and program ha as been given emphasis in African regional level. For Example, African Food Security Urban Network (AFSUN) was estabilished in 2008 as a network of African and international universities, non-governmental and community organizations, and municipal governance networks. Therefore building a strong link with this organization and other international organization will not only help develop economic, ecological and societal benefits.

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Appendix

1. **Urban Agriculture Knowledge and Information System**

Appendix1.1. Knowledge, Actor and Knowledge Transfer Mechanism (AGRIS)

Title	affiliation	Author	Publisher/Source	Year	AGRIS categories	Type of the sources of storage/transfer system
The food security challenges in Ethiopia	Ministry of Agriculture	Getahun Bilora,Professional Associations Joint Secretariat	PAJS,Addis Ababa	2004	Agricultural economics and policies	
Ethiopia child labour survey report 2001	Central Statistica Authority	CSA		2002	Labour and employment	**Statistical Bulletin**
Milk production, milk composition and body weight change of crossbred dairy cows in urban and peri-urban dairy production systems in Ethiopia	**Alemaya University, Dire Dawa (Ethiopia)); (International Livestock Research Insitute, Addis Abeba (Ethiopia)); Agricultural Research Center, Debre Zeit (Ethiopia)); N.N. Ummuna(International Livestock Research Insitute, Addis Abeba (Ethiopia))**	A Yoseph Mekasha zage Tegegne,Alemu Yami,N.N.Ummuna Azage Tegegne Alemu Yami(Debre Zeit	ESAP,Addis Ababa	2003	Animal genetics and breeding	summery
Prospects and opportunities of integrated fish culture in Ethiopia	Alemya university	**Eshete Dejen** ; **Tekelu tesfaye**	AESE	1999	Investment, finance and credit	conference
Assessment of urban household's solid organic waste management: implication for rural-urban linkage and environmental	Addis Ababa Universuity	Gorfu,B.T	Addis Ababa University	2008	Processing of agricultural wastes	Thesis
Study about the role of livestock in the income of poor people in urban areas of Addis Ababa. A project presented to Environmental Development Action (ENDA) and ILRI	**(Institut** ILRI **d'Agro-developpement international, Cergy Environmental Development Action, Addis Ababa (Ethiopia**	**Pyl, M. Van der (France))** ; **ILRI, Addis Ababa (Ethiopia);)**	ILRI	1997	Home economics, industries and crafts; Animal husbandry	
Dairy services delivery in DebreZeit milkshed of Ada'a District, central Ethiopia: analyzing options to develop pluralistic service delivery in the dairy sector	Alemya university	Girma,A.H.	Haremaya University	2008	Trade, marketing and distribution	Thesis
Market integration after the 1990 reform: the case of food grain markets in the Arsi catchment	**(National Urban Planning Institute, Addis Abeba (Ethiopia))** ;	**Bekele Sinke, Mulatu Demeke**	Ethiopian Journal of Development Research (Ethiopia)	1995	Trade, marketing and distribution	**Ethiopian Journal of Development Research**
Characterisation of postpartum ovarian activities using milk progestrone profiles in dairy cows in arban/peri-urban dairy production systems	**Alemya university**	**Yoseph Mekasha (alemaya University of Agriculture, dire Dawa (Ethiopia))** ; **Azage Tegegne** ; **Alemu Yami** ; **Umunna, N.N.**	ESAP,Addis Ababa	2000	Animal physiology - Reproduction	Conference
Suitability of home made hay-box chick brooder to the Ethiopian household paultry production system	**Jima college of agriculture**	Solomon Demeke	ESAP,Addis Ababa	2000	Animal husbandry	Conference
Milk processing and marketing options for rural small scale producers	**Ministry of Agriculture MoA, Addis Abeba (Ethiopia**	Tsehay Reda	ESAP,Addis Ababa	1998	Food processing and preservation	summery
Crop associations of home-gardens in Welayta and Gurage in southern Ethiopia	**Addis Ababa Universuity**	**Zemede Asfaw** ; **Zerihun Woldu**	SINET: Ethiopian Journal of Science (Ethiopia)	1997	Crop husbandry	**SINET: Ethiopian Journal of Science**
Review of fruit breeding and agronomy research in the last two and half decads	**EIAR,NARC**	Seifu G/medhin	Nazret Arc	1995	Crop husbandry	Summery
Managing ecosystems to improve human health and alleviate poverty	**International Centre of Insect Physiology and Ecology, Addis Abeba (Ethiopia). Centre for Analysis of Sustainable Agriculture Systems, Kensington, California (USA)**; **International Centre of Insect Physiology and**	Johann Baumgartner **,Getachew Tikubet,** Gianni Gilioli, Markus Bieri	Ethiopian Social Rehabilitation and Development Fund, Addis Abeba (Ethiopia	2003	Nature conservation and land resources	Summery

Bovine tuberculosis infection in animal and human populations in Ethiopia: a review	Addis ababa Urban agriculture Biureau and others	Shitaye, J.E.,Vyzkumny Ustav Veterinarniho Lekarstvi, Brno (Czech Republic); Tsegaye, W.,Addis Ababa Urban	Veterinarni Medicina - UZPI (Czech Republic)	2007	Animal diseases; Food contamination and toxicology	**Veterinarni Medicina - UZPI**
Nutrient recycling in pastures, rangeland fallow and cut- and carry systems in sub-Saharan Africa	**Department of Agronomy, University of Ibadan, Ibadan, Nigeria) ; International**	**Agboola, A.A. ; Kintomo, A.A**	*ILCA,Addis Ababa*	1995	Nature conservation and land resources; Cropping patterns and systems; Soil fertility	**International conference**
An overview of current milk marketing systems in Tanzania: successes and problems	**Sokoine Univ. of Agriculture, Morogoro (Tanzania). Dept. of Rural Economy) ; on Dairy Marketing in sub-Saharan Africa,**	**Ashimogo, G.C. ; Kurwijila, R.V.**	*ILCA,Addis Ababa*	1992	Domestic trade	**Symposium**
Microbial spoilage of market bulla and kotcho, traditional Ethiopian processed food products from Enset (Enset ventricosum)	**Awassa College of Agriculture**	Mogese Ashenafi,Yalemsew Abebe	Ethiopian Journal of Agricultural Science (Ethiopia)	1996	Food contamination and toxicology	**Ethiopian Journal of Agricultural Science**
Subregional Workshop "Feeding Cities in the Horn of Africa", Addis Adaba, Ethiopia, 7-9 May 2002. Final report	**Government of Ethiopia, Addis Ababa (Ethiopia) ; FAO, Rome (Italy) ; Subregional Workshop Feeding Cities in the Horn of Africa, Addis Adaba (Ethiopia), 7-9 May 2002**	FAO		2002	Agricultural economics and policies; Development economics and policies	Computer media
Dynamics of the HIV/AIDS epidemic in value chain development in rural Ethiopia and responses through market-led agricultural initiatives	**ILRI, Addis Ababa (Ethiopia). Improving Productivity and Market Success of Ethiopian Farmers Project (IPMS) ; Canadian International Development Agency, Addis**	**Bishop-Sambrook, C**	*ILRI,JILR-IPMS working paper*	2008	Rural sociology	Soft media
Promising multipurpose tree species and strategies of fodder production in Ada Woreda of Ethiopia	Ethiopian Society of Animal Production (ESAP)	Alemu, B.	Ethiopian Society of Animal Production (ESAP)	2000	Agroforestry; Agroforesterie; Agroforesteria; Agrosilvicultur; Farm forestry	Conference Proceedings
Analytical situations of land degradation and sustainable management strategies in Africa	**(Ethiopian Civil Service Coll., Addis Ababa (Ethiopia). Urban Management Masters Programme) ;**	**Ezeaku, P.I. Davidson, A.**	Journal of Agriculture and Social Sciences (Pakistan)	2008	Land economics and policies	**Journal of Agriculture and Social Sciences**
Forest dwellers' association (WAJIB) as an approach in participation: the case of Adaba-dodola forest priority in Bale zone of Oromiya region	Oromiya Burea of Agriculture, Bale (Ethiopia), Swedish University of Agricultural Siences, Uppsala	**Terefe Tolesa**	Swedish University of Agricultural Siences	2002	Forestry - General aspects	Thesis desertation
Food resources and nutritional management of dairy herds in urban and peri-urban dairy production systems in	Alemaya University,	**Yoseph Mekasha (Dire Dawa (Ethiopia)); Azage Tegegne; Alemu Yami; Ummuna, N.N.**	ESAP	2000		Article
Evaluation of the general farm characteristics and dairy herd structure in urban and peri-urban dairy production system in the Addis Ababa milk shed	**(Alemaya University, Dire Dawa (Ethiopia). Department of animal Sciences); (International Livestock Research Institute, Addis Abeba (Ethiopia)); (Debre Zeit Agricultural Research Center, Debre Zeit (Ethiopia));**	**Yoseph Mekasha Azage Tegegne Alemu Yami N.N. Umunna**	ESAP	2003		artiocle
Dynamics of the HIV/AIDS epidemic in value chain development in rural Ethiopia and responses through market-led agricultural initiatives	**Bishop-Sambrook, C. ILRI, Addis Ababa (Ethiopia). Improving Productivity and Market Success of Ethiopian Farmers Project (IPMS); Canadian International Development Agency, Addis Ababa (Ethiopia); Ethiopia. Ministry of Agriculture and Rural**		ILRI	2008		ILRI - IPMS Working Paper
Dairy production, processing and marketing systems of Shashemene-Dilla area, South Ethiopia	**Yigrem, S.; Beyene, F.; Tegegne, A.; Gebremedhin, B. ILRI, Nairobi (Kenya). Improving Productivity and Market Success of Ethiopian Farmers Project (IPMS); Hawassa University.**		ILRI		2008	ILRI - IPMS Working Paper
Dairy Production,processing and marketing systems of Shashemene-Dilla area,South Ethiopia.	**Sintayehu Yigrem;Fekadu Beyene;Azage Tegegne and Berhanu Gebremedhin(Researchers) Hawassa Univerisity**		Hawassa Univerisity;IPMS Ethiopia	2008		

Crop associations of home-gardens in Welayta and Gurage in southern Ethiopia	**Zemede Asfaw; Zerihun Woldu (Ethiopia))**	**(Addis Abeba University**		1997		SINET: Ethiopian Journal of Science (Ethiopia)
Income diversification strategy of poor urban households in the informal sector: The case of major urban centers of Ethiopia.	Addis Ababa Univerisity	Fitsum Daniel(Researcher)	Addis Ababa Univerisity	2009	Agricultural economics and policies; Extension	Thesis or Dissertation
Major health problems of dairy cattle in market-oriented urban and peri-urban production systems in the central highlands of Ethiopia	**Mekonen Lema (Addis Abeba Univ. (Ethiopia). Faculty of Veterinary Medicine); Tefa Kasa; Azage Tegegne**		ESAP	2000	Animal physiology - Reproduction	Conference
Report on average retail prices of goods and services on selected urban centers May 1993 - Aug 1994 (Ginbot 1985 - Nehase 1986)	Central Statistical Authority, Addis Abeba	Central Statistical Authority, Addis Abeba	Central Statistical Authority, Addis Abeba	1996	Trade, marketing and distribution	**CSA Statistical bulletin**
Report on average retail prices of goods and services by urban centers Mar 1995 - Aug 1995 (Megabit 1987 - Nehase 1987)	Central Statistical Authority, Addis Abeba	Central Statistical Authority, Addis Abeba	Central Statistical Authority, Addis Abeba	1996	Trade, marketing and distribution	**CSA Statistical bulletin**
Measuring the perceptions for the attributes of quality and safety in Milk and Butter: an application of conjoint to the case of urban Ethiopia -Addis	Addis Ababa Univerisity	**Osman Negus(Researcher)**	Addis Ababa Univerisity	2008	Animal husbandry; Animal feeding	Thesis or Dissertation
Land degradation in Addis Ababa due to industrial and urban development	(Addis University, Addis Abeba (Ethiopia) Department of Biology.); (Swedish Agricultural University, Swedish (Sweden). Department of Forest Soils)	**Fisseha Itanna Mats Olsson**	Institute of Development Research, Addis Ababa University	2004	Pollution	**Ethiopian Journal of Development Research**

Appendix1.2. **Knowledge, Actor and Knowledge Transfer Mechanism (RUAF)**

Title	Affiliation	Author	Year of made available online	RUAF Category	Type of the sources of storage/transfer system
Beyond Urban Gardens: Meeting the Growing N eeds of Ethiopia's Urban Population	**USAID**	Gultineh, D., J. Van Ness	2009		Proceedings/workshop by USAID (AUBs,NGOS,MOARD,AAU)
The Learning Alliance on Chain Empowerment; Burka Gudina	**The learning Allinace**	Goris W	2009	Local Economic Development, Finance &	Article
City Declarations on Urban Agriculture	AA City Administration		2009	Feeding Cities in the Horn of Africa	Workshop
Enhancing Household Food Security in Refugee Camps in Ethiopia	UNHCR	Mulugeta w.tsadik	2009	Crop Production Food Security & Nutrition	Article
Solid Waste Recycling in Addis Ababa, Ethiopia: Making a business of waste management	AAUAB	Berihun Tefera and Getachew Tikubet	2009	Crop Production Relief & Rehabilitation Reuse of Wastes & Wastewater	Article
Livestock in and around cities	ILRI	**Hans Schiere, Azage**	2007	Animal production	Editorial
Innovative livestock-keeping in Ethiopian cities	Institute for sustainable development ,A.A	**Hailu Araya, Alemayehu Ayalew, Azeb Werqu and Nigusie**	2008	Livestock Production Local Economic Development	Article
Participatory Innovation Development (PID): a Training of Facilitators Course	**International Institute of Rural Reconstruction (IIRR) with ETC EcoCulture and Prolinnova–Ethiopia**	PID experts from the **Prolinnova Country Programme in Ethiopia**	2007	Method ,Action Plan	Manual
The Living Garden : a Bio-intensive Approach to Urban Agriculture in Ethiopia	**AAUAB**	Yilma getachew	2005	Crop Production, reuse of wastes And waste water	Article
Livestock and Urban Waste in East Africa	**Natural Resources Institute, Chatham, UK.**	Sabine Guendel	2005	Livestock Production Food Security & Nutrition Reuse of Wastes & Wastewater	Article
Financing Market-Oriented Dairy Development: the case of Ada'a-Liben Woreda Dairy Association, Ethiopia	ILRI	**Azage Tegegne**	1998	Crop Production Food Security & Nutrition Finance & Credit	Article
Micro-technologies for Congested Urban Centers in Ethiopia	AAUAB	**Yilma Getachew**	2005	Crop Production Food Security & Nutrition	Article
PROLINNOVA	Direct link		2007		
FARM-Africa	Direct Link		2007		
Videoconference on Enhancing Participatory Governance in Local Democracy through ALGAF	Development partnership for eastern and Southern Africa (MDP-ESA), The World Bank Institute (WBI) and the Global Distance Learning Network (GDLN)	Municipal	2007	Policy options for participatory governance and local economic development in Africa	Electronic Conference

Urban Livestock Production and Gender in Addis Ababa, Ethiopia	IlRI	**Azage Tegegne**	2006	Livestock Production Gender Mainstreaming	Article
Urban agriculture, Cooperative Organisation and The Position of The Urban Poor in Addis Ababa, Ethiopia	na	Egziabher , Axumite G.	1993	urban agriculture; urban poor;urban perspective	paper
Dairy marketing by intra-urban, peri-urban and rural dairy producers near Addis ababa, Ethiopia	ILCA	Debrah S.	1992		Article
Farming in the city : the rise of urban agriculture(China, Uganda, Ethiopia, Dar es Salaam, Bolivia)	International Development Research Center	Mougeot, Luc JA (ed.)	1993	food security, income generation, livestock	Research report
Marketing efficiency, pricing and policy implications: a case study of milk marketing in Addis Ababa, Ethiopia	ILCA	Mbogoh SG.	1992	Milk	Article
Urban agriculture research in East Africa : record, capacities and opportunities(Kenya, Uganda, Tanzania, Ethiopia)	International Development Research Center, Mazingira Institute	Lamba, Davinder	1993	access to land, food production, nutrition, food security, income generation	Research report
Case study : Ethiopia	National Academy of Science	na	1980	deforestation; environmental degradation; Eucalyptus; fuelwood plantations, silviculture	Abstract
First International Symposium on Horticultural Economics in Developing Countries, held in Alemaya, Ethiopia, July 1989	Alemaya university	Jager, A (de); Verhaegh, AP (eds)	1991		proccesiding
Proceedings of the Workshop on Institutional Mechanisms for Environmental Management in Africa (Addis Ababa, Ethiopia)	IFPRI	na	1995	environment	reports/papers, conference paper
Factors affecting urban demand for live sheep: The case of Addis Ababa, Ethiopia	ILRI	Ehui, S.K., Benin, S. and Nega Gebreselassie	2000	marketing; urban livestock, socio-economics	Working paper
Advancing Participatory Technology Development Case studies on Integration into Agricultural Research,	IIRR, ETC , ACP-EU, CTA	Wettasinha, C., Veldhuizen, van L.	2003	institutional aspects	book

Extension and Education		& Waters-Bayer			
The growth of cities in East-Africa: consequences for urban food supply			2010	City Development Issues and Urbanization Trends	Article
Integrated water and land management research and capacity building priorities for Ethiopia: Proceedings of a MoWR/EARO/IWMI/ILRI international workshop held at ILRI, Addis Ababa, Ethiopia, 2-4 december 2002	Ethiopian Ministry of Water Resources, Ethiopian Agricultural Research Organization, International Water Management Institute, International Livestock Research Institute	McCornick, P.G.,Kamara, A.B. and Girma Tadesse	2003	Ethiopia, water management, Wastewater reuse, Land use planning	Proceedings
Addis Ababa Revised Master Plan Proposals Draft Summary december 2000	Addis Ababa City Government Office for the revision of the	na	2001	Ethiopia,policy, urban development, markets, housing, urban environment, poverty, unemployment, Land use planning	Proceedings
Scoping study on urban and peri-urban livestock production in Addis Ababa, Ethiopia	NRI, Aylesford	Tegegne, Azage, Million Tadesse, Zinash Sileshi	2002	livestock production, peri-urban livestock production	Study report
Ethiopian Farmer Grows Seeds Of Survival (Package 31, Script 1)	Ethiopia media resources, Africa (Eastern)		1994 Jan		Slide collections
Case study : Ethiopia	National Academy of Science	na	1980	deforestation; environmental degradation	chapters
Tomorrow will be better	Educaids network ethiopia, Educaids Netherlands Deelstra and de jong company	Na	2008		Video

Appendix1.3. Knowledge, Actor and Knowledge Transfer Mechanism (ISI)

S/N	Article (Title)	Affiliation	Source
1	Barley and identity in the Spanish colonial Audiencia of Quito: Archaeobotany of the 18th century San Blas neighborhood in Riobamba	1.Simon Fraser Univ, Dept Archaeol, Burnaby, BC V5A 1S6 Canada 2. Univ Wisconsin, Dept Hist Sci, Madison, WI	JOURNAL OF ANTHROPOLOGICAL ARCHAEOLOGY Volume: 29 Issue: 2
2	Causes and impacts of seasonal migration on rural livelihoods: Case studies from Amhara Region in Ethiopia	Addis Ababa university, Global mangt.program (A/A)	NORSK GEOGRAFISK TIDSSKRIFT-NORWEGIAN JOURNAL OF GEOGRAPHY Volume: 64 Issue: 1
3	No waste, but a resource: Alternative approaches to urban sanitation in Ethiopia	Hamburg Univ Technol, Inst Wastewater Management & Water Protect,	DESALINATION Volume: 248 Issue: 1-3
4	Performance and limitation of two dairy production systems in the North western Ethiopian highlands	BOKU-University of Natural sciences and	Tropical Animal Health and Production Volume: 41 Issue: 7
5	Estimation of undernutrition and mean calorie intake in Africa: methodology, findings and implications	Vrije Univ Amsterdam, Ctr World Food Studies, NL-1081 HV Amsterdam, Netherlands	INTERNATIONAL JOURNAL OF HEALTH GEOGRAPHICS Volume:
6	State formation and water resources management in the Horn of Africa: the Aksumite Kingdom of the northern Ethiopian highlands	1. Univ Cambridge, Dept Archaeol, Cambridge CB2 1TN, England 2. CSIC, Spanish Natl Res Council, Inst Mila & Fontanals, ICREA, Madrid, Spain	WORLD ARCHAEOLOGY Volume: 41 Issue: 1
7	Material flow analysis as a tool for sustainable sanitation planning in developing countries: case study of Arba Minch, Ethiopia	Tech.University of Hamburg,Prack Consult GmBH (Germany)	WATER SCIENCE AND TECHNOLOGY Volume: 59 Issue: 10
8	Seasonality, household food security, and nutritional status in Dinajpur, Bangladesh	Tufts Univ, Gerald J & Dorothy R Friedman Sch Nutr Sci & Poli, Boston, MA 02111 USA	FOOD AND NUTRITION BULLETIN Volume: 29 Issue: 3
9	Does food aid have disincentive effects on local production? A general equilibrium perspective on food aid in Ethiopia	Macaulay Inst, Socioecon Res Grp, Aberdeen AB15 8QH, Scotland	FOOD POLICY Volume: 32 Issue: 4
10	'Translation is not enough': using the Global Person Generated Index (GPGI) to assess individual quality of life in Bangladesh, Thailand, and Ethiopia	1.University of Newcastle 2. University of brth	**QUALITY OF LIFE RESEARCH** Volume: **16** Issue: **6**
11	agriculture in Mekelle, Tigray state, Ethiopia: Principal characteristics, opportunities and constraints for further research and development	1.University of Wales 2.University of Wales	**CITIES** Volume: **24** Issue: **3** Pages
12	Herbicide efficacy to control Parthenium (Parthenium hysterophorus) under grove conditions in Homestead, Florida	Crane, Jonathan H. ; Ctr Trop Res and Educ, 18905 SW 280 St, Homestead, FL 33031 USA	**Proceedings of the 119th Annual Meeting of the Florida State Horticultural Society** Volume: **119** Pages: **9-12**
13	Tropical Homegardens:A TIME-TESTED EXAMPLE OF SUSTAINABLE AGROFORESTRY	SPRINGER, PO BOX 17, 3300 AA DORDRECHT, NETHERLANDS(publisher)	**Tropical Homegardens:A TIME-TESTED EXAMPLE OF SUSTAINABLE AGROFORESTRY** Published: **2006**
14	Socioeconomic factors affecting farmers' perceptions of land degradation and stonewall terraces in Central Palestine	Norwegian Univ Life Sci, Dept Plant & Environm Sci,	**ENVIRONMENTAL MANAGEMENT** Volume: **37** Issue: **3**
15	The impact of donkey ownership on the livelihoods of female peri-urban dwellers in Ethiopia		**Tropical Homegardens:A TIME-TESTED EXAMPLE OF SUSTAINABLE**
16	A longitudinal survey of market donkeys in Ethiopia	Villardi Consulting, Singapore, Singapore,Holetta Ag.RC	**TROPICAL ANIMAL HEALTH AND PRODUCTION** Volume: **37**
17	Reduced milk production in udder quarters with subclinical mastitis and associated economic losses in crossbred dairy cows in Ethiopia	Kenyan Agricultural University	**TROPICAL ANIMAL HEALTH AND PRODUCTION** Volume: **37** Issue: **6**
18	Reproductive performance of crossbred dairy cows in different production systems in the central highlands of Ethiopia	ethiopian agricultural research organization	**TROPICAL ANIMAL HEALTH AND PRODUCTION** Volume: **35** Issue: **6**
19	Land under pressure: Soil conservation concerns and opportunities for Ethiopia	Centre for World Food Studies of the Vrije Universiteit (SOW-VU), Amsterdam, The Netherlands	**LAND DEGRADATION & DEVELOPMENT** Volume: **14** Issue: **1**
20	Evaluation of non-conventional agro-industrial by-products as supplementary feeds for ruminants: in vitro and metabolism study with sheep	Alemaya university International livestock research institute (A/A) ethiopian agricultural research organization	**SMALL RUMINANT RESEARCH** Volume: **44** Issue: **1**
21	Clinically manifested major health problems of crossbred dairy herds in urban and periurban production systems in the central highlands of Ethiopia	Addis ababa University Of Veterinary medicine,Univ Addis Ababa, Inst Pathobiol	**TROPICAL ANIMAL HEALTH AND PRODUCTION** Volume: **33** Issue: **2**
22	Soil management in the developing countries	Univ Addis Ababa, Fac Med Vet, Debre Zeit, Ethiopia	**JOURNAL OF VETERINARY**
23	Bovine dermatophilosis and its influencing factors in central Ethiopia	Univ Addis Ababa, Fac Med Vet, Debre Zeit, Ethiopia	**JOURNAL OF VETERINARY MEDICINE SERIES A-PHYSIOLOGY PATHOLOGY CLINICAL**
24	A research model on peri-urban dairy systems in sub-Saharan Africa	Rey, B. ; CIRAD/EMVT, c/o ILCA, P.O. Box 5689, Addis Abeba, Ethiopia	**EAAP Publication; Livestock farming systems: Research, development socio-**
25	EFFECT OF DAM NUTRITION AND SUCKLING ON LACTATION IN BORANA COWS AND GROWTH IN THEIR BORANA X FRIESIAN CROSSBRED CALVES IN AN EARLY WEANING SYSTEM IN ETHIOPIA	DURRANT PERIODICALS, WINTON LEA PENCAITLAND, EAST LOTHIAN, SCOTLAND EH34 5AY(publisher)	**ANIMAL PRODUCTION** Volume: **58**
26	ERITREA - DYNAMICS OF A NATIONAL QUESTION - MEDHANIE,T	US GOVERNMENT PRINTING OFFICE, SUPT OF DOCUMENTS, WASHINGTON, DC 20402-9325(publisher)	**PROBLEMS OF COMMUNISM** Volume: **39** Issue: **6**

2. Rural Agriculture Knowledge and Information System

Appendix2.1. Rural Agriculture Knowledge, Actor and Transfer Mechanism (AGRIS

S/N	Title	Author	Affiliation
1.	Advances in improving harvest index of maize	Mosisa Worku, Habtamu Zeleke , Girma Taye, Benti Tolesa,Legese Wolde, Wende Abera,Ashchalew Guta , Hadji Tuna	,EIAR,Crop Science society of Ethiopia
2.	Commercialization of new fuel system for household energy in Ethiopia-using ethanol from	Harry Stokes	Addis ababa university
3.	Distribution and importance of Ethiopian Vertisols and location of study sites	Srivastava, K.L. ,Mesfin Abebe ,Abiye Astatke, Mitiku Haile Hailu Regassa	ICRISAT,MOARD,AU
4.	Survey of viruses affecting legume crops in the Amhara and Oromia regions of Ethiopia	Bekele, B. ,Kumari, S.G. ,Aleppo (Syria)); Ali, K. ,Yusuf, A. ,Makkouk, K.M. ,Aleppo (Syria)); Aslake, M. ,Ayalew, M. (,Girma, G. ,Hailu, D. ,Robe	EIARI,CARDA,Au,AAU,ORAI
5.	Genetic diversity in sunflower (Helianthus annuus L.) varieties in	Haile Kefene,Efrem Bechere ,Hailu Gebremariam ,Dejene Mokonen	NGO,AU,University of California
6.	Gender differentials in smallholder livestock production in the central highlands of Ethiopia	Addis Tiruneh,Teklu Tesfaye ,Wilfred Mwangi,, Hugo Verkuiji	AAU,EIAR,CIMMYT
7.	Impacts of conservation bunds on crop yields in Degua Tembien, northern Ethiopia	Yibabe Tilahun, Kjell Esser, Mitiku Haile	NGO,MU
8.	Phenotypic diversity in the Ethiopian noug (Guizotia abyssinica cass.)	Tsige Genet,Ketema Belete	ADET,AU
9.	Wheat rust virulences in Ethiopia in 1988	yehu, G.; Badebo, A, Ginkel, M. van ,Haregewoin, M. , Hulluka, M. Andnew, Y.	EIAR,CIMMYT,AU
10.	Survey for chikpea and lentil virus diseases in Ethiopia [Cicer arietinum L. - Lens culinaris Medik.]	Tadesse, N. ,Ali, K.; Gorfu, D. ,Yusuf, A. ,Abraham, A. ,Ayalew, M. ,Lencho, A.; Makkouk, K.M.; Kumari, S.G. , Aleppo	EIAR,DARC,AU,ADET,SARC,ICARDA
11.	Carcass and edible non-carcass component yields in Menz and Horro ram lambs	Ewnetu Ermias,J.E.O. Rege,D.O. Anindo ,Hibret Amare ,Alemu Yami	AU,ILRI,AAU,EIAR
12.	Herbaceous species composition, dry matter production and condition of the major grazing areas in the mid rift	Amsalu Sisay, Robert Baars, Zinash Sileshi	AU,ILRI,DARC
13.	Variations in nutrient intake of dairy cows and feed balance in urban and peri-urban dairy production systems	Yoseph Mekasha, Azage Tegegne,Alemu Yami,N.N. Ummuna	AU,ILRI,DARC
14.	Milk production, milk composition and body weight change of crossbred	Azage Tegegne, Alemu Yami, N.N. Ummuna	AU,ILRI,DARC
15.	The potential of participatory research in Ethiopia: institutionalization of farmers' participatory research in	Asgelil Dibabe,Gemechu keneni,	HARC,AU,DARC
16.	Evaluation of forage crops in sub-humid climate of western Ethiopia:	Diriba Geleti ,Robert Baars	BARC,AU

17.	Relative importance and pathogenic variability of barley net and spot form of net blotch (Pyrenophora teres)in	Asnakech Tekalign	SHENOARC,AU
18.	Parasitoid species diversity and rates of parasitism on maize and sorghum stem borers in the central rift valley of	Abiy Tilahun	MARC,AU
19.	Improved management of Vertisols for sustainable crop-livestock production in the Ethiopian highlands: Synthesis report 1986-92	Tekalign Mamo ,Abiye Astatke, Srivastava, K.L. ,Asgelil Dibabe , Technical Committee of the Joint Vertisol Project	AU,ILCA,EIAR
20.	Land, soil and water management	Srivastava, K.L., Abiye Astatke , Mitiku Haile ,Hailu Regassa,Selamyihun Kidanu	ICRISAT,ILCA,AU,EIAR,
21.	Agricultural policy in Ethiopia's economic development: scope, issues and prospects	Workineh Nigatu,Legese Dadie,Abebe hailegebriel	AAU, IDR,EIAR,Ethiopian Civil Service College
22.	Effect of plant height at cutting, sources and levels of fertilizer on yield, chemical composition and in vitro dry matter digestibility of Napier grass (pennisetum purpureum	Tesema Zewdu, R.M.T Baars, Alemu Yami	EIAR,AU,DARC
23.	Co-integration and error correction approaches to the integration of Sidama and central Ethiopia coffee markets	Admasu Shibru, Belay Kassa(Alemaya University, Dire Dawa, Mulat Demeke	JARC,AU,AAU
24.	Reproduction efficiency of zebu and crossbred cows as measured by the inter-estrus and inter-service intervals at Bako	Gebregziabher Gebreyohanes ,Azage Tegegne,Diedhiou, B.P. Hegde	BAR,ILRI,AU
25.	Body weight dynamics of zebu and crossbred cows in relation to postpartum reproduction under sub humid climate of Bako	Gebregziabher Gebreyohannes Azage Tegegne,M.L. Diedhiou,B.P. Hegde	BARC,ILRI,AU
26.	Evaluation of the general farm characteristics and dairy herd structure in urban and peri-urban dairy	Yoseph Mekasha, Azage Tegegne, Alemu Yami, N.N. Umunna	AU,ILRI,DARC
27.	On-station and on-farm evaluation of the 'Hay-box chick brooder' using different insluation materials at the Debre Zeit Agricultural Research	Negussie Dana, Alemu Yami,Tadele Desie ,Samuel Woldehana,	DARC,MU
28.	Plant growth characteristics and productivity of Napier grass (Pennisetum Purpurem	Tesema Zewdu, R.M.T Baars Alemu Yami	ADET,AU,DARC
29.	Effect of plant height at cutting on rumen organic matter and neutral detergent fibre degradation of Napier	Tessema Zewdu, R.M.T. Baars, Alemu Yami	ADET,AU,DARC
30.	Understanding participatory research processes: the case of participatory improved agroecosystem management	Tilahun Amede ,Ejigu Jofa, Daniel Dauro , Legesse Seyoum	CIAT,NGO,,SNNPRSRRC,SNNPRSBA,
31.	Combining ability in 8 X 8 diallel crosses of early and drought tolerant maize (Zea mays L.) populations	Mandefro Nigussie,Habtamu Zelleke	MARC,AU
32.	Phenotypic diversity in Tigray barley landraces	Aderjew Haddis, Trgve Berg, Mitiku Haile	MEKELE ARC,NOAGRIC,MU
33.	Molecular genetics map and QTL analysis of agronomic traits based on a Eragrostis tef x E. pilosa	Chanyalew, S.; Singh, H.; Tefera, H. ,Sorrels, M.	MARC,AU,DARC,Cornnel University
34.	Wheat disease survey in Ethiopia in 1988	Gebeyehu, G.; Ginkel, M. van); Kebede, T.; Haregewoin, M.; Desta, R.; Bainbridge, A. Hulluka, M.; Andnew, Y.; Tadesse, D.; Gorfu, A.; Badebo, A. (Institute of Agricultural Research, Addis Ababa	EIAR,CIMMYT,AU
35.	Nutrient management	Haque, I.; Mesfin Abebe; Tekalign Mamo); Asgelil Dibabe	ILCA,MOARD,AU,DARC
36.	Technology validation and transfer	Getachew Asamenew ; Hailu Beyene; Adugna Haile ; Workeneh Negatu	ILCA,EIAR,AU
37.	Cool-season food legumes of Ethiopia [Pisum sativum, Lens culinaris, Cicer arietinum, Lathyrus sativus, Vicia	Telaye, A. ; Bejiga, G. ; Saxena, M.C.Aleppo ; Solh, M.B.	DARC,ICARDA,AU,Swedish Agency for Research Cooperation with Developing Countries

38.	Improved varieties of Durum wheat in Ethiopia: releases of 1966-1994	Efrem Bechere; Tesfaye Tesema; Demisie Mitiku	AU,DARC
39.	Draught performance of F1 crossbred dairy cows and local oxen under	Mengistu Alemayehu	WARC,AU
40.	Research on the integration of forage legumes in wheat-based cropping	Daniel Keftasa	DARC,AU
41.	Crop rotation effects on grain yield and yield components of bread wheat in the bale highlands of south-eastern Ethiopia	Geleto, T.; Nefo, K.	SARC,AU
42.	Biology and control of bean anthracnose in Ethiopia	Tesfaye Beshire,	EIAR,University of South Africa
43.	Studies on the level of inclusion of rapeseed meal (b. napus vs 'tower') in broiler finisher rations	Amsalu Asfaw); Alemu Yami; Solomon Mogus	ARARI,EIAR,JU
44.	Variations in dry matter yield and nutritive value of Panicum coloratum and Stylosanthes guianensis mixed pasture as influenced by harvesting cycles	Diriba Geleti,Robert Baars; M.Y. Kurtu	BARC,AU
45.	Effect of leaf type and plant spacing on growth, yield and fiber properties of irrigated upland cotton (Gossypium hirsutum L.) in middle Awash	Abraham Gebrehiwet Biru	EIAR,Au
46.	Characterization and divergence analysis in cassava (Manihot	Amsalu Nebiyu	JARC,JU
47.	Determinants of fertilizer use in Gununo area, Ethiopia	Million Tadesse, Belay Kassa	AWASA ARC,AU
48.	The response of tef to nitrogen and phosphorus applications at Bichena	Abebe Halegabriel	,ADET,EIAR,Crop science society of Ethiopia
49.	Adoption of improved bread wheat	Alemu Gebrewold	ADET,Eiar,CIMMYT
50.	Agronomic and economic evaluation	Maru, S.; Girma, K., Tanner, D.G.	HARC,EIAR,CIMMYT
51.	Performace of two and three way crossbred dairy cattle at Holetta Research Center in central highlands	Aynalem Haile ,S. Tembely,R.L. Baker,D.O. Anindo,E. Mukasa-Mugerwa ,J.E.O. Rege ,Alemu Yami	HARC,EIAR
52.	New approaches for food security through sustainable management of	Mandefro Nigussie, Gezahegne Bogale, Benti Tolessa	GTZ,Ethiopian ,professional joint secretariate
53.	Phenotype and yield potential-based similarity study on enset (Ensete ventricosum welw. Cheesman)clones	Ayele Badebo, Alemtaye Andarghe, Bedada Girma, Thomas Payne	AARC,NARC,DARC,EIAR,Ethiopian crop Science Society
54.	S sub(1)selection for early maturity in an open pollinated maize variety and its effect on other important	Gezahegne Bogale, Mandefro Nigussie, Gelana Seboksa	BARC,Ethiopian crop Sciencce society
55.	Features of grain marketing networks in Ethiopia: a synopsis of the implications for achieving regional	Mandefro Nigusie, Gazahegne Bogale , Gelanan Seboke	Civil Service College,Ethiopian professional joint secretariat
56.	Role of draft oxen power in Ethiopia agriculture	Abebe Yadessa , Diriba Bekere, Taye Bekele	EIAR
57.	Evaluation of herbicides for the control of brome grass in wheat in	Berhanu Bebremedhin , Don Peden	KARC,CIMMYT
58.	Effect of dietary protein supplementation on the resistance of lambs to artificial infection with	Hune Nega	ILRI,EIAR
59.	Top-cross performance and heterotic patterns of thirty-one maize	Sutcliffe, J.P.	NARC,EIAR
60.	Double sources of resistance to Puccinia striiformis and P. graminis f. sp. tritici in CIMMYT bread wheat	Paulos Dubale; Demil Tektay	KARC,CIMMYT
61.	Performance of CIMMYT drought tolerant maize genotypes in the moisture deficit zone of Ethiopia	Mulugeta Kebede	NARC

62.	Evaluation of maize genotypes in the drought stressed areas of Ethiopia	DEMIL Tekltay	NARC,Ethiopian Crop Science society
63.	Maize grain yield under taungya system with different multipurpose	Betre Alemu; Tekalign Mamo; Alemayehu Zemedie; Ebrahim Ahmed	BARC,Ethiopian crop Sciencce society
64.	Policies and institutions to enhance the impact of irrigation development in crop-livestock mixed systems in the	Aguidie, A. , Tanner, D.G., Maiz y Trigo , Liben, M.; Dessalegne, T.; Kebede, B.	BARC,Profesional joint Secretrait
65.	Rainwater harvesting technologies and their contribution to household food security in dry land areas of Ethiopia	Sendeta, F,Demil Teketay	MOARD,professional joint secretariat
66.	Soil conservation and land tenure in highland Ethiopia	Agajie Tesfay, Chilot Yirga, Mengistu Alemayehu, Elias Zerfu, Aster Yohanes	MOARD
67.	The need for forest coffee germplasm conservation in Ethiopia and its signifcance in the control of coffee	Yohanes Gojam, Azage Tegegne, Alemu Gebrewold, Mengistu Alemayehu,Zelalem Yilma	EIAR
68.	Use of oxen traction in traditional farming system of western Ethiopia: experience in Bako	Yohanes Gojam, Zelalem Yilma, Gizachew Bekele, Alemu Gebrewold, Sendros Demeke	BARC
69.	Vegetation types and forest fire management in Ethiopia	Kenea Yadeta, Legese Dadi, Alemu Yami	EIAR
70.	Promising multipurpose three species and their response to land form on highland vertisols at Chefe Donsa,	Kindu Mekonnen, Agajie Tesfaye, Teklu Tesfaye, Taye Bekele, Bekele Kassa	EIAR
71.	Farmer participatory evaluation of	Setegn Gebeyehu, Belay Simane, Roger Kirkby	CIMMYT,ADET
72.	Soil seed banks in plantations and adjacent natural dry Afromontane	Negash Geleta, Chemeda Daba, Setegn Gebeyehu	Wondo Genet Forestry college,EIAR
73.	Smallholder livestock production systems and constraints in the highlands of north and west shewa	Shimelis Dejene , Mathewos Belisa,Gemechu Shale , Diriba Geleti , Mohammed Hassena	EIAR
74.	Testicular growth and its relationship with linear body measurements in	Rezene Fessehaie; Mekasha Chichayibelu; Mengistu Hailegeorgis	EIAR,ILRI
75.	Milk yield and reproductive performance of Borana cows and	Carucci,Volli	EIAR
76.	Poultry marketing: structure, spatial	Getinet Alemaw; Nigussie Alemayehu	EIAR
77.	Experiences of participatory research in integrated pest management	Awgechew Kidane	EIAR
78.	Biological efficiency and system	Bekele Geleta; Amanuel Gorfu; Getnet Gebeyehu	NARC,DARC,ethiopian Crop Science
79.	Determination of plant population and planting time in maize (Zea mays	Abdurahman Abdulahi	BARC,Ethiopian crop Sciencce society
80.	FRG and FEG approach: experience from Bako Agricultural Research	Habtamu Admasu; Reddy, M.S.; Teshale Alemu; Jibril Mohamed	BARC,OARC
81.	Spread and ecological consequences of parthenium hysterophorus in	Abebe Halegabriel	Ethiopian Weed Science Society, Addis Ababa (Ethiopia)
82.	Sustainable land managment as key enabling elemernt to end poverty in	Alemu Gebrewold	Ethiopian Society of Soil Science
83.	Production and Research on Oilseeds in Ethiopia	Maru, S.; Girma, K., Tanner, D.G.	EIAR
84.	The National Quarantine Policy for Maize import and introductions	Aynalem Haile ,S. Tembely,R.L. Baker,D.O. Anindo,E. Mukasa-Mugerwa ,J.E.O. Rege ,Alemu Yami	EIAR
85.	Wheat Production and Research in Ethiopia: Constraints and	Mandefro Nigussie, Gezahegne Bogale, Benti Tolessa	EIAR
86.	The status of pesticide registration in Ethiopia	Ayele Badebo, Alemtaye Andarghe, Bedada Girma, Thomas Payne	MOARD,
87.	Maize based cropping systems for sustainable agriculture in semi-arid	Gezahegne Bogale, Mandefro Nigussie, Gelana Seboksa	EIAR
88.	The food security challenges in Ethiopia	Getahun Bilora	MOARD
89.	Challenges and opportunities of livestock marketing in Ethiopia	Belachew Hurisa; Jemberu Eshetu	MOARD

90.	Improved crop varieties, food deficit, seed and land use in Ethiopia: trend	Demese Chanyalew, Addis Abeba (Ethiopia)	Unity University
91.	Trade agreement on agriculture and domestic support and future position	Demese Chanyalew Ababa (Ethiopia))	Unity University
92.	Yield losses in sorghum due to covered kernel smut in Northeast	Eshetu Belete Temam Hussein	Eiar,AU
	Distribution of meloidogyne incognita (root-knot nematode) in some	Tadele Tefera; Mengistu Huluka	AU
93.	Camel Marketing in eastern Ethiopia	Tezera Getahun Bekele Tafese	AU
94.	Camel production and productivity in eastern lowlands of Ethiopia	Bekele Tafese; Kebebew Tufa	AU
95.	s and prospects of food security in Ethiopia	Mulat Demeke)	AAU
96.	ty of Arabica coffee populations in Afromontane rainforests of Ethiopia	Arega Zeru	AAU
97.	Beef cattle production system and opportunities for market orientation in	Tewodros, D.	
98.	Animal genetic resources and breed characterisation work in Ethiopia	Beyene Kebede; Beruk	MOARD
99.	Further Investigation of Freshwater Snails of Ethiopia	Hailu Birrie; Lo, C.T.; Berhanu Erko; Abraham Reda; Negash Gemeda	AAU

Appendix2.2. Rural agriculture Knowledge, Actor and Knowledge Transfer (ISI)

	Title	Author(s)	Affilation(s)
1.	climatic variables and malaria transmission dynamics in jimma town, south west ethiopia	alemu a (alemu, abebe)[1,2], abebe g (abebe, gemeda)[1,3], tsegaye w (tsegaye, wondewossen)[1], golassa l (golassa, lemu)[1]	1. jimma univ, dept med lab sci & pathol, jimma, ethiopia 2. univ gondar, coll med & hlth sci, dept med lab sci, gondar, ethiopia 3. univ antwerp, dept epidemiol & social med, b-2020 antwerp, belgium
2.	study on reproductive performance of	kassa, tesfu ; univ addis ababa, aklilu lemma inst pathobiol, pob 1176, addis	katholieke univ leuven, div forest nat & landscape, be-3001 louvain, belgium
3.	semi-forest coffee cultivation and the conservation of ethiopian	aerts r (aerts, raf)[1], hundera k (hundera, kitessa)[1,2], berecha g (berecha, gezahegn)[3,4],	1.jimma univ, dept biol, jimma, ethiopia 2. katholieke univ leuven, plant ecol lab, be-3001 louvain, belgium 3. jimma univ, dept hort & plant sci, jimma, ethiopia
4.	deficit irrigation practices as alternative means of	ayana m (ayana, mekonen)	arba minch univ, dept water resources & irrigat engn, n omo, Ethiopia
5.	zai improves nutrient and water productivity in the ethiopian highlands	amede t (amede, tilahun)[1,2,3], menza m (menza, mesfin)[4], awlachew sb (awlachew, seleshi bekele)[3]	1.int livestock res inst, addis ababa, ethiopia 2. challenge programme water & food, addis ababa, ethiopia 3. int water management inst, addis ababa, ethiopia 4. wollega univ, addis ababa, ethiopia
6.	analysis of gaps and possible interventions for improving water productivity in crop livestock systems of	descheemaeker k (descheemaeker, katrien)[1,2,3], amede t (amede, tilahun)[1,2,3], haileslassie a (haileslassie, amare)[4],	1.subreg off nile basin & e africa, iwmi, addis ababa, ethiopia 2. ilri ethiopia, addis ababa, ethiopia 3. ilri, addis ababa, ethiopia 4.int livestock res inst ilri icrisat, patancheru 502234, andhra pradesh india
7.	irrigation water productivity as affected by water management in a small-scale irrigation	derib sd (derib, sisay demeku)[1], descheemaeker k (descheemaeker, katrien)[2,3], haileslassie a	1.sarc, woldya, ethiopia 2. ilri, addis ababa, ethiopia 3.iwmi, addis ababa, Ethiopia
8.	performance of irrigation: an assessment at	awulachew sb (awulachew, seleshi bekele)[1], ayana m (ayana,	1. iwmi, addis ababa, Ethiopia 1. arba minch univ, arba minch, Ethiopia
9.	comparison of landuse and landcover changes, drivers and impacts for a moisture-sufficient and drought-prone region in the ethiopian highlands	ali h (ali, hussien)[1], descheemaeker k (descheemaeker, katrien)[2,3], steenhuis ts (steenhuis, tammo s.)[1,4], pandey s (pandey, suraj	1.cornell bahir dar masters program integrated wate, bahir dar, ethiopia 2. int livestock res inst, addis ababa, ethiopia 3. int water management inst, addis ababa, ethiopia 4. cornell univ, ithaca, ny usa 5. int crops res inst semi arid trop, bulawayo, zimbabwe
10.	livestock water	mekonnen s (mekonnen,	1.univ hawassa, hawassa, ethiopia

	productivity in a water stressed environment in northern ethiopia	semira)[1], descheemaeker k (descheemaeker, katrien)[2,3,4], tolera a (tolera, adugna)[1], amede t (amede, tilahun)[2,3,4]	2. subreg off nile basin & e africa, int water management inst, addis ababa, ethiopia 3. ilri ethiopia, addis ababa, ethiopia 4. int livestock res inst, addis ababa, ethiopia
11.	institutional implications of governance of local common pool resources on livestock water	deneke tt (deneke, tilaye teklewold)[1], mapedza e (mapedza, everisto)[2], amede t (amede, tilahun)[2,3]	1.humboldt univ, div resource econ, d-10099 berlin, germany 2. int water management inst, addis ababa, ethiopia 3.int livestock res inst, addis ababa, ethiopia
12.	agricultural investment and international land deals: evidence from a multi-country study in africa	cotula l (cotula, lorenzo)[1], vermeulen s (vermeulen, sonja)[1], mathieu p (mathieu, paul)[2], toulmin c (toulmin, camilla)[1]	1.int inst environm & dev, nat resources grp, london wc1h 0dd, england 2. food & agr org united nations, i-00153 rome, italy . univ kassel, d-37213 witzenhausen, germany 2. univ gottingen, d-37213 witzenhausen, germany 3. sultan qaboos univ, coll agr & marine sci, dept anim & vet sci, muscat, oman
13.	characterisation and genetic diversity analysis of selected chickpea cultivars of nine countries using simple sequence repeat (ssr) markers	Sefera t (sefera, tadesse)[1,2,3], abebie b (abebie, bekele)[3], gaur pm (gaur, pooran m.)[1], assefa k (assefa, kebebew)[2], varshney rk (varshney, rajeev k.)[1,4]	1. icrisat, patancheru 502324, andhra pradesh india 2. eiar, addis ababa, Ethiopia 3. haramaya univ, dept plant sci, dire dawa, Ethiopia 4. cimmyt, genom gene discovery sub programme, gcp, mexico city 06600, df mexico
14.	two rapid appraisals of fao-56 crop coefficients for semiarid natural vegetation of the northern ethiopian highlands	Descheemaeker k (descheemaeker, k.)[1,2], raes d (raes, d.)[3], allen r (allen, r.)[4,5], nyssen j (nyssen, j.)[6], poesen j (poesen, j.)[3], muys b (muys, b.)[3], haile m (haile, m.)[7], deckers j (deckers, j.)[3]	1. iwmi, subreg off nile basin & e africa, addis ababa, Ethiopia 2. ilri, addis ababa, Ethiopia 3. katholieke univ leuven, dept earth & environm sci, be-3001 louvain, belgium 4. univ idaho, dept biol & agr engn, res & extens ctr, kimberly, id 83341 usa 5. univ idaho, dept civil engn, res & extens ctr, kimberly, id 83341 usa 6. univ ghent, dept geog, be-9000 ghent, belgium 7. mekelle univ, dept land resource management & environm protect, mekelle, ethiopia
15.	milk production and feeding behavior in the camel (camelus dromedarius) during	Bekele t (bekele, t.)[1], lundeheim n (lundeheim, n.)[2], dahlborn k (dahlborn, k.)[1]	1.swedish univ agr sci, dept anat physiol & biochem, se-75007 uppsala, sweden 2. swedish univ agr sci, dept anim breeding & genet, se-75007 uppsala, sweden
16.	socio-economic determinants of land degradation in pishin sub-basin,	Qasim s (qasim, s.)[1], shrestha rp (shrestha, r. p.)[1], shivakoti gp (shivakoti, g. p.)[1], tripathi	1.asian inst technol, serd, pathuthani, thailand 2. asian inst technol, set, pathuthani, thailand
17.	stable isotopic analysis of human and animal diets from two pre-aksumite/proto-aksumite archaeological sites in northern ethiopia	D'andrea ac (d'andrea, a. catherine)[1], richards mp (richards, michael p.)[2,5], pavlish la (pavlish, laurence a.)[3], wood s (wood, shannon)[1], manzo a (manzo, andrea)[4], wolde-kiros hs (wolde-kiros, h. s.)[6]	1. simon fraser univ, dept archaeol, burnaby, bc v5a 1s6 canada 2. univ british columbia, dept anthropol, vancouver, bc v6t 1z1 canada 3. univ toronto, isotrace radiocarbon lab, dept phys, toronto, on m5a 1a7 canada 4. univ naples federico 2, dipartimento studi ric africa & paesi arabi, naples, italy 5. max planck inst evolutionary anthropol, dept human evolut, d-04103 leipzig, germany 6. washington univ, dept anthropol, st louis, mo 63130 usa
18.	the effect of long-term maresha ploughing on soil physical properties in the central rift valley of ethiopia	biazin b (biazin, birhanu)[1,2], stroosnijder l (stroosnijder, leo)[2], temesgen m (temesgen, melesse)[3], abdulkedir a (abdulkedir, abdu)[1], sterk g (sterk, geert)[4]	1. hawassa univ, wondo genet coll forestry & nat resources, shashemene, ethiopia 2. wageningen univ, nl-6700 aa wageningen, netherlands 3. univ addis ababa, dept civil engn, addis ababa, ethiopia 4. univ utrecht, dept phys geog, nl-3508 tc utrecht, netherlands
19.	breeding tef [eragrostis tef (zucc.) trotter]: conventional and	Assefa k (assefa, k.)[2], yu jk (yu, j. -k.)[1], zeid m (zeid, m.)[1], belay g (belay, g.)[2], tefera h (tefera, h.)[2],	1.cornell univ, dept plant breeding & genet, ithaca, ny 14853 usa 2.debre zeit agr res ctr, ethiopian inst agr res, debre zeit, Ethiopia

20.	row and plant spacing effects on yield and yield components of soya bean varieties under	Worku m (worku, m.)[2], astatkie t (astatkie, t.)[1]	1.nova scotia agr coll, dept engn, truro, ns b2n 5e3 canada 2.jimma univ coll agr & vet med, dept hort & plant sci, jimma, ethiiopia
21.	gm crops in ethiopia: a realistic way to increase agricultural performance?	azadi h (azadi, hossein)[1], taisma n (taisma, nanda)[2], ho p (ho, peter)[3], zarafshani k (zarafshani, kiumars)[4]	1.univ ghent, dept geog, ghent, belgium 2. univ groningen, fac social sci, nl-9700 ab groningen, netherlands 3. leiden univ, fac humanities, lias, nl-2300 ra leiden, netherlands 4. razi univ, dept agr extens & rural dev, kermanshah, iran
22.	effects of strategic helminthosis control on age at first lambing and	aragaw, k.; teferi, m.; haile, a.; tibbo, m. (m.tibbo@cgiar.org)	
23.	qtl mapping for yield and lodging resistance in an enhanced ssr-based map for tef	zeid, m.; belay, g.; mulkey, s.; poland, j.; sorrells, m. e. (mes12@cornell.edu)	sorrells, m. e.; cornell univ, dept plant breeding and genet, 252 emerson hall, ithaca, ny 14853 usa
24.	property rights in a very poor country: tenure insecurity and investment in ethiopia	ali da (ali, daniel ayalew)[1], dercon s (dercon, stefan)[2], gautam m (gautam, madhur)[3]	1.`world bank, washington, dc 20433 usa 2. univ oxford, dept int dev, oxford ox1 3tb, england 3. darwb, tanzania country off, world bank, dar es salaam, tanzania
25.	regional perspective on rainfall change and variability in the	rosell s (rosell, staffan)	univ gothenburg, dept earth sci, s-40530 gothenburg, sweden
26.	perception of and adaptation to climate change by farmers in the nile basin of ethiopia	Deressa tt (deressa, t. t.)[1], hassan rm (hassan, r. m.)[2], ringler c (ringler, c.)[1]	1.int food policy res inst, environm & prod technol div, washington, dc 20006 usa 2. univ pretoria, dept agr econ, fac nat & agr sci, ceepa, za-0002 pretoria , south Africa
27.	genetic and phenotypic parameter estimates	dana, nigussie (negussiedana@yahoo.com); vander waaij, e. h.;	
28.	first-time detection of mycobacterium species from goats	agga, getahun ejeta;	lovelace resp res inst, 2425 ridgecrest dr se, albuquerque, nm 87108 usa
29.	occurrence and financial loss	bekele, jemere (jemerebek@gmail.com);	bekele, jemere ; hawassa univ, sch vet med, pob 1337, hawassa, Ethiopia
30.	analysis of seed potato systems in ethiopia	hirpa, adane; meuwissen, miranda p. m.; tesfaye, agajie; lommen, willemien j. m.; lansink, alfons oude;	struik, paul c.; wageningen univ, ctr crop syst anal, pob 430, nl-6700 ak wageningen, Netherlands
31.	comparison of sire evaluation methods	haile a (haile, aynalem), joshi bk (joshi, b. k.),	natl dairy res inst, div dairy cattle breeding, karnal 132001, haryana india
32.	effect of wood ash, tagetus minuta extract and hot	gemu, mesele (meselegemu@yahoo.com); addis, temesgen	gemu, mesele ; awassa agr res ctr, sari, pob 06, awasa, etiopia
33.	wheat seed system in ethiopia: farmers'	bishaw, zewdie (z.bishaw@cgiar.org);	bishaw, zewdie ; icarda, seed sect, pob 5466, aleppo, Syria
34.	a tool for rapid assessment of erosion risk to support decision-	Mutekanga fp (mutekanga, fiona p.)[1,2], visser sm (visser, saskia m.)[1], stroosnijder l	wageningen univ, soil sci ctr, land degradat & dev grp, nl-6700 aa wageningen, Netherlands kyambogo univ, fac sci, kyambogo, Uganda
35.	different seed selection and conservation practices for fresh	Kraft kh (kraft, kraig h.)[1], luna-ruiz jd (de jesus luna-ruiz, jose)[2], gepts p (gepts, paul)[1]	1.univ calif davis, dept plant sci, davis, ca 95616 usa 2. univ autonoma aguascalientes, aguascalientes, mexico
36.	climate change, drought, and jamaican agriculture: local knowledge and the climate record	Gamble dw (gamble, douglas w.)[1], campbell d (campbell, donovan)[2], allen tl (allen, theodore l.)[3], barker d (barker, david)[2], curtis s (curtis, scott)[4], mcgregor d (mcgregor, duncan)[5], popke j (popke, jeff)[4]	1.univ n carolina, dept geog & geol, wilmington, nc 28403 usa 2. univ w indies mona, dept geog & geol, mona, Jamaica 3. univ miami, rosenstiel sch marine & atmospher sci, miami, fl 33149 usa 4. e carolina univ, dept geog, greenville, nc 27858 usa 5. royal holloway univ london, dept geog, london, England

37.	effect of defoliation frequency and cutting height on growth, dry-matter yield and nutritive	Tessema zk (tessema, z. k.)[1], mihret j (mihret, j.)[2], solomon m (solomon, m.)[3]	1.haramaya univ, coll agr, dept anim sci, dire dawa, ethiopia 2. bur agr & rural dev off, bahir dar, Ethiopia 3.ethiopian inst agr res, debre zeit agr res ctr, debre zeit, ethiopia
38.	farmers' perceptions of livestock, agriculture, and natural resources in		1.swiss trop & publ hlth inst, basel, Switzerland 2.ahri alert, addis ababa, ethiopia
39.	adaptation and performance of cimmyt spring wheat genotypes targeted	tadesse w (tadesse, w.)[1], manes y (manes, y.)[1], singh rp (singh, r. p.)[1], payne t (payne, t.)[1], braun	cimmyt, mexico city 06600, df mexico
40.	allelic variation and geographical patterns of prolamins in the usda-ars khorasan wheat germplasm	Rodriguez-quijano m (rodriguez-quijano, marta)[1], lucas r (lucas, regina)[1], ruiz m (ruiz, magdalena)[2], giraldo p (giraldo, patricia)[1], espi a	1. univ politecn madrid, escuela tecn super ingenieros agronomos, dep biotecnol, unidad genet, e-28040 madrid, spain 2. inst nacl invest & tecnol agr & alimentaria, ctr nacl recursos fitogenet, alcala de henares 28800, spain
41.	effect of residual calf suckling on clinical and sub-clinical infections of mastitis in dual-purpose cows:	Gonzalez-sedano m (gonzalez-sedano, m.)[1,3], marin-mejia b (marin-mejia, b.)[1,2], maranto mi (maranto, m. i.)[3], de magalhaes-labarthe acl	1.univ nacl autonoma mexico, ctr ensenanza invest & extens ganaderia trop, fac med vet & zootec veracruz mexico 2. univ nacl autonoma mexico, ctr ensenanza invest & extens prod altiplano, fac med vet & zootecnia, t mexico 3.univ veracruzana, fac quim farmaceut biol, xalapa 91000, veracruz mexico
42.	determinants of choice of market-oriented indigenous	alemayehu, befikadu; bogale, ayalneh (ayalnehb@yahoo.com);	bogale, ayalneh ; humboldt univ, berlin, germany
43.	land-use/cover dynamics in northern afar rangelands, ethiopia		1.norwegian univ life sci, dept ecol & nat resource management, n-1432 as, norway 2. mekelle univ, dept anim rangeland & wildlife sci, mekelle, ethiopia 3. norwegian univ life sci, dept int environm & dev studies, n-1432 as, norway 4. univ bonn, ctr dev res zef c, d-53113 bonn, germany
44.	optimal operation of a multipurpose multireservoir system in the eastern nile river basin	goor q (goor, q.)[2], halleux c (halleux, c.)[2], mohamed y (mohamed, y.)[3,4], tilmant a (tilmant, a.)[1]	1. swiss fed inst technol, inst environm engn, zurich, switzerland 2. catholic univ louvain, earth & life inst, b-1348 louvain, belgium 3. unesco ihe, dept management & inst, delft, netherlands 4. delft univ technol, dept water resources, delft, netherlands
45.	experimental investigations of water fluxes within the soil-vegetation-atmosphere system:	wenninger j (wenninger, jochen)[1,3], beza dt (beza, desta tadesse)[1,2], uhlenbrook s (uhlenbrook, stefan)[1,3]	1. unesco ihe, dept water engn, nl-2601 da delft, netherlands 2. tigray bur water resource dev, mekelle, ethiopia 3. delft univ technol, dept water resources, nl-2600 ga delft, netherlands
46.	effects of integrated watershed management on livestock water	descheemaeker k (descheemaeker, katrien)[1,2], mapedza e (mapedza, everisto)[2],	1. ilri, addis ababa, ethiopia 2.ilri ethiopia, subreg off nile basin & e africa, iwmi, addis ababa, ethiopia
47.	genetic characterization of puccinia graminis f.sp tritici populations from ethiopia by ssrs	admassu b (admassu, belayneh)[1,2], friedt w (friedt, wolfgang)[3], ordon f (ordon, frank)[3]	1. plant protect res ctr, ethiopian inst agr res, ambo, ethiopia 2. inst resistance res & stress tolerance, fed res inst cultivated plants jki, julius kuehn inst, d-06484 que germany 3. univ giessen, inst crop sci & plant breeding 1, d-35392 giessen, germany
48.	farmers' preferences for crop variety traits: lessons for on-farm conservation and technology adoption	asrat s (asrat, sinafikeh)[2], yesuf m (yesuf, mahmud)[1], carlsson f (carlsson, fredrik)[3], wale e (wale, edilegnaw)[4]	1. kansas state univ, manhattan, ks 66506 usa 2. ifpri, addis ababa, ethiopia 3. univ gothenburg, dept econ, sch business econ & law, s-40530 gothenburg, sweden 4. sch agr sci & agribusiness, dept agr econ, za-3209 pietermaritzburg, south africa
49.	is poverty driving borana herders in southern ethiopia to	tache, boku; oba, gufu (gufu.oba@umb.no)	oba, gufu; norwegian univ life sci, dept int environm and dev studies, pob 5003, n-1432 as, norway
50.	farmers' willingness to contribute to tsetse and trypanosomosis	pokou k (pokou, koffi)[1], kamuanga mjb (kamuanga, mulumba jean-bosco), n'gbo, agm	univ abidjan cocody, fac management & econ, abidjan 08, cote ivoire

51.	land-use/cover dynamics in	tsegaye, diress (diress.alemu@umb.no);	tsegaye, diress ; norwegian univ life sci, dept ecol and nat resource management , pob 5003, n-1432 as, norway
52.	genetic divergence among barley accessions from ethiopia	setotaw ta (setotaw, tesfahun alemu)[1], dias lad (dos santos dias, luis antonio)[2], missio rf (missio, robson fernando)[3]	1. kulumsa agr res ctr, assela, ethiopia 2. univ fed vicosa, dept fitotecnia, br-36570000 vicosa, mg brazil 3. univ fed parana, br-85950000 palotina, pr brazil
53.	farmers' preferences for crop variety traits: lessons for	asrat, sinafikeh (sinafik12@yahoo.com); yesuf, mahmud	yesuf, mahmud ; kansas state univ, 337b waters hall, manhattan, ks 66506 usa
54.	chemical composition, in vitro dry matter digestibility and in	melaku, solomon (solmelay@yahoo.com); aregawi, teferi; nigatu, lisanework	melaku, solomon ; haramaya univ, pob 138, dire dawa, ethiopia
55.	impact of drought and hiv on child nutrition in eastern	Mason jb (mason, john b.)[1], chotard s (chotard, sophie), bailes a (bailes,	tulane univ, dept int hlth & dev, sch publ hlth & trop med, new orleans, la 70112 usa
56.	identifying priorities for emergency intervention from child wasting and mortality estimates in vulnerable areas of the horn of africa	mason jb (mason, john b.)[1], chotard s (chotard, sophie), cercone e (cercone, emily), dieterich m (dieterich, megan)[2], oliphant np (oliphant, nicholas p.)[3], mebrahtu s	1. tulane univ, dept int hlth & dev, sch publ hlth & trop med, new orleans, la 70112 usa 2. whitman walker clin, washington, dc usa 3. no hlth author, prevent publ hlth dept, ft st john, bc canada 4. unicef reg off eastern & so africa, nairobi, kenya
57.	supplementation of farta sheep fed hay with graded levels of concentrate mix consisting of noug	asmare b (asmare, bimrew)[2], melaku s (melaku, solomon)[1], peters kj (peters, kurt j.)[3]	1. haramaya univ, dept anim sci, dire dawa, ethiopia 2. woreta agr tvet coll, woreta, ethiopia 3. humboldt univ, fachgebiet tierzucht tropen & subtropen, d-10115 berlin, germany
58.	production objectives and trait	Dana n (dana, nigussie)[1,2], van der waaij lh (van der	. ethiopian agr res inst, debre, zeit ethiopia 2. wageningen univ, anim breeding & genom ctr, nl-6700 ah wageningen, netherlands
59.	economic performance of small ruminants in	legesse g (legesse, getahun)[1,2], siegmund-schultze m (siegmund-	1. univ hohenheim, dept anim prod trop & subtrop, d-70593 stuttgart, germany 2.hawassa univ, dept anim & range sci, awasa, ethiopia 3. wageningen univ, adaptat physiol grp, nl-6700 ah wageningen, netherlands
60.	challenges and responses to agricultural	bahir, asmamaw legass; univ addis ababa, dept geog and environm	4. int livestock res inst, addis ababa, ethiopia challenges and responses to agricultural practices in gerado area, south wello, ethiopia
61.	impact of parthenium hysterophorus on grazing land	Nigatu l (nigatu, lisanework) [1], hassen a (hassen, asresie)[1], sharma j (sharma,	1. haramaya univ, dept plant sci, dire dawa, ethiopia 2.univ queensland, sch land crop & food sci, brisbane, qld Australia
62.	morphological diversity of ethiopian barleys (hordeum	abebe td (abebe, tiegist dejene)[1], bauer am (bauer, andrea michaela)[1],	. univ bonn, inst crop sci & resource conservat, de-53115 bonn, germany
63.	test of aquacrop model in simulating biomass and yield of water deficient and irrigated barley (hordeum vulgare)	araya a (araya, a.)[1], habtu s (habtu, solomon)[2], hadgu km (hadgu, kiros meles)[3], kebede a (kebede, afewerk)[1], dejene t (dejene, taddese)[4]	1.mekelle univ, dept crop & hort sci, mekelle, tigray ethiopia 2. mekelle univ, dept land resources management & environm protect, mekelle, ethiopia 3. mekelle univ, coll dryland agr & nat resources, mekelle, ethiopia 4. mekelle univ, dept biol, mekelle, ethiopia
64.	poultry production and performance in the federal	Wilson rt (wilson, r. t.)	1. bartridge partners, umberleigh ex37 9as, devon England
65.	companion cropping to manage parasitic plants	Pickett ja (pickett, john a.)[1], hamilton ml (hamilton, mary l.)[1], hooper am (hooper, antony m.)[1], khan	1.rothamsted res, harpenden al5 2jq, herts england 2.int ctr insect physiol & ecol, nairobi, Kenya
66.	yield loss of faba bean (vicia faba) due to chocolate spot (botrytis fabae)	sahile, samuel (samuelsahile@yahoo.com); fininsa, chemeda; sakhuja, p. k.; ahmed,	sahile, samuel ; haramaya univ, dept plant sci, pob 138, dire dawa, ethiopia
67.	multivariate patterns of diversity in ethiopian barleys	bjornstad a (bjornstad, asmund)[1], abay f (abay, fetien)[2]	1. norwegian univ life sci, dep plant & environm sci, n-1432 as, norway 2. mekelle univ, dep dry land crop & hort sci, mekelle, ethiopia
68.	study on the early effects of several weed-control	goodall j (goodall, j.)[1], braack m (braack, m.)[2], de klerk j (de klerk, j.)[1], keen	1.arc plant protect res inst, za-3245 hilton, south africa 2.kzn dept agr & environm affairs, invas alien species programme, za-3245 hilton, south Africa

69.	general/specific, local/global: comparing the beginnings of agriculture in the	Harrower mj (harrower, michael j.)[1], mccorriston j (mccorriston, joy)[2], d'andrea ac (d'andrea, a. catherine)[3]	1.univ calif los angeles, cotsen inst archaeol, los angeles, ca 90095 usa 2. ohio state univ, dept anthropol, columbus, oh 43210 usa 3.simon fraser univ, dept archaeol, burnaby, bc v5a 1s6 canada
70.	effects of different soil amendments on bacterial wilt caused by ralstonia	Yadessa gb (yadessa, g. b.)[1], van bruggen ahc (van bruggen, a. h. c.)[2,3], ocho fl (ocho, f. l.)[1]	1. univ jimma, coll agr & vet med, dept hort & plant sci, jimma, ethiopia 2. univ florida, dept plant pathol, gainesville, fl 32611 usa 3. univ wageningen, nl-6700 an wageningen, netherlands
71.	interrelationship	Arabi mie (arabi, m. i. e.)[1],	aecs, dept mol biol & biotechnol, damascus, Syria
72.	ectoparasites are the major causes of various types of skin lesions in small ruminants in	chanie m (chanie, mersha)[1], negash t (negash, tamiru)[2], sirak a (sirak, asegedech)[3]	1. wollo univ, coll agr & vet med, dessie, ethiopia 2. univ gondar, fac vet med, gondar, ethiopia 3. natl anim hlth diag & invest ctr, sebeta, ethiopia
73.	non-genetic factors influencing reproductive traits and calving weight	Almutairi se (almutairi, sallal e.)[2], boujenane i (boujenane, ismail)[1], musaad a (musaad,	1. rabat inst, inst agronom & vet hassan ii, dept anim prod & biotechnol, rabat 10101, morocco 3.camel & range res ctr, camel breeding protect & improvement project, al jouf, saudi Arabia
74.	prevalence, risk factors, and distribution of cysticercus	Samuel w (samuel, woinshet)[2], zewde gg (zewde, girma g.)[1]	1. univ addis ababa, fac vet med, debre zeit, ethiopia 2. so nations national & peoples reg, dilla, ethiopia
75.	gastrointestinal nematode infections in small ruminants under the traditional	abebe r (abebe, rahmeto)[1], gebreyohannes m (gebreyohannes, mebrahtu)[1], mekuria s	1. hawassa univ, fac vet med, hawassa, ethiopia
76.	ectoparasites of small ruminants in three selected agro-ecological sites of tigray region	Mulugeta y (mulugeta, y.)[2], yacob ht (yacob, hailu t.)[1], ashenafi h (ashenafi, hagos)[1]	1. univ addis ababa, dept pathol & parasitol, fac vet med, debre zeit, ethiopia 2.tigray reg state bur agr & rural dev, mekelle, ethiopia
77.	occurrence of mastitis and associated risk	megersa b (megersa, bekele)[1], tadesse c (tadesse, chala)[1], abunna	. hawassa univ, fac vet med, hawassa, ethiopia
78.	a new agro-climatic classification for crop suitability	Araya a (araya, a.)[1], keesstra sd (keesstra, s. d.)[2], stroosnijder l	1. mekelle univ, dept crop & hort sci, mekelle, ethiopia 2. univ wageningen & res ctr, dept land degradat & dev, nl-6708 pb wageningen, netherlands
79.	distribution of sugarcane stem borers and their natural enemies in small-scale farmers' fields, adjacent margins and	Assefa y (assefa, y.)[1], conlong de (conlong, d. e.)[2,3], van den berg j (van den berg, j.)[1], mitchell a (mitchell, a.)[4]	1. north west univ, sch environm sci & dev, za-2520 potchefstroom, south africa 2. s african sugarcane res inst, za-4300 mt edgecombe, south africa 3. univ kwazulu natal, sch biol & conservat sci, za-3209 pietermaritzburg, scottsville south africa 4. wagga wagga agr inst, nsw dept primary ind, wagga wagga, nsw 2650 australia
80.	a cross-sectional study on bovine tuberculosis in hawassa town and its surroundings,	regassa a (regassa, alemayehu)[1], tassew a (tassew, asmelash)[1], amenu k (amenu, kebede)[1], megersa b	1. hawassa univ, fac vet med, hawassa, ethiopia 2. univ addis ababa, aklilu lemma inst pathobiol, addis ababa, ethiopia 3. inst trop med, dept anim hlth, b-2000 antwerp, belgium
81.	pheromone-based mating and aggregation in the sorghum chafer, pachnoda interrupta	Bengtsson jm (bengtsson, jonas m.)[1], chinta sp (chinta, satya prabhakar)[2], wolde-hawariat y (wolde-hawariat, yitbarek)[1,3,4], negash m (negash, merid)[3,5], seyoum e (seyoum, emiru)[3], hansson bs (hansson, bill s.)[1,5], schlyter f (schlyter	1. swedish univ agr sci, dept plant protect biol, s-23053 alnarp, sweden 2. tech univ carolo wilhelmina braunschweig, inst organ chem, d-3300 braunschweig, germany 3. univ addis ababa, dept biol, addis ababa, ethiopia 4. wollo univ, dept plant sci, dessie, ethiopia 5.max planck inst chem ecol, dept evolutionary neuroethol, jena, germany
82.	farmers' perspectives of rodent damage and	yonas, meheretu	mekelle univ, dept biol, pob 3102, mekelle, ethiopia
83.	adaptation and diversity along an altitudinal gradient in ethiopian barley	hadado, tesema tanto; rau, domenico; bitocchi, elena; papa, roberto	papa, roberto; univ politecn marche, dipartimento sci ambientali and prod vegetali, via brecce bianche, i-60131 ancona, italy
84.	seeds for livelihood: crop biodiversity	di falco s (di falco, salvatore)[1], bezabih m	1. london sch econ, dept geog & environm, london, england

	and food production in ethiopia	(bezabih, mintewab)[2], yesuf m (yesuf, mahmud	2. univ portsmouth, portsmouth po1 2up, hants england
85.	policies to promote cereal intensification in ethiopia: the search for appropriate public	Spielman dj (spielman, david j.)[1], byerlee d (byerlee, derek)[2], alemu d (alemu, dawit)[3], kelemework d	1. int food policy res inst, addis ababa, ethiopia 2. world bank, washington, dc 20433 usa 3.ethiopian inst agr res, addis ababa, ethiopia
86.	economic and distributional impacts of climate change: the case of ethiopia	Mideksa tk (mideksa, torben k.)[1,2]	1. harvard univ, john f kennedy sch govt, cambridge, ma 02138 usa 2. univ oslo, ctr int climate & environm res oslo, n-0318 oslo, norway
87.	epidemiology of nematode parasites of sheep around jimma, southwestern	haile a (haile, aynalem)[1,2], gashaw a (gashaw, abebaw)[2], tolemariam t (tolemariam, taye)[2], tibbo m (tibbo, markos)[1,3]	1. ilri, addis ababa, ethiopia 2. jimma univ, coll agr, jimma, ethiopia 3. int ctr agr res dry areas, aleppo, syria
88.	effect of supplementation of simada sheep with graded levels of concentrate meal on feed intake,	Dessie j (dessie, jemberu)[2], melaku s (melaku, solomon)[1], tegegne f (tegegne, firew)[3], peters kj (peters, kurt j.)[4]	1. haramaya univ, dire dawa, ethiopia 2. s gondar agr & rural dev off, simada, ethiopia 3. bahir dar univ, bahir dar, ethiopia 4. humboldt univ, fachgebiet tierzucht tropen & subtropen, d-101185 berlin, germany
89.	hydatidosis of sheep and goats slaughtered at addis ababa abattoir: prevalence and risk	erbeto k (erbeto, kebebe)[2], zewde g (zewde, girma)[1], kumsa b (kumsa, bersissa)[1]	1. univ addis ababa, fac vet med, debre zeit, ethiopia 2.addis ababa city urban agr off, addis ababa, ethiopia
90.	distribution of drug resistance among enterococci and salmonella from	bekele b (bekele, behailu)[2], ashenafi m (ashenafi, mogessie)[1]	1. univ addis ababa, inst pathobiol, addis ababa, ethiopia 2. univ addis ababa, dept biol, addis ababa, ethiopia
91.	milk yield and associated economic losses in quarters with	Tesfaye gy (tesfaye, gebreyohannes y.)[2], regassa fg (regassa, fekadu gudeta)[1], kelay b	1. univ addis ababa, fac vet med, debre zeit, ethiopia 2.moa, agr & rural dev, bahir dar, amhara regional ethiopia
92.	pulmonary adenomatosis and maedi-visna in ethiopian central highland sheep: a microscopic study	Woldemeskel m (woldemeskel, moges)[1,2], tibbo m (tibbo, m.)[3,4]	1. univ georgia, tifton diagnost & invest lab, coll vet med, tifton, ga 31793 usa 2. univ addis ababa, fac vet med, debre zeit, ethiopia 3. int livestock res inst, addis ababa, ethiopia 4. icarda, diversificat & sustainable intensificat prod syst, aleppo, syria
93.	study on the prevalence of cystic hydatidosis and its economic	regassa f (regassa, feyesa)[1], molla a (molla, alemante)[1], bekele j (bekele, jemere)[2]	1. jimma univ, coll agr & vet med, jimma, ethiopia 2.hawassa univ, fac vet med, hawassa, ethiopia
94.	analysis of wheat (triticum aestivum l.) yellow rust (puccinia	florencia rodriguez-garcia, m. (rodriguez.maria@inifap.g	
95.	effect of strategic helminthosis control on mortality of	tibbo, m. aragaw, k.; teferi, m.; haile, a.	(m.tibbo@cgiar.org);
96.	effects and interactions of origin of sheep in ethiopia (highland vs lowland areas), feeding and lengths of rest and feeding on harvest	Merera c (merera, c.)[2,3], abebe g (abebe, g.), sebsibe a (sebsibe, a.)[5], goetsch al (goetsch, a. l.)[1]	1. langston univ, amer inst goat res, langston, ok usa 2. univ hawassa, dept anim & range sci, hawassa, ethiopia 3. bako agr res ctr, bako, ethiopia 4. ethiopia sheep & goat prod improvement program, addis ababa, ethiopia 5. ethiopian meat & dairy technol inst, debre zeit, ethiopia
97.	skip-row planting and tie-ridging for sorghum production in semiarid areas of ethiopia	Mesfin t (mesfin, tewodros)[2], tesfahunegn gb (tesfahunegn, gebreyesus brhane)[3], wortmann cs (wortmann,	1. univ nebraska, dep agron & hort, lincoln, ne 68583 usa 2. melkassa agr res ctr, ethiopia inst agr res, nazret, ethiopia 3. mekele agr res ctr, mekelle, ethiopia
98	Diversity, distribution and management of yam landraces	Tamiru M (Tamiru, Muluneh)[3,1], Becker HC (Becker, Heiko C.)[2], Maass BL (Maass,	1. Univ Gottingen, Dept Corp Sci Agron Trop, D-37077 Gottingen, Germany 2. Univ Gottingen, Dept Crop Sci Plant Breeding, D-37075 Gottingen, Germany 3. . Hawassa Univ, Awasa, Ethiopia

99	Performance of in situ rainwater conservation tillage techniques on dry spell mitigation and erosion control in	McHugh OV (McHugh, Oro V.)[1], Steenhuis TS (Steenhuis, Tarammo S.)[1], Abebe B (Abebe, Berihun)[2], Fernandes ECM (Fernandes, Erick C. [3]	1. Cornell Univ, Dept Biol & Environm Engn, Ithaca, NY 14853 USA 2. Dryland Agr & Community Participat Consultant, Meket, Ethiopia 3.world Bank, Dept Agr & Rural Dev, ESSD, ARD, Washington, DC 20433 USA
100	A new approach to detecting vegetation and land-use change using high-resolution lipid biomarker records in stalagmites	Blyth AJ (Blyth, Alison J.), Asrat A (Asrat, Asfawossen), Baker A (Baker, Andy), Gulliver P (Gulliver, Pauline), Leng MJ (Leng, Melanie J.), Genty D (Genty, Dominique)	1. Univ Newcastle Upon Tyne, Sch Civil Engn & Geosci, Newcastle Upon Tyne NE1 7RU, Tyne & Wear E 2. Univ Addis Ababa, Dept Earth Sci, Addis Ababa, Ethiopia 3. Univ Birmingham, Sch Geog Earth & Environm Sci, Birmingham B15 2TT, W Midlands England 4. Scottish Enterprise Technol Pk, NERC, Radiocarbon Lab, Glasgow G75 0QF, Lanark Scotland 5. NERC, Isotope Geosci Lab, British Geol Survey, Keyworth NG12 5GG, Notts England 6. Univ Nottingham, Sch Geog, Nottingham NG12 5GG, England 7. L Orme Merisiers CEA Saclay, CNRS, CEA, LSCE,UMR 1572, F-91191 Gif Sur Yvette, France

Appendix3. Disimilarity index for rural agricultutre knowledge and information system

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46
1	0.0000	0.5641	0.4872	0.8462	0.6923	0.5128	0.8205	1.1282	0.7436	0.7179	0.9487	0.5385	0.6667	0.6667	0.7436	0.6923	0.6923	0.7692	0.7692	1.0256	1.0256	1.0000	1.0000	0.8462	0.8205	0.7436	0.7949	0.8974	0.9231	0.7179	0.8718	0.8462	0.8462	0.9231	0.9231	0.9231	0.9744	0.6154	0.7179	1.0513	0.8718	0.9231	0.7949	0.8462	0.8974	0.8974
2	0.5641	0.0000	0.4872	0.3846	0.3333	0.8718	0.3590	0.6667	0.2821	0.3590	0.4359	0.2821	0.1538	0.5128	0.2308	0.3846	0.1282	0.4103	0.4103	0.4615	0.4615	0.4359	0.4359	0.2821	0.3077	0.2821	0.2821	0.3333	0.3590	0.2051	0.3590	0.2821	0.4359	0.3590	0.3590	0.3590	0.4103	0.3590	0.3077	0.4872	0.3590	0.3590	0.2308	0.2821	0.3846	0.3846
3	0.4359	0.4359	0.0000	0.4615	0.4615	0.7949	0.4359	0.7949	0.4103	0.4359	0.5128	0.4103	0.3333	0.7436	0.4103	0.4103	0.5641	0.4359	0.4359	0.5897	0.5897	0.6667	0.6667	0.5128	0.5385	0.5128	0.4615	0.5128	0.5385	0.6410	0.5385	0.5128	0.5641	0.5897	0.5897	0.5897	0.5897	0.3846	0.4359	0.6154	0.5385	0.5897	0.4615	0.5128	0.5641	0.5641
4	0.8462	0.2821	0.4103	0.0000	0.1026	0.8974	0.2821	0.5385	0.2564	0.1795	0.3590	0.3590	0.2308	0.5897	0.2051	0.2051	0.3077	0.2821	0.2821	0.3846	0.3846	0.3077	0.3077	0.1538	0.1795	0.2051	0.1538	0.1538	0.3333	0.3333	0.2308	0.1538	0.2051	0.2308	0.2308	0.2308	0.2308	0.2821	0.3846	0.2308	0.3590	0.2308	0.2308	0.2564	0.1538	0.2051	0.2564
5	0.7436	0.3846	0.5128	0.1026	0.0000	0.8974	0.3333	0.5385	0.1538	0.2821	0.2564	0.3077	0.2308	0.6923	0.1538	0.3077	0.2564	0.3333	0.3333	0.3333	0.3333	0.3333	0.3077	0.3077	0.1538	0.2821	0.3077	0.2051	0.2051	0.3333	0.3333	0.2308	0.1538	0.2051	0.2308	0.2308	0.2308	0.2821	0.3846	0.3333	0.3590	0.2308	0.2308	0.1538	0.2564	0.2051	0.2564
6	0.6154	0.8718	0.9487	0.9487	0.8974	0.0000	1.0256	1.2308	0.9487	0.7692	1.1538	0.7436	0.8718	0.5128	0.9487	0.9487	0.9487	1.0769	1.0769	1.2308	1.2308	1.1026	1.1026	1.0513	1.0256	1.0000	1.0000	1.1026	1.1282	0.9231	1.0769	1.0513	1.0000	1.1282	1.1282	1.1282	1.1795	0.7692	0.9231	1.2564	1.0769	1.1282	1.0000	1.0513	1.0513	1.0513
7	0.6667	0.2564	0.2821	0.2821	0.3333	0.8205	0.0000	0.3590	0.1795	0.2564	0.2821	0.2821	0.2051	0.6154	0.2308	0.1795	0.3333	0.1026	0.1026	0.2051	0.2051	0.2308	0.2308	0.1795	0.1026	0.1795	0.1282	0.1795	0.1026	0.2564	0.1538	0.1795	0.1795	0.1538	0.1538	0.1538	0.1538	0.2564	0.1538	0.1795	0.2564	0.1538	0.2308	0.0769	0.1795	0.1282
8	1.0769	0.6667	0.7949	0.5385	0.5385	1.1795	0.3590	0.0000	0.4872	0.6154	0.4872	0.6410	0.5641	0.7179	0.4872	0.3846	0.5385	0.3590	0.3590	0.2051	0.2051	0.3333	0.3333	0.3846	0.4103	0.5385	0.3846	0.3846	0.3077	0.5128	0.3590	0.3846	0.3846	0.3590	0.3590	0.3590	0.2564	0.5641	0.5128	0.1795	0.4615	0.3590	0.4359	0.3846	0.3846	0.3333
9	0.7436	0.3333	0.4615	0.2564	0.1538	0.9487	0.2308	0.4872	0.0000	0.4359	0.2564	0.2564	0.1282	0.5897	0.1026	0.3590	0.2051	0.2821	0.2821	0.2821	0.2821	0.2564	0.2564	0.1026	0.2308	0.2051	0.1538	0.1538	0.2821	0.2821	0.1795	0.1026	0.2564	0.1795	0.1795	0.1795	0.2308	0.2308	0.2308	0.3077	0.1795	0.1795	0.1026	0.2051	0.2051	0.2051
10	0.6667	0.3077	0.4359	0.2308	0.2308	0.7179	0.4103	0.6154	0.3846	0.0000	0.4872	0.3846	0.2564	0.5128	0.3333	0.3333	0.4359	0.4103	0.4103	0.5641	0.5641	0.4359	0.4359	0.3846	0.4103	0.4359	0.3333	0.3846	0.4615	0.5128	0.4615	0.3846	0.3846	0.4615	0.4615	0.4615	0.5128	0.3590	0.3590	0.5897	0.4103	0.4615	0.3846	0.3846	0.4359	0.4359
11	0.8462	0.4359	0.5128	0.2564	0.1538	1.1026	0.3333	0.4872	0.2051	0.4872	0.0000	0.3590	0.2821	0.7436	0.2051	0.3590	0.3077	0.3846	0.3846	0.2821	0.2821	0.1538	0.1538	0.2051	0.3333	0.3590	0.2564	0.2564	0.3333	0.3846	0.2821	0.2051	0.3077	0.2821	0.2821	0.2821	0.2821	0.4359	0.3846	0.3077	0.2821	0.2821	0.1538	0.3077	0.2564	0.3077
12	0.2821	0.2821	0.3590	0.3077	0.2564	0.5897	0.3333	0.6410	0.2051	0.3846	0.4103	0.0000	0.1282	0.3846	0.2051	0.2051	0.2564	0.3333	0.3333	0.4872	0.4872	0.4615	0.4615	0.3077	0.3333	0.3077	0.2564	0.3590	0.4872	0.3333	0.3333	0.3077	0.3590	0.3846	0.3846	0.3846	0.4359	0.1795	0.2308	0.5128	0.3846	0.3846	0.3077	0.3077	0.3590	0.3590
13	0.6154	0.1538	0.3846	0.2821	0.2308	0.8718	0.2564	0.5641	0.0769	0.3590	0.3333	0.1282	0.0000	0.4103	0.1282	0.3333	0.2308	0.3077	0.3077	0.3590	0.3590	0.3333	0.3333	0.1795	0.2051	0.1795	0.1795	0.2308	0.3590	0.3077	0.2564	0.1795	0.3333	0.2564	0.2564	0.2564	0.3077	0.2051	0.1538	0.3846	0.2564	0.2564	0.1795	0.1795	0.2821	0.2821
14	0.6154	0.4615	0.7949	0.5897	0.6410	0.5128	0.7179	0.6667	0.5897	0.6154	0.7949	0.4359	0.5128	0.0000	0.6410	0.5897	0.4872	0.7179	0.7179	0.7692	0.7692	0.7436	0.7436	0.6923	0.7179	0.6410	0.6410	0.7436	0.8718	0.6154	0.7692	0.6923	0.7436	0.7692	0.7692	0.7692	0.8205	0.5128	0.5641	0.6923	0.7692	0.7692	0.6410	0.6923	0.7436	0.7436
15	0.6923	0.1795	0.4103	0.2051	0.1538	0.8462	0.2308	0.4872	0.1026	0.3333	0.2564	0.1538	0.0769	0.5897	0.0000	0.2564	0.1538	0.2308	0.2308	0.2821	0.2821	0.2564	0.2564	0.1026	0.1282	0.1538	0.1026	0.1538	0.2821	0.2308	0.1282	0.1026	0.2564	0.1795	0.1795	0.1795	0.2308	0.1795	0.1282	0.3077	0.1795	0.1795	0.1026	0.1026	0.2051	0.2051
16	0.5897	0.3333	0.4103	0.2564	0.3077	0.8974	0.2821	0.4872	0.3590	0.3333	0.4615	0.3077	0.3333	0.6923	0.3077	0.0000	0.3077	0.2821	0.2821	0.4872	0.4872	0.4103	0.4103	0.2564	0.2821	0.3077	0.2051	0.3077	0.3333	0.3333	0.3333	0.2564	0.3077	0.3333	0.3333	0.3333	0.2821	0.3333	0.2821	0.4615	0.3333	0.3333	0.3590	0.2564	0.3077	0.3077
17	0.6923	0.0769	0.5641	0.3077	0.2564	0.8462	0.3333	0.5385	0.2051	0.4359	0.3590	0.2051	0.1795	0.4872	0.1538	0.3077	0.0000	0.3333	0.3333	0.3846	0.3846	0.3590	0.3590	0.2051	0.2308	0.2051	0.2051	0.2564	0.3846	0.1282	0.2821	0.2051	0.3590	0.2821	0.2821	0.2821	0.3333	0.3333	0.2821	0.4103	0.2821	0.2821	0.1538	0.2051	0.3077	0.3077
18	0.8205	0.3077	0.3846	0.2821	0.3333	1.0256	0.1538	0.4103	0.2821	0.3590	0.3846	0.3333	0.2564	0.7179	0.2308	0.2308	0.3333	0.0000	0.0000	0.3077	0.3077	0.2308	0.2308	0.1795	0.1026	0.2308	0.1282	0.1795	0.2564	0.2564	0.1538	0.1795	0.1795	0.1538	0.1538	0.1538	0.2051	0.3077	0.2051	0.2821	0.2564	0.1538	0.2821	0.0769	0.1795	0.1282
19	0.8205	0.3077	0.3846	0.2821	0.3333	1.0256	0.1538	0.4103	0.2821	0.3590	0.3846	0.3333	0.2564	0.7179	0.2308	0.2308	0.3333	0.0000	0.0000	0.3077	0.3077	0.2308	0.2308	0.1795	0.1026	0.2308	0.1282	0.1795	0.2564	0.2564	0.1538	0.1795	0.1795	0.1538	0.1538	0.1538	0.2051	0.3077	0.2051	0.2821	0.2564	0.1538	0.2821	0.0769	0.1795	0.1282
20	0.9744	0.4615	0.6410	0.3846	0.2821	1.1795	0.2564	0.2051	0.2308	0.5641	0.2308	0.3846	0.3077	0.8205	0.2308	0.4872	0.3333	0.3077	0.3077	0.0000	0.0000	0.2821	0.2821	0.2308	0.2564	0.3846	0.2821	0.2308	0.2564	0.3077	0.2051	0.2308	0.2821	0.2051	0.2051	0.2051	0.2051	0.4615	0.4103	0.0256	0.3077	0.2051	0.1795	0.2308	0.2308	0.2308
21	0.9744	0.4615	0.6410	0.3846	0.2821	1.1795	0.2564	0.2051	0.2308	0.5641	0.2308	0.3846	0.3077	0.8205	0.2308	0.4872	0.3333	0.3077	0.3077	0.0000	0.0000	0.2821	0.2821	0.2308	0.2564	0.3846	0.2821	0.2308	0.2564	0.3077	0.2051	0.2308	0.2821	0.2051	0.2051	0.2051	0.2051	0.4615	0.4103	0.0256	0.3077	0.2051	0.1795	0.2308	0.2308	0.2308
22	1.0000	0.4359	0.6667	0.3077	0.3077	1.1538	0.2308	0.3333	0.2564	0.4872	0.1538	0.4615	0.3333	0.7436	0.2564	0.4103	0.3590	0.2308	0.2308	0.2821	0.2821	0.0000	0.0000	0.1538	0.1795	0.3077	0.2051	0.1538	0.2308	0.2821	0.1282	0.1538	0.2051	0.1282	0.1282	0.1282	0.1795	0.4872	0.3333	0.2564	0.2308	0.1282	0.2564	0.1538	0.1538	0.1538
23	1.0000	0.4359	0.6667	0.3077	0.3077	1.1538	0.2308	0.3333	0.2564	0.4872	0.1538	0.4615	0.3333	0.7436	0.2564	0.4103	0.3590	0.2308	0.2308	0.2821	0.2821	0.0000	0.0000	0.1538	0.1795	0.3077	0.2051	0.1538	0.2308	0.2821	0.1282	0.1538	0.2051	0.1282	0.1282	0.1282	0.1795	0.4872	0.3333	0.2564	0.2308	0.1282	0.2564	0.1538	0.1538	0.1538
24	0.8462	0.2821	0.5128	0.1538	0.1538	1.0513	0.1795	0.3846	0.1026	0.3846	0.2564	0.3590	0.1795	0.6923	0.1026	0.2564	0.2051	0.1795	0.1795	0.2308	0.2308	0.1538	0.1538	0.0000	0.1282	0.1538	0.0513	0.0513	0.1795	0.2308	0.0769	0.0000	0.1538	0.0769	0.0769	0.0769	0.1282	0.3333	0.1795	0.2051	0.0769	0.0769	0.1026	0.1026	0.1026	0.1026
25	0.7692	0.2564	0.5385	0.2308	0.2821	0.9744	0.1538	0.4103	0.2308	0.4103	0.3333	0.3333	0.2051	0.7179	0.1795	0.2821	0.2821	0.1538	0.1538	0.2564	0.2564	0.1795	0.1795	0.1282	0.0000	0.1282	0.1282	0.1282	0.2051	0.1538	0.1026	0.1282	0.1795	0.1026	0.1026	0.1026	0.1538	0.3077	0.2051	0.2308	0.1538	0.1026	0.2308	0.0256	0.1282	0.1282

26 0.6410 0.1795 0.4615 0.2564 0.3077 0.8974 0.2308 0.5385 0.1538 0.4359 0.4103 0.3590 0.1795 0.5897 0.2051 0.3077 0.2051 0.2821 0.2821 0.3846 0.3846 0.3077 0.3077 0.1538 0.1282 0.0000 0.1538 0.2051 0.3333 0.2821 0.2308 0.1538 0.3077 0.2308 0.2308 0.2308 0.2821 0.3333 0.1795 0.3590 0.1795 0.2308 0.2564 0.1538 0.2051 0.2051

27 0.7436 0.1795 0.4103 0.1538 0.2051 0.8974 0.1282 0.3846 0.1538 0.2308 0.3077 0.2564 0.1282 0.5897 0.1026 0.1026 0.2051 0.0769 0.0769 0.2821 0.2821 0.2051 0.2051 0.0513 0.0769 0.1026 0.0000 0.1026 0.2308 0.2308 0.1282 0.0513 0.1538 0.1282 0.1282 0.1282 0.1795 0.1795 0.0769 0.2564 0.1282 0.1282 0.1538 0.0513 0.1538 0.1026

28 0.8462 0.2821 0.4615 0.1026 0.1538 1.1026 0.1795 0.3846 0.1026 0.3333 0.2564 0.3590 0.1795 0.6923 0.1026 0.2564 0.2051 0.1795 0.1795 0.2308 0.2308 0.1538 0.1538 0.0000 0.1282 0.1538 0.0513 0.0000 0.1795 0.2308 0.0769 0.0000 0.1026 0.0769 0.0769 0.0769 0.1282 0.3333 0.1795 0.2051 0.0769 0.0769 0.1026 0.1026 0.1026 0.1026

29 0.9231 0.4103 0.5385 0.3333 0.3333 1.1282 0.1538 0.3590 0.2821 0.4615 0.2821 0.4872 0.3590 0.8718 0.2821 0.3333 0.3846 0.2564 0.2564 0.2051 0.2051 0.2308 0.2308 0.1795 0.2051 0.3333 0.2308 0.1795 0.0000 0.3077 0.1538 0.1795 0.2308 0.1538 0.1538 0.1538 0.0513 0.5128 0.3590 0.1795 0.2564 0.1538 0.2308 0.1795 0.1795 0.1795

30 0.6154 0.1026 0.5897 0.3333 0.2821 0.7692 0.2564 0.5128 0.2308 0.4615 0.3333 0.1795 0.2051 0.6154 0.1795 0.3333 0.0769 0.2564 0.2564 0.3077 0.3077 0.2821 0.2821 0.2308 0.1026 0.2308 0.2308 0.2308 0.3077 0.0000 0.2051 0.2308 0.2821 0.2051 0.2051 0.2051 0.2564 0.3077 0.3077 0.3333 0.2564 0.2051 0.1795 0.1282 0.2308 0.2308

31 0.8205 0.3590 0.5385 0.2308 0.2308 1.0256 0.1538 0.3590 0.1795 0.4615 0.2821 0.3333 0.2564 0.7692 0.1282 0.3333 0.2821 0.1538 0.1538 0.2051 0.2051 0.1282 0.1282 0.0769 0.1026 0.2308 0.1282 0.0769 0.1538 0.2051 0.0000 0.0769 0.1282 0.0513 0.0513 0.0513 0.1026 0.3590 0.2051 0.1795 0.1538 0.0513 0.1795 0.0769 0.0769 0.0769

32 0.8462 0.2821 0.5128 0.1538 0.1538 1.0513 0.1795 0.3846 0.1026 0.3846 0.2564 0.3590 0.1795 0.6923 0.1026 0.2564 0.2051 0.1795 0.1795 0.2308 0.2308 0.1538 0.1538 0.0000 0.1282 0.1538 0.0513 0.0513 0.1795 0.2308 0.0769 0.0000 0.1538 0.0769 0.0769 0.0769 0.1282 0.3333 0.1795 0.2051 0.0769 0.0769 0.1026 0.1026 0.1026 0.1026

33 0.7436 0.4359 0.5128 0.1538 0.1026 0.8462 0.1795 0.3846 0.2564 0.2821 0.3077 0.3590 0.3333 0.7436 0.2564 0.2051 0.3590 0.1282 0.1282 0.2821 0.2821 0.2051 0.2051 0.1538 0.1795 0.3077 0.1538 0.1026 0.2308 0.2821 0.1282 0.1538 0.0000 0.1282 0.1282 0.1282 0.1795 0.3846 0.2821 0.2564 0.2308 0.1282 0.2564 0.1538 0.1026 0.1026

34 0.9231 0.3590 0.5897 0.2308 0.2308 1.1282 0.1538 0.3590 0.1795 0.4615 0.2821 0.3846 0.2564 0.7692 0.1795 0.3333 0.2821 0.1538 0.1538 0.2051 0.2051 0.1282 0.1282 0.0769 0.1026 0.2308 0.1282 0.0769 0.1538 0.2051 0.0513 0.0769 0.1282 0.0000 0.0000 0.0000 0.1026 0.4103 0.2564 0.1795 0.1538 0.0000 0.1795 0.0769 0.0769 0.0769

35 0.9231 0.3590 0.5897 0.2308 0.2308 1.1282 0.1538 0.3590 0.1795 0.4615 0.2821 0.3846 0.2564 0.7692 0.1795 0.3333 0.2821 0.1538 0.1538 0.2051 0.2051 0.1282 0.1282 0.0769 0.1026 0.2308 0.1282 0.0769 0.1538 0.2051 0.0513 0.0769 0.1282 0.0000 0.0000 0.0000 0.1026 0.4103 0.2564 0.1795 0.1538 0.0000 0.1795 0.0769 0.0769 0.0769

36 0.9231 0.3590 0.5897 0.2308 0.2308 1.1282 0.1538 0.3590 0.1795 0.4615 0.2821 0.3846 0.2564 0.7692 0.1795 0.3333 0.2821 0.1538 0.1538 0.2051 0.2051 0.1282 0.1282 0.0769 0.1026 0.2308 0.1282 0.0769 0.1538 0.2051 0.0513 0.0769 0.1282 0.0000 0.0000 0.0000 0.1026 0.4103 0.2564 0.1795 0.1538 0.0000 0.1795 0.0769 0.0769 0.0769

37 0.9744 0.4103 0.5897 0.2821 0.2821 1.1795 0.1538 0.3077 0.2308 0.5128 0.2308 0.4359 0.3077 0.8205 0.2308 0.2821 0.3333 0.2051 0.2051 0.1538 0.1538 0.1795 0.1795 0.1282 0.1538 0.2821 0.1795 0.1282 0.0513 0.2564 0.1026 0.1282 0.1795 0.1026 0.1026 0.1026 0.0000 0.4615 0.3077 0.1282 0.2051 0.1026 0.1795 0.1282 0.1282 0.1282

38 0.4103 0.3077 0.4359 0.4359 0.3846 0.6154 0.3590 0.6154 0.2308 0.4103 0.4872 0.1795 0.1538 0.4103 0.2308 0.3333 0.3846 0.3590 0.3590 0.5128 0.5128 0.4872 0.4872 0.3333 0.3077 0.3333 0.2821 0.3846 0.5128 0.4103 0.3590 0.3333 0.4359 0.4103 0.4103 0.4103 0.4615 0.0000 0.2564 0.5385 0.3590 0.4103 0.3333 0.3333 0.4359 0.3846

39 0.5641 0.2051 0.3846 0.2821 0.3333 0.7692 0.2051 0.5128 0.1795 0.3077 0.4359 0.2821 0.1026 0.3590 0.1795 0.2308 0.3333 0.2051 0.2051 0.4103 0.4103 0.3333 0.3333 0.1795 0.2051 0.1795 0.1282 0.2308 0.3590 0.3590 0.2051 0.1795 0.2821 0.2564 0.2564 0.2564 0.3077 0.2051 0.0000 0.3846 0.2564 0.2564 0.2821 0.1795 0.2821 0.2308

40 1.0513 0.4872 0.6667 0.3590 0.3590 1.2564 0.2308 0.1795 0.3077 0.5897 0.3077 0.5128 0.3846 0.7949 0.3077 0.4615 0.4103 0.2821 0.2821 0.0256 0.0256 0.2564 0.2564 0.2051 0.2308 0.3590 0.2564 0.2051 0.2308 0.3333 0.1795 0.2051 0.2564 0.1795 0.1795 0.1795 0.1795 0.5385 0.3846 0.0000 0.2821 0.1795 0.2564 0.2051 0.2051 0.2051

41 0.8205 0.3590 0.5385 0.2308 0.2308 1.0256 0.2564 0.4615 0.1795 0.4103 0.3333 0.4359 0.2564 0.7692 0.1795 0.3333 0.2821 0.2564 0.2564 0.3077 0.3077 0.2308 0.2308 0.0769 0.1538 0.1795 0.1282 0.1282 0.2564 0.2564 0.1538 0.0769 0.2308 0.1538 0.1538 0.1538 0.2051 0.3590 0.2564 0.2821 0.0000 0.1538 0.1795 0.1795 0.1282 0.1282

42 0.9231 0.3590 0.5897 0.2308 0.2308 1.1282 0.1538 0.3590 0.1795 0.4615 0.2821 0.3846 0.2564 0.7692 0.1795 0.3333 0.2821 0.1538 0.1538 0.2051 0.2051 0.1282 0.1282 0.0769 0.1026 0.2308 0.1282 0.0769 0.1538 0.2051 0.0513 0.0769 0.1282 0.0000 0.0000 0.0000 0.1026 0.4103 0.2564 0.1795 0.1538 0.0000 0.1795 0.0769 0.0769 0.0769

43 0.7949 0.2308 0.5128 0.2564 0.1538 0.9487 0.2308 0.4359 0.1026 0.4359 0.1538 0.3077 0.1795 0.5897 0.1026 0.3590 0.1538 0.2821 0.2821 0.1795 0.1795 0.2564 0.2564 0.1026 0.2308 0.2564 0.1538 0.1538 0.2308 0.1795 0.1795 0.1026 0.2564 0.1795 0.1795 0.1795 0.1795 0.3333 0.2821 0.2051 0.1795 0.1795 0.0000 0.2051 0.2051 0.2051

44 0.8462 0.2308 0.5128 0.2051 0.2564 1.0513 0.1282 0.3846 0.2051 0.3846 0.3077 0.3077 0.1795 0.6923 0.1538 0.2564 0.2564 0.1282 0.1282 0.2308 0.2308 0.1538 0.1538 0.1026 0.0256 0.1538 0.1026 0.1026 0.1795 0.1795 0.0769 0.1026 0.1538 0.0769 0.0769 0.0769 0.1282 0.3333 0.1795 0.2051 0.1795 0.0769 0.2051 0.0000 0.1026 0.1026

45 0.8462 0.3846 0.5128 0.1538 0.1538 0.9487 0.1795 0.3846 0.2051 0.4359 0.2564 0.3590 0.2821 0.7436 0.2051 0.2564 0.3077 0.1795 0.1795 0.2308 0.2308 0.1538 0.1538 0.1026 0.1282 0.2051 0.1538 0.1026 0.1795 0.2308 0.0769 0.1026 0.1026 0.0769 0.0769 0.0769 0.1282 0.4359 0.2821 0.2051 0.1282 0.0769 0.2051 0.1026 0.0000 0.0513

46 0.8462 0.3846 0.5641 0.2564 0.2564 0.9487 0.1282 0.3333 0.2051 0.3846 0.3077 0.3590 0.2821 0.7436 0.2051 0.2564 0.3077 0.0769 0.0769 0.2308 0.2308 0.1538 0.1538 0.1026 0.1282 0.2051 0.1026 0.1026 0.1795 0.2308 0.0769 0.1026 0.1026 0.0769 0.0769 0.0769 0.1282 0.3333 0.2308 0.2051 0.1282 0.0769 0.2051 0.1026 0.0513 0.0000

Appendix4.Disimilarity Indices of urban agriculture knowledge and information system

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	0.0000	0.3137	0.1961	0.2353	0.1961	0.3137	0.2745	0.3529	0.3137	0.3137	0.3137	0.3137	0.3529	0.3137	0.2745	0.5098	0.3137	0.3137	0.3137	0.5490	0.2745
2	0.3137	0.0000	0.0392	0.0784	0.1176	0.1569	0.0392	0.0392	0.1569	0.0784	0.0000	0.0000	0.1961	0.0784	0.0392	0.6667	0.0000	0.0000	0.0000	0.6275	0.0392
3	0.2745	0.1176	0.0000	0.0392	0.0000	0.1176	0.0784	0.1569	0.1961	0.1176	0.1176	0.1176	0.2353	0.1176	0.0784	0.7059	0.1176	0.1176	0.1176	0.7451	0.0784
4	0.2353	0.0784	-0.0392	0.0000	-0.0392	0.0784	0.0392	0.1176	0.1569	0.0784	0.0784	0.0784	0.1961	0.0784	0.0392	0.7451	0.0784	0.0784	0.0784	0.7059	0.0392
5	0.1961	0.1176	0.0000	0.0392	0.0000	0.1176	0.0784	0.1569	0.1961	0.1176	0.1176	0.1176	0.2353	0.1176	0.0784	0.7843	0.1176	0.1176	0.1176	0.7451	0.0784
6	0.3137	0.1569	0.0392	0.0784	0.0392	0.0000	0.1176	0.1176	0.0784	0.0784	0.1569	0.1569	0.1176	0.0784	0.1176	0.6667	0.1569	0.1569	0.1569	0.6275	0.1176
7	0.2745	0.0392	0.0000	0.0392	0.0000	0.1176	0.0000	0.0784	0.1961	0.1176	0.0392	0.0392	0.2353	0.1176	0.0784	0.6275	0.0392	0.0392	0.0392	0.5882	0.0000
8	0.3529	0.0392	0.0784	0.1176	0.1569	0.1176	0.0784	0.0000	0.1176	0.1176	0.0392	0.0392	0.1569	0.1176	0.0784	0.6275	0.0392	0.0392	0.0392	0.5882	0.0784
9	0.3137	0.1569	0.1176	0.1569	0.1961	0.0784	0.1961	0.1176	0.0000	0.0784	0.1569	0.1569	0.1176	0.0784	0.1176	0.6667	0.1569	0.1569	0.1569	0.6275	0.1961
10	0.3137	0.0784	0.0392	0.0784	0.1176	0.0784	0.1176	0.1176	0.0784	0.0000	0.0784	0.0784	0.1176	0.0000	0.0392	0.7451	0.0784	0.0784	0.0784	0.7059	0.1176
11	0.3137	0.0000	0.0392	0.0784	0.1176	0.1569	0.0392	0.0392	0.1569	0.0784	0.0000	0.0000	0.1961	0.0784	0.0392	0.6667	0.0000	0.0000	0.0000	0.6275	0.0392
12	0.3137	0.0000	0.0392	0.0784	0.1176	0.1569	0.0392	0.0392	0.1569	0.0784	0.0000	0.0000	0.1961	0.0784	0.0392	0.6667	0.0000	0.0000	0.0000	0.6275	0.0392
13	0.3529	0.1961	0.1569	0.1961	0.2353	0.1176	0.2353	0.1569	0.1176	0.1176	0.1961	0.1961	0.0000	0.1176	0.1569	0.6275	0.1961	0.1961	0.1961	0.5882	0.2353
14	0.3137	0.0784	0.0392	0.0784	0.1176	0.0784	0.1176	0.1176	0.0784	0.0000	0.0784	0.0784	0.1176	0.0000	0.0392	0.7451	0.0784	0.0784	0.0784	0.7059	0.1176
15	0.2745	0.0392	0.0000	0.0392	0.0784	0.1176	0.0784	0.0784	0.1176	0.0392	0.0392	0.0392	0.1569	0.0392	0.0000	0.7843	0.0392	0.0392	0.0392	0.7451	0.0784
16	0.5882	0.8235	0.7843	0.8235	0.7843	0.7451	0.7843	0.7843	0.7451	0.8235	0.8235	0.8235	0.7059	0.8235	0.8627	0.0000	0.8235	0.8235	0.8235	0.0392	0.7843
17	0.3137	0.0000	0.0392	0.0784	0.1176	0.1569	0.0392	0.0392	0.1569	0.0784	0.0000	0.0000	0.1961	0.0784	0.0392	0.6667	0.0000	0.0000	0.0000	0.6275	0.0392
18	0.3137	0.0000	0.0392	0.0784	0.1176	0.1569	0.0392	0.0392	0.1569	0.0784	0.0000	0.0000	0.1961	0.0784	0.0392	0.6667	0.0000	0.0000	0.0000	0.6275	0.0392
19	0.3137	0.0000	0.0392	0.0784	0.1176	0.1569	0.0392	0.0392	0.1569	0.0784	0.0000	0.0000	0.1961	0.0784	0.0392	0.6667	0.0000	0.0000	0.0000	0.6275	0.0392
20	0.5490	0.7843	0.7451	0.7843	0.7451	0.7059	0.7451	0.7451	0.7059	0.7843	0.7843	0.7843	0.6667	0.7843	0.8235	-0.0392	0.7843	0.7843	0.7843	0.0000	0.7451
21	0.2745	0.0392	0.0000	0.0392	0.0000	0.1176	0.0000	0.0784	0.1961	0.1176	0.0392	0.0392	0.2353	0.1176	0.0784	0.6275	0.0392	0.0392	0.0392	0.5882	0.0000

Appendix5. Disimilarity Indices for collective analysis

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60
61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100 101 102 103 104 105 106 107 108 109 110 111 112 113 114

1 0.0000 0.5641 0.4872 0.8462 0.6923 0.5128 0.8205 1.1282 0.7436 0.7179 0.9487 0.5385 0.6667 0.6667 0.7436 0.6923 0.6923 0.7692 0.7692 1.0256 1.0256 1.0000 1.0000 0.8462 0.8205 0.7436 0.7949 0.8974 0.9231 0.7179 0.8718 0.8462 0.8462 0.9231 0.9231 0.9231 0.9744 0.6154 0.7179 1.0513 0.8718 0.9231
0.7949 0.8462 0.8974 0.8974 1.1282 0.9744 1.0000 0.9744 1.0000 1.0256 1.0000 1.0000 1.0256 0.9744 0.9744 0.9744 1.0513 0.9744 0.9487 1.5128 0.9744 0.9744 0.9744 1.4872 1.0000 0.9744 0.9744 0.9744 1.0000 0.9744 0.9744 1.0000 1.0000 1.0000 1.0000 1.0256 1.0000 0.9744 0.9487 0.9744 0.9744 1.0000 0.9744
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2 0.5641 0.0000 0.4872 0.3846 0.3333 0.8718 0.3590 0.6667 0.2821 0.3590 0.4359 0.2821 0.1538 0.5128 0.2308 0.3846 0.1282 0.4103 0.4103 0.4615 0.4615 0.4359 0.4359 0.2821 0.3077 0.2821 0.2821 0.3333 0.3590 0.2051 0.3590 0.2821 0.4359 0.3590 0.3590 0.3590 0.4103 0.3590 0.3077 0.4872 0.3590 0.3590
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3 0.4359 0.4359 0.0000 0.4615 0.4615 0.7949 0.4359 0.7949 0.4103 0.4359 0.5128 0.4103 0.3333 0.7436 0.4103 0.4103 0.5641 0.4359 0.4359 0.5897 0.5897 0.6667 0.6667 0.5128 0.5385 0.5128 0.4615 0.5128 0.5385 0.6410 0.5385 0.5128 0.5641 0.5897 0.5897 0.5897 0.5897 0.3846 0.4359 0.6154 0.5385 0.5897
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4 0.8462 0.2821 0.4103 0.0000 0.1026 0.8974 0.2821 0.5385 0.2564 0.1795 0.3590 0.3590 0.2308 0.5897 0.2051 0.2051 0.3077 0.2821 0.2821 0.3846 0.3846 0.3077 0.3077 0.1538 0.1795 0.2051 0.1538 0.1538 0.3333 0.3333 0.2308 0.1538 0.2051 0.2308 0.2308 0.2308 0.2821 0.3846 0.2308 0.3590 0.2308 0.2308
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5 0.7436 0.3846 0.5128 0.1026 0.0000 0.8974 0.3333 0.5385 0.1538 0.2821 0.2564 0.3077 0.2308 0.6923 0.1538 0.3077 0.2564 0.3333 0.3333 0.3333 0.3333 0.3077 0.3077 0.1538 0.2821 0.3077 0.2051 0.2051 0.3333 0.3333 0.2308 0.1538 0.2051 0.2308 0.2308 0.2308 0.2821 0.3846 0.3333 0.3590 0.2308 0.2308
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6 0.6154 0.8718 0.9487 0.9487 0.8974 0.0000 1.0256 1.2308 0.9487 0.7692 1.1538 0.7436 0.8718 0.5128 0.9487 0.9487 0.9487 1.0769 1.0769 1.2308 1.2308 1.1026 1.1026 1.0513 1.0256 1.0000 1.0000 1.1026 1.1282 0.9231 1.0769 1.0513 1.0000 1.1282 1.1282 1.1282 1.1795 0.7692 0.9231 1.2564 1.0769 1.1282
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7 0.6667 0.2564 0.2821 0.2821 0.3333 0.8205 0.0000 0.3590 0.1795 0.2564 0.2821 0.2821 0.2051 0.6154 0.2308 0.1795 0.3333 0.1026 0.1026 0.2051 0.2051 0.2308 0.2308 0.1795 0.1026 0.1795 0.1282 0.1795 0.1026 0.2564 0.1538 0.1795 0.1795 0.1538 0.1538 0.1538 0.1538 0.2564 0.1538 0.1795 0.2564 0.1538
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8 1.0769 0.6667 0.7949 0.5385 0.5385 1.1795 0.3590 0.0000 0.4872 0.6154 0.4872 0.6410 0.5641 0.7179 0.4872 0.3846 0.5385 0.3590 0.3590 0.2051 0.2051 0.3333 0.3333 0.3846 0.4103 0.5385 0.3846 0.3846 0.3077 0.5128 0.3590 0.3846 0.3846 0.3590 0.3590 0.3590 0.2564 0.5641 0.5128 0.1795 0.4615 0.3590
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