ICTD Interventions: Trends Over the Last Decade

Christopher Chepken
University of Cape Town
Rondebosch, South Africa
27-790-691-979
chepken@gmail.com

Raymond Mugwanya
University of Cape Town
Rondebosch, South Africa
27-791-927-506
ray.mugwanya@gmail.com

Gary Marsden
University of Cape Town
Rondebosch, South Africa
27-21-650-2663
gaz@cs.uct.ac.za

Edwin Blake
University of Cape Town
Rondebosch, South Africa
27-21-650-2663
edwin@cs.uct.ac.za

ABSTRACT

In this study, we examine Information and Communication Technology for Development (ICT4D) technology interventions that have been developed over the last decade. The purpose is to provide a snapshot of the trends that have characterized ICT4D technology interventions from the period starting 1995 to 2010. This paper presents three general dimensions i.e. ICTs, development and research which are further broken down into seven variables used to categorize projects over this period. The seven variables include: telecommunication, terminal device, target group, domain area, region, research methods and discipline. Results suggest that applied research stood out as the methodology of choice; health and education as the most researched areas; hand-held interventions as the most popular choice of solutions; and Computer Science, Informatics and Information Systems as the disciplines that offer ICT4D technology interventions. Consequently, we argue that these trends will facilitate understanding the past performance of ICT4D, both as an academic field and as an area of development practice, and identify defining ideas on the potential directions for the future.

Categories and Subject Descriptors

H.5.2 [**Information Interfaces and Presentation (e.g., HGI)**]: User Interfaces – *miscellaneous*

General Terms

Design, Human Factors

Keywords

ICTD trends, ICTD technology interventions, design and evaluation methodology, systematic reviews

1. INTRODUCTION

Recent years have seen a growing research interest in both the design, use of Information and Communication Technologies (ICTs) in the context of developing regions and the impact technology adoption has on economic and social development. The history of ICT4D in Computer Science dates back to the 1990s when Liebenberg and Blake reported on Cyber Tracker [1] – a field computer system designed to support scientific data collection from expert animal trackers who were not textually literate. Since then, research has concentrated on aspects such as economic growth; the Millennium Development Goals (MDGs); and peoples' livelihoods [18]. Attempts to elicit general trends in ICT4D research have been undertaken by researchers in this area. Such studies include those by Heeks [2] and Patra et al. [3]. However, from a Computer Science point of view, limited or no work has been done to review ICT4D technology interventions. In the context of this study, we define a technology intervention as an information technology based information system, for example a web based application for capturing claim forms for nurses in the field. They are also referred to as computer artefacts when used in Computer Science and may include e.g. commercially available products, prototypes, user interfaces, mock-ups, etc. We excluded any other research that involved impact studies or those whose focus was the use of technology. Therefore, this paper presents a review of technology interventions from 1995 to 2010. We identify three general dimensions i.e. ICT, development and research. These dimensions are broken down into seven variables namely: terminal device, telecommunication, domain area, target group, region of study, research methods used and discipline. We postulate that the findings from this review can be used to facilitate understanding the past performance of ICTD as an academic field as well as an area of development practice; and identify defining ideas on the potential directions for the future. The rest of this paper is organized as follows: Section two explores related work; Section three details the systematic review methodology used in this study; Section four details the variable identification process while section five explores the ICT4D technology intervention trends and discussions. Section six presents our conclusions.

2. RELATED WORK

In this section, we present some related studies that review ICTD literature. In their study titled ICTD State of the union: Where we have reached and where we are headed, Patra et al. [3] presented a

literature review and interviewed 50 ICTD researchers in order to examine the history and growth of ICTD since the 1990s. Their study revealed the trends defining ICTD research and examined the progress in areas that have come to dominate discussion in ICTD; for example the researchers areas of affiliation and practice, area of specialization, location of researchers and areas of future importance among others.

In another review, Bussell [4] highlights key trends on the uses of technology and the goals of ICT for development initiatives. She further reveals perspectives, potential barriers to success and strategies for overcoming these barriers. She analyzed 39 reports produced in the period 1994-2005 by ten different organizations. In another study by Hedström and Grönlund [5], they reviewed literature from ICTD journals. They investigated the degree to which case study research on eGovernment and ICTD focuses on ICTs role for development in developing countries or regions and examined the extent to which evaluations of ICTD-projects focus on development assessment. Ho et al. in their work [6] reviewed the past, present and future of Human Computer Interaction for Development (HCI4D) research in order to articulate some of the histories and provide an overview of existing work in HCI4D spanning numerous venues and research traditions. In particular, the review aims to emphasize works that are representative of major trends and topics identified in the various workshops at CHI, Mobile HCI, Interact, Participatory Design Conference (PDC), and DIS, as well as ongoing discussions within the IFIP Special Interest Group. They relate them to one another to provide a conceptual roadmap for making sense of this emerging literature.

Research work involving technology interventions has evolved differently over time in different regions due to different constraints. For instance the developed world, has witnessed a trend towards cloud based services, green computing and so on whereas in developing countries which are typically characterized by a high prevalence of cell phones, technology interventions should evolve differently. However, to the best of our knowledge, there is limited research that reviews ICT4D technology interventions. It is therefore on this basis that this paper attempts to highlight trends that have characterized ICT4D technology interventions over the last decade.

3. METHODOLOGY

In this paper, we set out to identify emerging trends in ICTD research particularly involving technology interventions. The analysis in many aspects draws on a systematic review methodology [7][22] and to some extent snowball sampling [20][21]. A systematic review is *a means of identifying, evaluating and interpreting all available research relevant to a particular research question, or topic area, or phenomenon of interest whereas* snowball sampling refers to a non-probability sampling technique used in Statistics and Sociology where existing study subjects recruit future subjects from among their acquaintances. This sampling technique is often used in hidden populations which are difficult for researchers to access. Example populations would be drug users or sex workers and in the context of this study, hidden population encompasses work presenting ICTD technology interventions.

The systematic review involved searching through conference and journal articles using keywords i.e. "ICT4D interventions, development, ICTD publications, etc" via online databases such

as Google Scholar, ACM, IEEE and Science Direct among others. These searches covered the time period between 1995 and 2010 because we believe that it is around 1995 that ICTD research started. Moreover, it is in this time period that Liebenberg and Blake reported on Cyber Tracker [1]. The keyword searches proved challenging because ICTD as a discipline is relatively young, and the first ICTD conference was only held five years ago in 2006 [6]. We therefore adapted the snowball sampling technique for our review by identifying key researchers in the ICTD field via scanning through recent ICTD proceedings (i.e. Kentaro, Heeks, Donner, etc.); searched through their personal Websites for published works and through bibliographies of their articles to obtain further studies. What started out as a reasonably large body of studies (i.e. over 400) conference and journal papers was trimmed significantly. A total of about 220 articles were excluded based on their titles and abstracts. This was followed by a further inclusion/exclusion of articles based on whether they presented ICT4D technology interventions in literature as their core. ICTD is a multidisciplinary field where researchers are not necessarily required to create technology in order to publish their findings in conferences and/or journals. These researchers are to a great extent typically interested in the impact of technology and using ethnographies to explore its use. However, as computer scientists interested in designing technology, what trends should we look out for? Or what should other researchers look out for? In order to achieve this goal, a total of 116 articles met the selection criteria and were presented for further review. 23 articles were then excluded because despite having relevant titles, abstracts and full text, they did not offer/present technological interventions which left us with 93 articles for further analysis (see http://people.cs.uct.ac.za/~cchepken/ICTD2012Bib.pdf). In the following section, we describe the variables derived from our review.

4. VARIABLE IDENTIFICATION

In order to identify and describe the variables derived from our critical analysis of ICT4D technology interventions literature, we utilize the work presented by Heeks [2], Kjeldskov and Graham [8] and Gitau et al. [10] to provide the framework for this section. We identify three broad dimensions derived from the conceptualization of ICT4D – which deals with the application of ICTs within the fields of socio-economic development, international development and human rights [23]. Therefore, the first dimension is ICTs – which includes technologies that facilitate via electronic means the creation, storage management and dissemination of information [24]. The importance of ICTs is to bridge digital divide by providing access to a target group. This involves transmission of information and/or data from one point to another. Once information or data has been transmitted, the consumer needs a device to access and make use of it. Therefore ICT is broken down into two variables namely: telecommunication (as a result of data transmission through ICT usage) and terminal device (through which the target groups access data). In addition, the variables terminal device and telecommunications were also adopted from Heeks who distinguishes two phases of ICT4D while exploring various key areas such as terminal devices, sustainability, scalability and telecommunications among others.

The second dimension is development which deals with improving the social and economic livelihoods of the poor [25] [26]. The development dimension can be broken down into three variables i.e. target group or population; domain area (as ICT

2

initiatives have different requirements for the various domains e.g. agriculture, education, etc.); and region. Poverty is a key word normally used in conceptualizing development and a number of ICTD studies are undertaken in regions that are characterized as developing or poorer e.g. Africa, Asia and Latin America [2]. Gitau et al. [10] present an analysis of the role played by African researchers in disseminating ICT4D research.

They go on to classify the regions from which ICT4D literature tends to originate. Therefore, it is from research presented in [10] that the variable region was derived. Target group and domain area variables where derived from the conceptualization of ICT4D studies and/or initiatives.

Table 1. Dimensions vs. variables.

	Dimension	Variable
1	ICT	- Telecommunication - Terminal device
2	Development	- Domain area - Target group - Region of study
3	Research	- Research methods applied - Discipline of study

The last dimension is Research which is the core of this study. It involves building technology interventions using methods from various disciplines. Therefore, we break down the research dimension into research methods and discipline of study [27]. Moreover, Kjeldskov and Graham review and classify mobile HCI methods while relating them to their purpose(s). This review uses the research methods presented in [8] and details their usage trends over time. In addition, the millennium development goals (MDGs) and people's livelihoods indicators [19] provided the domain area and discipline variables. The seven variables are as illustrated in table 1 below and described thereafter.

Telecommunication – Refers to the transmission of messages over significant distances for the purpose of communication. In earlier times, telecommunications involved the use of visual signals such as smoke, signal flags and audio messages among others. VSATs during the 1980s and 1990s gave way to a focus on land-based transmission systems. Most recently according to Heeks [2], wireless is becoming the delivery mode of choice to provide connectivity to poor communities in the developing regions. We therefore categorize telecommunication into the following variables: Internet, wireless telephone, wired telephone, short range wireless, doesn't need network and Television. Figure 1 shows a graph with telecommunication trends.

Terminal Device – Since the mid-nineties, models serving the developed world consisted of a personal computer (PC) connected via landline. Over time, researchers in ICTD and other disciplines are realizing that globalization of technology is costly, unsustainable and does not offer viable solutions due to the various social, cultural and infrastructural constraints. Instead, there is need for low-specification, low-cost, robust terminal devices to meet the needs of the developing world poor. Within the scope of this paper, "terminal devices" is used to refer to the "technology intervention or end device that the user interacts with". As a result, we identify a number of terminal devices such as: PC, Hand held devices e.g. personal digital assistants (PDAs),

fixed line applications and visual display unit/television (VDU/TV) based applications among others. The terminal devices that could not be classified were categorized as others (see figures 2[a] and 2[b]).

Domain Area – In September 2000, building upon a decade of major United Nations conferences and summits, world leaders came together at United Nations Headquarters in New York to adopt the United Nations Millennium Declaration, committing their nations to a new global partnership to reduce global extreme poverty (http://www.un.org/millenniumgoals/bkgd.shtml). In order to achieve these, there was need for major reforms and improvements in various economic sectors and most recently the use of ICTs to foster human development. Borrowing from this, we identify a number of domain areas derived from the MDGs and other literature. The domain areas identified include: Agriculture, Education, Health, Knowledge, Economics and Fundamental Problems (see figure 3 for domain area analysis).

Target Group – ICTD research is normally associated with target users, groups or a problem area. In our review, we identify several categories such as the rural poor, urban poor, problem as target (which refers to articles such as those that attempt to solve a caching problem or present applications for use in limited bandwidth environments) and lastly developing world — those projects that mention that they are developing technology for use in these regions with no reference to any user group. Figure 4(a) in the section that follows shows the distribution and frequencies of target groups used in ICT4D projects over the last decade.

Region – We classify articles based on geographical location in which the research was undertaken. It is clear that majority of the world's poor originate from Asia, Africa and Latin America. Figure 5 therefore gives a distribution indicating the regions where ICT4D technology interventions have tended to concentrate in the last decade.

Research Methods Used – Our review reveals that defining and differentiating research methods is a challenging exercise. This is because terminologies used are ambiguous, definitions sometimes tend to be vague and often methods overlap and are not used in their strictest sense. Since defining and differentiating research methods is beyond the scope of this work, we adopt the classification provided in [9] and reproduced in [8]. As a result, we classify articles based on whether they applied any of the eight methods, namely: Case Studies, Field Studies, Action Research, Laboratory Experiments, Survey Research, Applied Research, Basic Research and Normative Writings. Figures 6 and 7 give an indication of the research methods and their distribution across projects over the study period.

Discipline – In this section, we group our studies based on the general subject area. Figure 8 indicates four areas, namely Computer Science, Information Systems, Human Computer Interaction and Multi–Disciplinary projects. ICT4D research as presented in [2] and [10] spans many other disciplines such as development studies, anthropology and ergonomics among others but because we reviewed articles that presented technology interventions, it was clear that they fell under the more technically oriented subject areas such as Computer Science.

5. RESULTS
In this section, we provide a descriptive analysis for each variable to determine the distribution of ICT4D technology projects over

the last decade and highlight some factors that may have contributed to the trends. We found that the early part of the decade recorded very few ICT4D interventions possibly because it is a fairly young discipline. Similarly, it is possible that researchers and stakeholders initially focused more on large scale projects like the Digital Villages. Below is an exploration of the variables from which our trends are generated.

5.1 Telecommunications

In this sub-section, we present an analysis of telecommunications and their usage distribution in ICT4D over the last decade.
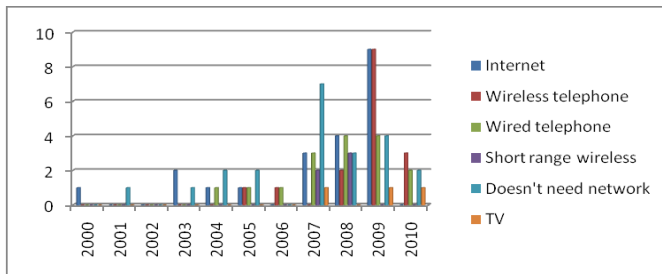
Figure 1. Telecommunications.

Interventions that do not need a means of connectivity dominated ICT4D technology projects prior to 2007. Although these remained the choice of applications throughout the decade, they were overtaken by internet and wireless telephone technologies in 2008 and 2009 respectively. A possible explanation for this is the upsurge of mobile phones and internet penetration in developing countries. It is during this time that a number of ICT4D studies that utilized mobile phones started to rise. These studies might have influenced the telecommunication trends during this period. In 2007, 2009 and 2010, TV was seen as having the greatest potential as the transmission mechanism compared to other means. In fact, we envisage the re-emergence of TV as an alternative means to counter the high cost of internet and mobile telephone charges in developing countries.

5.2 Terminal Device

This variable describes the point of contact between the technology intervention built and the end user. Figures 2(a) and 2(b) show the trends and distribution of terminal devices. In particular, figure 2(a) reveals that since 2004 fixed line terminal devices rose until 2006, remained fairly stable in 2007 and 2008 and dropped in 2010. The research that selected handsets as their terminal device was mostly done in India, biased towards voice applications and presented illiteracy as the problem they were providing solutions for. Examples of such studies are presented in [11], [12] and [13].

For the second half of the decade, hand held devices remained the preferred terminal device of choice. They surpassed the personal computer category after 2008 and since then, the number of handheld based interventions has remained high. One reason that can be advanced for this trend is the pervasiveness of mobile phones and their ability to withstand the developing world's conditions that other terminal devices may not. Such conditions may include intermittent electricity, poor infrastructure and high cost. However, overall, the PC still remains the second most used terminal device. It accounted for about 41.7% (see figure 2[b]) of

the terminal devices used in the last decade. The persistence of the PC can be attributed to the fact that it was the de-facto computing device most of the time covered by our survey. Fixed line telephone terminals seem to have constituted a great share over the last decade.
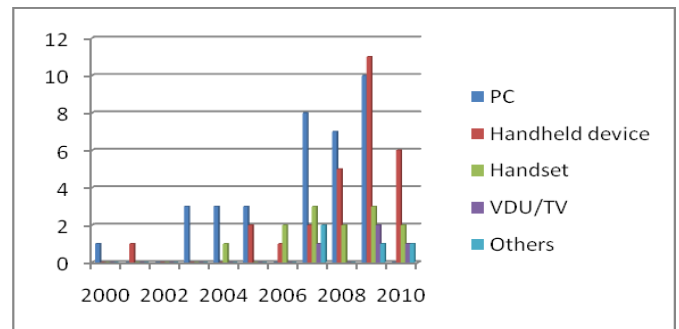
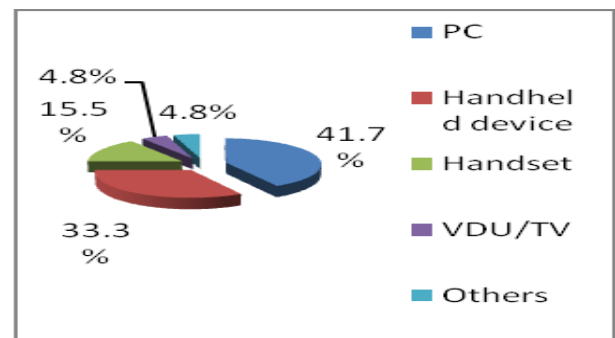

Figure 2(a). Terminal/platform analysis.

Figure 2(b). Terminal percentages share.

5.3 Domain Area

In order to give an indication of the domain areas that have been covered by ICT4D researchers over the last decade, we firstly identify a number of areas from literature and partly through various aspects for instance economic growth; the Millennium Development Goals (MDGs) and people's livelihoods [18]. As a result, we identified a number of domain areas as presented in figure 3. Clearly, health and education related technology interventions dominated ICT4D research in the last ten years. Agriculture started to appear in 2003, died out in 2004, rose in 2006 and started to decline thereafter. This may be because over two thirds of the populations in developing countries depend on agriculture as the main source of livelihood in addition to bad climate conditions. In addition, research that focused on economics/finance started appearing in 2005 and for reasons we were not able to speculate, maintained its share in 2006 and 2009. The domain categorization 'other' refers to interventions that could not be classified into the general domain areas. These include disaster, computer literacy, special groups, digital divide and service provision.
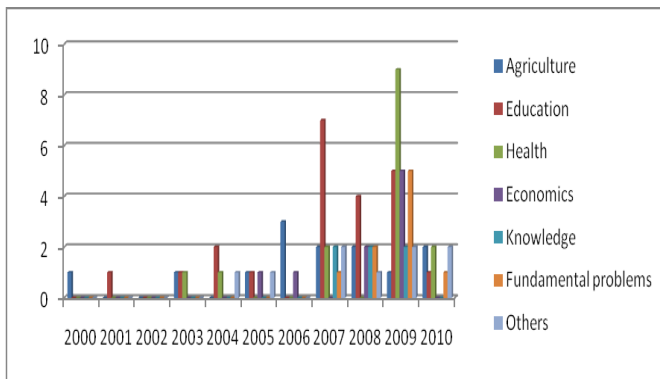
Figure 3. Domain area.

5.4 Target Group

In this subsection, we present a distribution of the target users that ICT4D research has tended to use over the last decade. Although majority of the articles we reviewed make mention of their target groups, others do not. In particular, researchers do not define specific "problems as a target" when presenting their interventions' but simply state that the solution is meant for the developing world. Figure 4 shows the four different target groups identified.
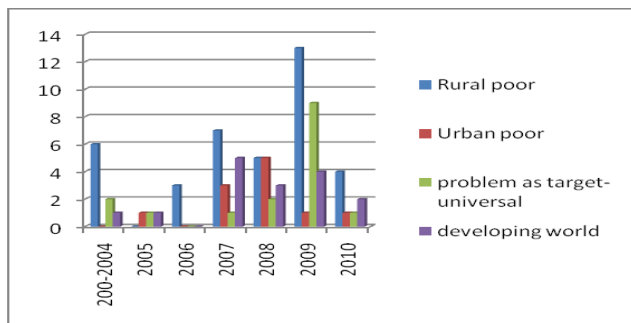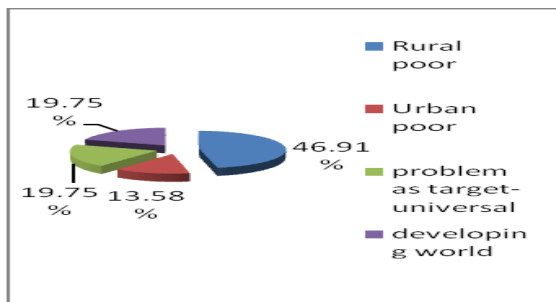

Figure 4(a).Target groups.

Figure 4(b). Percentage of each target group.

Figure 4(a) reveals that the focus of ICT4D research over the review period was on the rural poor with 2009 presenting the highest number of articles focusing on this group. The articles that present "problem as a target" seemed to reduce from 2004 to 2005, remained constant up until 2008 and rose significantly in 2009. These results reiterate the arguments put forward in [14], where they reveal that articles have tended to concentrate on users living in rural areas, with low income and education levels and present mobile phone applications based on these needs. To our surprise, articles that use the urban poor as target groups constituted 13.58% − the lowest in the group (see figure 4[b]). It should be noted that urbanization in the developing world is on the rise leading to an increasing number of urban poor in the cities [15]. Therefore, one would have expected to see the urban poor as a key target group.

5.5 Regions

An analysis of literature revealed the following as the regions for the development of ICT4D technology interventions: Asia, Africa and Latin America. Africa, despite having high poverty levels [17] still ranks low compared to Asia and Latin America. Moreover, research done in these regions tends to be done by researchers from the developed world hence very limited representation of scholars from the developing world [10]. Figure 5 reveals that up to 60% of all the ICT4D work was done in Asia, most of it being done in India and by Indians, whereas 30% was in Africa. ICT4D research involving technology interventions done in Latin America only contributed 5%.
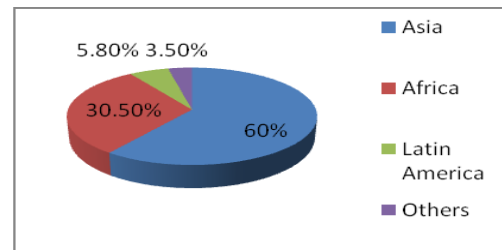

Figure 5. Percentage of ICT4D works by region.

5.6 Research Methods

Identifying and categorizing research methods is challenging because some of the articles reviewed do not clearly describe them [7]. In such cases, the authors made inferences from descriptions of the approaches used, the target group(s) and the general research processes. In instances where it was not clear what methods were used, we classified them as "unspecified". Since this paper concentrated on analyzing technology interventions, it was interesting to find that, as shown in figure 6, applied research stood out as the most employed method across the different areas, particularly in education, health and agriculture. This was consistently followed by Field Studies over the same time period. Action Research, Case Studies and Basic Research did not appeal to researchers during this period. The reason for this could be that their time requirements, commitment and high cost due to the fact that majority of ICT4D work done to date is undertaken by researchers from the developed world who may not be in position to visit developing regions for long durations.

Similarly, applied research seemed most popular with researchers with a significant number of studies consistently undertaken in Asia, followed by Africa and Latin America. This was followed by field studies for the same regions and survey research (see figure 8). ICT4D solutions are intended to enhance human development in some way – hence the need for deployment in real world contexts and the need for triangulation that applied research methodologies provide. For instance during the different phases/iterations in the various action research cycles, researchers may be involved in using a number of methods such as

5

ethnographies, participatory design, etc. which normally generate richer data and reduce bias.
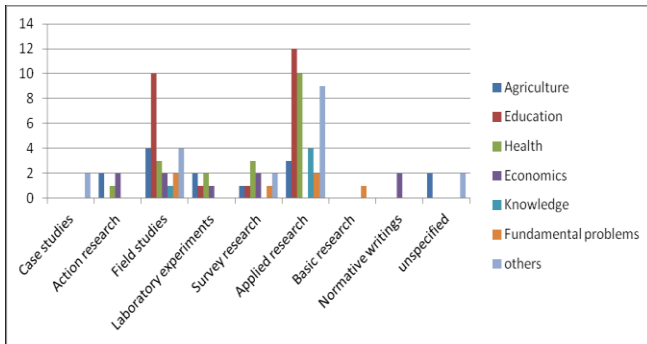

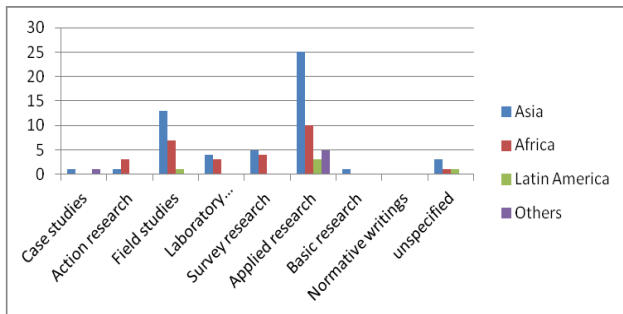**Figure 6. Methods vs. domain area.**

Figure 7. Methods vs. region.

ICT4D research covers a number of disciplines and as a result, researchers have proposed the adoption of Social Science methods. However, methods such as action research were applied sparingly. One major reason for this may be because such methods require that researchers spend several months in the field. In an attempt to identify which methods were successful we looked at project outcomes and attainment of research goals. Evaluation outcome according to Heeks [28] can be measured by whether or not different stakeholder groups attain their goals. We therefore identify the following types of evaluation outcomes namely: academic success – which refers to those projects that were evaluated successfully in a laboratory environment; deployment success – refers to those that were successfully deployed in a real world setting; failure − those that failed; and unclear – those in which the researchers could not ascertain their success or failure.

From our review, deployment success seemed to dominate the evaluation outcome. For instance projects such as those reported in [32][33][34] presented deployment successes. This was followed by academic successes presented in [29] [30][31]. We also noted that some researchers mentioned that their projects were not successful or did not meet their goals. In such instances, such projects were considered to have failed (see for example [35], [36] and [37]). In other cases, it was difficult to ascertain success or failure of projects and thus projects evaluation outcome was categorized as 'unclear'. Examples of projects categorized as unclear are [38] and [39].

5.7 Research Discipline

Heeks [2] predicted that champions of ICT4D should be drawn from Computer Science, Human Computer Interaction and Development Studies disciplines. However, our study reveals contradictory results. For instance, the majority of the ICT4D articles seemed to have been authored collaboratively with CS and Health experts, Information Systems and agricultural experts or HCI with finance researchers among others.
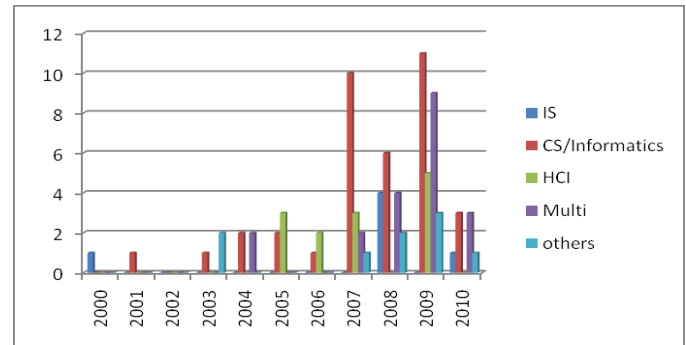

Figure 8. Research disciplines.

Figure 8 shows the share of ICT4D articles within the various disciplines over the last decade. Computer Science and Informatics remains the highest contributor overall followed by Information Systems. Clearly, in the last quarter of the decade, multidisciplinary research grew considerably, getting to comparable numbers with CS/informatics and IS research by 2010. This growth of multidisciplinary work goes against Raitis's comments that ICT4D is multidisciplinary while its authors are predominantly not multidisciplinary [16]. Information Systems is lagging behind HCI and CS, as traditionally IS researchers rarely build technology in their research. Those categorized as "others" include anthropology, engineering, economics, media and development studies.

6. CONCLUSIONS

This study was organized with the purpose of identifying variables and the trends that have tended to categorize ICT4D technology interventions over time. As a result, a systematic review of ICT4D literature using a keyword index and article title search was undertaken. Results suggest that Applied research stood out as the methodology of choice; health and education as the most researched areas; hand-held interventions as the most popular choice of solutions; and Computer Science, Informatics and Information Systems as the disciplines that offer ICT4D technology interventions. Clearly, ICT4D has made strides since the 1990s expanding the inclusion and use of research methods used, the domain areas covered, terminal devices of choice, the various target groups of interest by researchers, the research disciplines and telecommunications choice. Overall, we found that there was limited research activity in the latter half of the 1990's and early half of the last decade. However, this increased dramatically from 2006 after the hosting of the first international ICTD conference. A fairly large body of ICTD researchers have now been in the field long enough to think critically and retrospectively on progress in this work. We hope that this document will serve as another step in that direction.

7. ACKNOWLEDGMENTS

8. REFERENCES

[1] Blake E.H., Steventon L., Edge J. and Foster A.: *"A Field Computer for Animal Trackers," System*: The 2nd South African Conference on Human-Computer Interaction, Pretoria (South Africa). [Online at:] www.chi-sa.org.za/CHI-SA2001/chisa2001New.htm {accessed} March 2011

[2] Heeks R. 2008. ICT4D 2.0: The Next Phase of Applying ICT for International Development. *Computer* 41, 2008. 26-33.

[3] Patra R., Pal J., and Nedevschi S. 2009. ICTD state of the union: Where have we reached and where are we headed. 2009 International Conference on Information and Communication Technologies and Development (ICTD 2009). 357-366.

[4] Bussell J. L (March 2011). International Norms on ICTs for Development: New Data, Initial Findings and Opportunities for Analysis. *Paper presented at the annual meeting of the American Political Science Association, Marriott Wardman Park, Omni Shoreham, Washington Hilton, Washington, DC* [Online at:] http://www.allacademic.com/meta/p41697_index.html {Accessed} 2011-03-1

[5] Hedström K. and Grönlund A. 2008. The Quest for Development – Reviewing ICT4D Research, *GlobDev 2008.*

[6] Ho M., Smyth T., Kam M., & Dearden A. 2009: Human-Computer Interaction for Development: The Past, Present, and Future. *Information Technologies and International Development* **5**, 2009, 1-18.

[7] Kitchenham B., Pearlbrereton O., Budgen D., Turner M., Bailey J. and Linkman S. 2009. Systematic literature reviews in software engineering – A systematic literature review. *Information and Software Technology*, vol. 51, 2009, 7-15.

[8] Kjeldskov J. and Graham C. 2003. A Review of Mobile HCI Research Methods. *In Proceedings of Mobile HCI 2003, published by Springer-Verlag*, 2003, 317-335.

[9] Wynekoop J .L and Conger S. A. 1990. A Review of Computer Aided Software Engineering Research Methods. *Proceedings of the IFIP TC8 WG 8.2 Working Conference on the Information Systems Research Arena of the 90's, Copenhagen, Denmark*, (1990).

[10] Gitau S., Plantinga P. and Kathleen D. 2010. ICTD Research by Africans: Origins, Interests, and Impact. *Proceedings of the 4th International Conference on Information and Communication Technologies and Development ICTD, (2010).*

[11] Findlater L., Balakrishnan R. and Toyama K. 2009. Comparing semiliterate and illiterate users' ability to transition from audio+text to text-only interaction. *Proceedings of the 27th international conference on Human factors in computing systems - CHI '09, (2009).* 1751.

[12] Prasad A., Medhi A., Toyama K. and Balakrishnan R. 2008. Exploring the feasibility of video mail for illiterate users. *AVI '08: Proceedings of the working conference on advanced visual interfaces, 2008.* 103–110.

[13] Lahiri A., Chattopadhyay S. J. and Basu A. 2005. Sparsha: A comprehensive Indian language toolset for the blind. In *Proceedings of the 7th international ACM SIGACCESS conference on Computers and accessibility (Assets '05). ACM, New York, NY, USA*, 2005. 114-120.

[14] Wyche S., Smyth T., Chetty M., Aoki P. & Grinter R. 2010. Deliberate interactions: characterizing technology use in Nairobi, Kenya. *Proceedings of the ACM Conference on Human Factors in Computing Systems, 2010.* 2593-2602

[15] Wesolowski A. & Eagle N. 2009. Parameterizing the Dynamics of Slums. *AID* 2009.

[16] Raiti G. 2006. The lost sheep of ICT4D research. *Information Technologies and International Development 3, 2006.* 1-7.

[17] Sachs J. et al. 2004. Ending Africa's Poverty - Trap Brookings Papers on Economic Activity [online at:] http://www.unmillenniumproject.org/documents/BPEAEndingAfricasPovertyTrapFINAL.pdf {Accessed} March 2011.

[18] Department for International Development (DfID) (2001): Sustainable livelihoods guidance sheets, 1 to 7. [Online at:] http://www.livelihoods.org {Accessed} March 2011.

[19] Millennium Development Goals [Online at:] http://www.undp.org/mdg/basics.shtml {accessed} March 2011.

[20] The Experiment.com resources Website. 2008-2011. [Online at:] http://www.experiment-resources.com/snowball-sampling.html#ixzz1O8HXUgzl {accessed} March 2011.

[21] Goodman, L.A. 1961. "Snowball sampling". *Annals of Mathematical Statistics* **32** (1): 148–170. doi:10.1214/aoms/1177705148

[22] Budgen .D and Brereton .P (2006) Performing systematic literature reviews in software engineering. In *Proceedings of the 28th international conference on Software engineering* (ICSE '06). ACM, New York, NY, USA, 1051-1052. DOI=10.1145/1134285.1134500 http://doi.acm.org/10.1145/1134285.1134500

[23] Medhi, I., Menon, G., and Toyoma, K. (2008): Challenges in Computerized Job Search for the Developing World. In Proceedings of the 26th international Conference on Human Factors in Computing Systems, pp. 2079-2094. ACM

[24] Alampay .N .E .T .A: Mapping Ict4d Projects in the Philippines. [online at:] http://www.ict4d.ph/proceedings/docs/ICT4D_Project_Inventory.pdf. {accessed} 14-10-2011

[25] Qureshi .S. (2009): Social and economic perspectives on the role of information and communication technology for development, Information Technology for Development, 15:1, 1-3

[26] Midgley .J (2003): Social development: the intellectual heritage. Journal of International Development 15(7): 831—844. Wiley Online Library

[27] Raiti, G.C. (2007): The Lost Sheep of ICT4D Research. Information Technologies and International Development, 3(4). Pp. 1-7. USC Annenberg School for Communication & Journalism

[28] HEEKS .R (2010): Failure, Success and Improvisation of Information Systems Projects in Developing Countries.

[Online at:]
http://unpan1.un.org/intradoc/groups/public/documents/nispacee/unpan015601.pdf. {accessed} Nov 2010

[29] Medhi .I, Gautama .S.N.N., and Toyama .K (2009): "A comparison of mobile money-transfer UIs for non-literate and semi-literate users," Proceedings of the 27th international conference on Human factors in computing systems - CHI '09, p. 1741.

[30] Medhi .I, Sagar .A, and Toyama .K (2007): "Text-Free User Interfaces for Illiterate and Semiliterate Users," Information Technologies and International Development, vol. 4, pp. 37-50.

[31] Plauché .M (2006): "Tamil Market: A Spoken Dialog System for Rural India," In the proceedings of the IEEE CS and ComSoc in Pervasive Computing English, p15-23.

[32] Kumar .A, Rajput .A, Agarwal .S, Chakraborty . D and Nanavati A. A. (2008): "Organizing the unorganized - employing IT to empower the under-privileged," Proceeding of the 17th international conference on World Wide Web - WWW '08, p. 935.

[33] Blake E.H., Steventon .L, Edge .J and Foster .A (2001): "A Field Computer for Animal Trackers," System. Presented at 2nd South African Conference on Human-Computer Interaction (CHI-SA2001). Pretoria, South Africa. September [Online at:] www.chi-sa.org.za/CHI-SA2001/chisa2001New.htm {accessed} October 2011

[34] Nissilä .J (2010): "COOPWORKS – A CASE STUDY ON AN INFORMATION SYSTEM MEANT TO ENHANCE THE CAPACITIES OF AGRICULTURAL CO-OPERATIVES," System. Proceedings of the 10th International Conference on Social Implications of Computers in Developing Countries, Dubai, UAE, May 2009. [Online at:] http://www.ifip.dsg.ae/Docs/FinalPDF/Full%20Papers/ifip_25_nissila,%20tanhua,%20phuakinen.pdf {accessed} Nov 2010.

[35] Frohlich .D.M., Jones .M, and Park .S (2009): "Democracy, Design, and Development in Community Content Creation: Lessons from the StoryBank Project," Information Technologies and International Development, vol. 5, pp. 19-35.

[36] Chetty M (2006): Developing locally relevant applications for rural South Africa: A telemedicine example. Unpublished MSc, University of Cape Town, Cape Town, South Africa.

[37] Cervantes .R and Sambasivan .N (2008): "VoiceList: User-driven Telephone-based Audio Content," MobileHCI 2008, September 2–5, 2008, pp. 499-500. [37]

[38] Sin .M, Escobedo .M, and Best .M (2004): "A directory service for multi-literate users," 2004 IEEE International Conference on Multimedia and Expo (ICME) (IEEE Cat. No.04TH8763), pp. 1295-1298.

[39] Sherwani .J, Ali .N, Mirza .S, Fatma .A, Memon .Y, Karim .M, Tongia .R, and Rosenfeld .R (2007): "HealthLine: Speech-based access to health information by low-literate users," International Conference on Information and Communication Technologies and Development, Dec. 2007, pp. 1-9.