TDT4900

Kenneth Børtveit

May 28, 2014

Abstract

Acknowledgments

Contents

List of Figures

List of Tables

List of Abbreviations

AD Anno Domini. 10

ANC Antenatal Care. 19

BC Before Christ. 10

CHD Community Help Desk. 17, 20

CHW Community Health Worker. 4, 17–20

CoIA Commission on Information and Accountability. 12

DHIS2 District Health Information System 2. 12

DOT directly observed treatment. 18

GNI Gross National Income. 9, 10

HC Health Center. 19

HISP Health Information System Program. 11, 12

ICT information and communication technology. 12

MOH Ministry of Health. 17

NCD non-communicable disease. 18

RPF Rwandan Patriotic Front. 10, 11

TB tuberculosis. 18

UiO University of Oslo. 12

Chapter 1

Introduction

1.1 Philosophy

I will try to take on both an interpretive and a positivist view of my research. The reason I do this is that I believe that one does not exists without the other. No one really have a shared reality, and is never completely different. The positive researcher will concentrate on the shared knowledge in a community, while the interpretive will try to harmonize the different realities. The users of the knowledge I am trying to create are the academics, focused in the field of Information Systems and Computer Science. The quality of this research is of course, only evaluated by the reader.

1.2 Purpose

My reason for doing this is divided. Firstly, I am a student using research to add to my own knowledge in the field of computers in order to being able to offer a better service in the computer industry. Secondly, I am trying to add to the body of knowledge in the academic literature. Starting this research project, I have privilege to know the organization HISP. Through HISP I've been participating in the configuration and implementation of a open source software called DHIS2 in Rwanda. After a quick analysis of the requirements I took notice that the software in question should indeed be able to offer solutions to each one of them. So why is it that it is not currently doing so? So this is my purpose, to find out why a software that to me seems to support all the necessary requirements is not doing so.

1.3 Products of this research

By participating in the configuration and implementation of DHIS2 as an intern at the MSH, one of the products of this research will be a working computer application. The other part is an in-depth study of this process. Hopefully contributing to the collection of data existing on the topic of ICT's in developing countries.

1.4 Research Questions

Suggestions

1. Hva gjør det vanskelig for en bruker å benytte seg av IKT som verktøy?
2. Hva er grunnen til at en bruker, i ett land med begrensede ressurser, ikke får utnyttet IKT verktøy maksimalt?
3. Hvilke hinder er det som står imellom bruker og IKT som verktøy i et land med begrensede ressurser og i en helse-setting?
4. Hva karakteriserer utfordringen, "å ta ibruk IKT-verktøy" i helse-sektoren i et land med begrensede ressurser?
5. I denne oppgaven, hvordan skal jeg vinkle målet med IT (Tar gjerne imot forslag)?
   (a) Få slutt på fattigdom?
   (b) Øke livskvaliteten til folket?
   (c) Mer kontroll til staten?
   (d) Øke kunnskapsbasen om informasjons systemer?
   (e) Ved bruk av IT, kan en bruke begrensede ressurser mer effektivt?

1.5 Background

1.6 Motivation

Chapter 2

Literature Review

2.1 Information and Communication Technologies in Developing Countries

Chapter 3

Case Context

Our case is located in Rwanda. Rwanda is on the border of central and east Africa and is located just south of the border of Uganda. The area is $26338 km^2$ which makes it $\approx 7\%$ of Norway. Still their population count is over the double that of Norway's. In 2014 the population count in Rwanda was 12337138 citizens which makes their population density $468.42 citizen/km^2$. Compared to Norway with a population density at 13.26. There are no strict criteria for calling a country a developing one, but if the term is to be used, Rwanda is one of them. Gross National Income (GNI) is a way of measure how much value is added by all producers who are resident in a country. The world bank did a GNI per. capita ranking of the world's countries in 2012 and Rwanda made it at 195th of the 213th economies ranked. The world bank categories economies in four classes:

High Income: $[\$12616, \$\infty]$

Upper Middle Income: $[\$4086, \$12615]$

Lower Middle Income: $[\$1036, \$4085]$

Low Income: $[-\$\infty, \$1035]$

By this, Rwanda is in the lowest income category with \$600 per. citizen, and in this paper, a developing country. It is noteworthy to say that with a population density at 13.26, Rwanda's

population would be ≈ 354509. Rwanda's GNI in 2012 is \$6858$\circ$ 10^6, making their GNI per. citizen ≈ 19345. This would argue for making more cost effective solutions and lowering the fertility rate in order to have a sustainable economy.

[2] [14] [17] [18]

3.1 Brief History

The first inhabitants of Rwanda was probably the ancestors of Twa people. Findings suggesting this goes back to somewhere between 8000Before Christ (BC)–3000BC. Jumping forward to around 700BC–Anno Domini (AD)500 there are evidence suggesting that the Bantu people entering Rwanda. The Bantu's was first farmers and then cattle owners. The Hutu's are believed to be mostly farmers and Tutsi cattle owners so it is natural to assume that this is the source for making any difference between the two peoples. There is a Tutsi rule around AD1800, but at a conference in 1890 Rwanda was given to Germany. They favored the Tutsi people and contributed to ethnic discrimination. After World War 1, Rwanda was ruled by Belgium. The introduced identity cards that would categorize every individual as a Tutsi, Hutu, Twa or Naturalized. Under Belgium the Tutsi was still favored. In AD1959 Hutu activist began killing Tutsi people, making 20000–100000 Tutsi flee the country. In AD1962 Grégoire Kayibanda was the first elected president. He sat out to abolish the Hutu suppression, but that led to Tutsi discrimination. In AD1973 there was a military coup by president Habyaramana. Up until AD1990 there was a pro Hutu discrimination. In AD1990 the Tutsi dominant Rwandan Patriotic Front (RPF) lead by Paul Kagame (current president of Rwanda) invaded Rwanda from the north. This is the start of a civil war lasting up until a peace agreement in 93. In AD1994 president Habyaramana's plane is shot down and started the

history's most brutal genocide. 800000–1000000 Tutsi killed by Hutu in 3 months. Stopped by RPF when they entered Kigali in July the same year. The first president after the genocide was the Hutu president Pasteur Bizimungu, followed by the RPF general, Paul Kagame. After the genocide many fled the country. An estimate of 1 million Hutu fled to Zaire, now renamed and known as Democratic Republic of Congo (DRC). In 1996 Rwanda invaded DRC and assisted on allocate the president and started the first Congo war. In 1998 they were asked to back out their forces, but Rwanda refused. This was the start of the second Congo war. After peace negotiations the Rwandian forces pulled out of DRC in 2002.

3.2 More Recent

[2] [16] [15]

3.3 Health Information System Programme

The Health Information System Program (HISP) is a global network established, managed and coordinated by the Department of Informatics at the University of Oslo. They design, implement and sustain Health Information Systems by a participatory approach. This means including the local users when developing the system in hopes of a more sustainable and successful projects. The system developed aims for supporting health care delivery and information flows in selected health facilities, districts and provinces.

Vision To strengthen the development and use of integrated health information systems within a public health inspired framework in India and the South Asian region.

Mission To enable networks of collaborative action with like-minded actors who aspire to the ideology of open source software, open standards and decentralized decision-making to create complementary strengths in providing integrated and public health friendly health information systems.

In the 1970 and 80's the HISP approach to action research and system design was influenced by a number of union based action research projects in Scandinavia. The focus were on empowering workers who were affected or threatened by new technology. Methods may have changed over time, but the philosophy remains the same. Explore ways in which disadvantaged people could appropriate information and communication technology (ICT)'s for their own empowerment. Original key member of the HISP team had background as social political activists in the anti apartheid struggle and other social movements. DHIS, a software organized and developed within the HISP network, was actually born out of the political processes following the fall of apartheid. During apartheid and until 1994 there were 14 departments of health in South Africa. Because of this fragmentation it was a lot of different procedures, collection tools and data definitions.

[4] [3] [5]

3.3.1 HISP Strategy

The core focus of HISP is District Health Information System 2 (DHIS2). It through this software that HISP will effectively make changes. DHIS2 are now active in 46 countries around the world. This includes 70% of the global fund high impact countries and 55% of the Commission on Information and Accountability (CoIA) countries. HISP are based at the University of Oslo (UiO). This is were the core developers of DHIS2 are located.

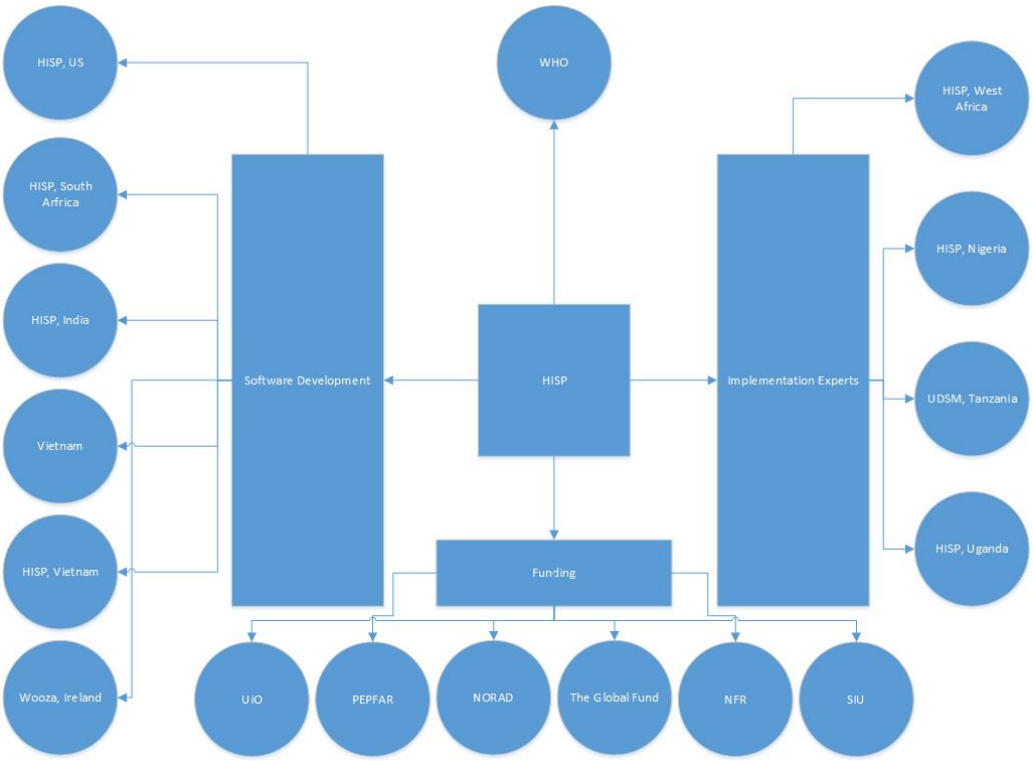

Figure 3.1: HISP Network of Action

One of HISP's biggest strengths is in their network of action. As illustrated in figure 3.1. There is a huge support network for facilitating the development and implementation of DHIS2 and is clearly one of the key success factors of why DHIS2 has been so successful in strengthening the health infrastructure world wide. Recently HISP is trying to add to network the East-Africa region. HISP East-Africa will include countries like Tanzania, Rwanda, Uganda and Kenya. Making relations between countries is essential for sustainability purposes. Sharing experiences and knowledge through neighboring countries is beneficial for sorting out local implementation problems. HISP has been able to arrange for these network building activities with DHIS2 workshops and academies. The primary focus is to train users in the use and implementation of DHIS2, but a beneficial side effect is network building cross countries. With DHIS2 there has been great progress with the process of gathering of data, but two issues remain. Data quality and using data for action. These to areas are now focus areas for the HISP-team at UiO.

[7] [6] [9]

3.4 District Health Information System

HISP's main product is DHIS2. In short, it is an open source software to manage health information data. It also facilitates both the gathering and presentation of the data. With the aid of this program we are able to collect data on site independent of location and to present those data on the same terms. Usually dependent on an internet connection, but it is possible to gather data on a regular Global System for Mobile (GSM) network. The importance of this last quality is *huge* in underdeveloped countries. Internet is nowadays usually taken for granted in most places, but when it comes to villages located outside internet coverage, even a mobile connection cannot be taken for granted.

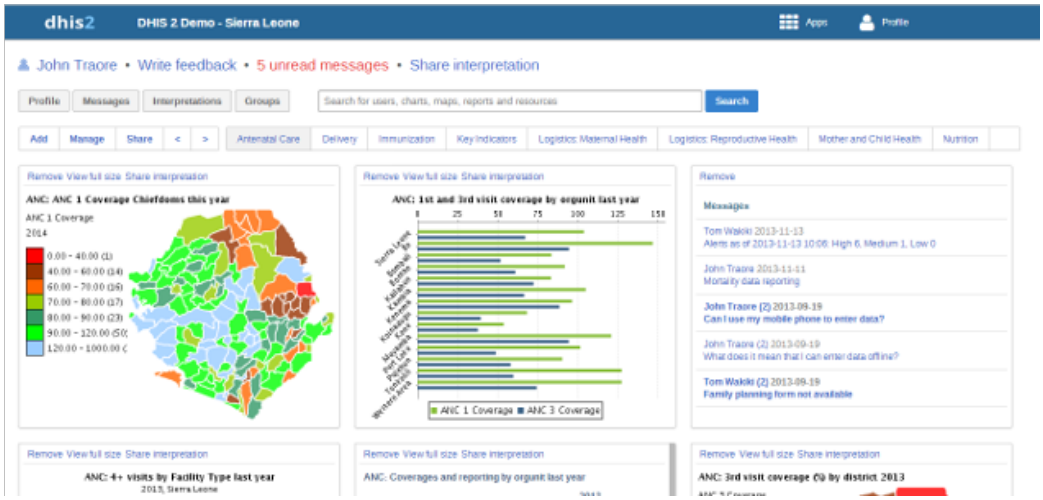

Figure 3.2: Screenshot of Dashboard

In 2012 there was an internet coverage of 33.4% of the worlds population, so assuming an internet connection when working on a global scale is unwise. The system manages data as predefined variables called data elements. These are then grouped together with formulas and description in order to adapt to a health environment. This feature makes it very adaptable to different use cases. We see new systems almost daily nowadays. The smart phone era as boomed the software development, so the need for interoperability is ever increasing. Because of this, a system must be able to work as a piece of the puzzle rather than a silo, but then again new challenges arises. Standardization across departments and health instances needs to be made and it calls for an increased level of cooperation and transparency.

3.4.1 Gathering

DHIS2 allows for data entry for as low-tech as Simple Message Service (SMS) to the new high-tech smart phones. As mentioned earlier, SMS support is very important since over half of our population does not have internet coverage.

Phone Number:	2000
Message:	Stock condom11
Send	

Table 3.1: Example SMS

An example SMS in table 3.1. One use case is that a CHW would like to report the stock on condoms at the end of month. The user would usually go through the following steps.

1. Enter the phone number assigned the reporting service.
2. Enter the codeword for this type of report.
3. Enter the codeword for the item that is being reported followed by a integer value.
4. Hit send.

There are some extra features, but this is the basic idea. At a first glance, this seem alright, but in most cases there are more than one item involved. Let's say that our example message could represent an average reported SMS and that the standard SMS is restricted to be 160 characters long. The codeword is 5 chars. The codeword for the item is 6 and the value is 2. One would usually like to have some kind of separator for each item, so we +1 here. That makes room for approximately 17 items pr. message. I don't know about the general population, but I know it is a pain to write 160 char SMS's on a button based phone and if you have more than 17 items one has also to write another SMS. Also, it is very easy to make mistypes. So it is preferable to report using some of the more advanced devices. But, better than not being able to report. A little more sophisticated option is using a simple phone. These are still cheaper than the most basic smart phones and widely used in underdeveloped countries. They offer a basic G (GUI) that offers some

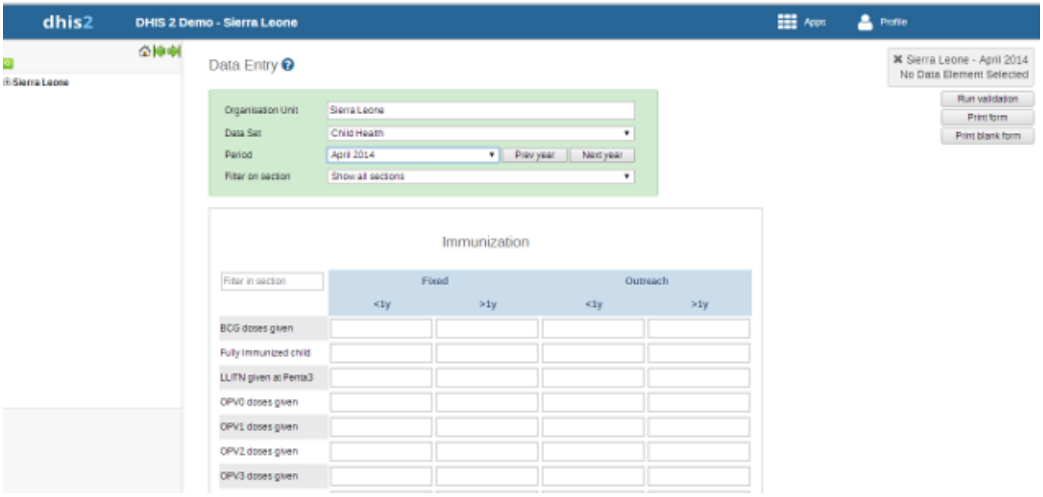

Figure 3.3: Screenshot of data entry in regular browser.

more description than the cryptic codes. A note on the SMS entry is that it is usually supplemented with a reporting card that describes the different codes. The more high-tech devices has support for modern browsers so data entry would be very similar to a any other Hypertext Markup Language (HTML) form.

3.4.2 Managing

Once the data are inside the system it is managed with a data structure designed specifically for DHIS2, see figure 3.4. At the bottom of the hierarchy and the most basic structure is the dataelement. It is essentially a value of a certain type. Any variable value in the system would usually be a dataelement. The dataelement also has several attributes like a datestamp, description etc. Now, with these elements, one can either combine several or make some mathematical manipulations to them. This variable are then stored indicators. Both of these data types can be grouped together in groups as dataelement group or indicator group. The indicator group can further be classified

Figure 3.4: Basic Data Structure

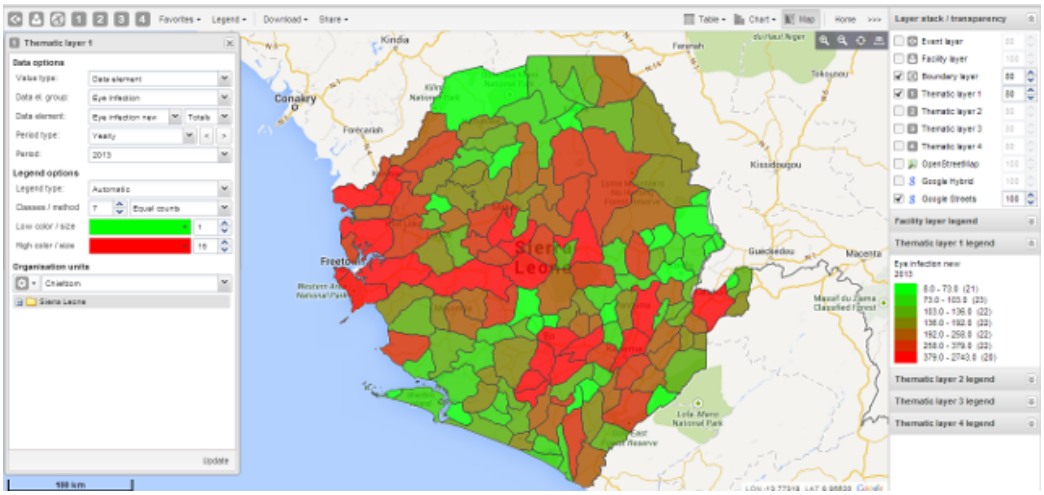

Figure 3.5: GIS Example

in indicator group set. This then a group of groups. The most frequently used group type is the data set. It can be a combination of dataelements and indicators. All of these data structure comes with descriptions and other kind of meta data in order to be able to analyze the data in an efficient manner.

3.4.3 Presenting

There are several ways of looking at data in DHIS2. Of them the most interesting is the Geographic Information System (GIS), as seen in figure 3.5. In the figure one can see a count of eye infection in 2013 based on color and Chiefdoms. Green being low and red high. There is a sense of overview by looking at this kind of map. While getting a graphical visualization one has numbers pinpointing the exact number range. Extremely useful when in need to get an updated status on a situation. Some other tools for analyzing and visualizing data is the pivot table, the basic charts and the generation of reports.

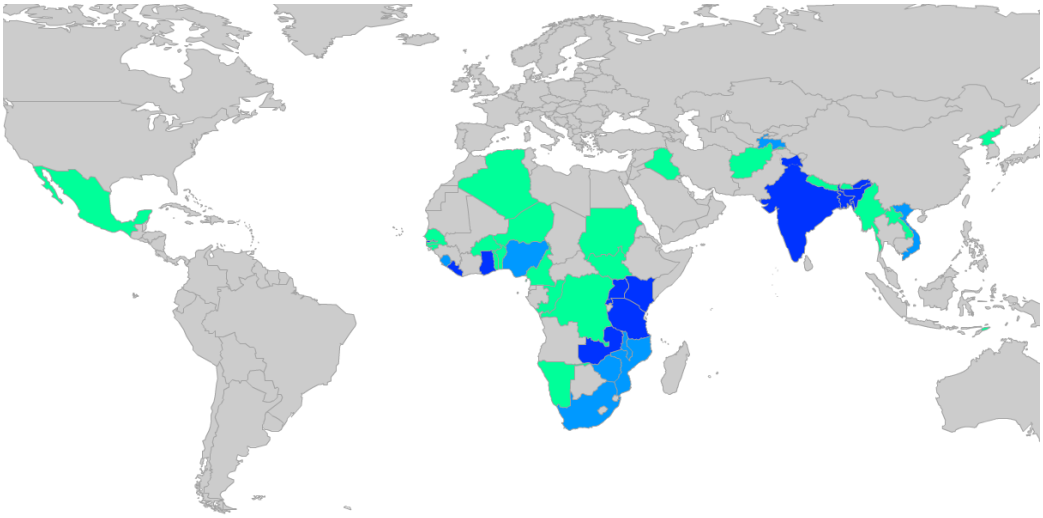

Figure 3.6: (Blue, National rollout)-(Light-Blue, Programs/partial)-(Green, Pilot/early phase)

3.4.4 Application Development

DHIS2 is meant to be a platform for health information. As a result from silos forming in different departments of the health sector, the choice of health information systems are different. This causes a fragmentation that makes interoperability between systems hard to achieve. As a response to this problem, DHIS2 is now being designed to work much like an appstore. This allows users to develop their own applications that meets their specific needs while keeping the core functionality of DHIS2. Not only does this benefit the users, but makes collaboration between developers much easier.

[1] [8]

3.5 Administrative Structure

Rwanda has a strict hierarchical structure in their country. The country is divided in Provinces, Districts, Sectors, Cells and Villages.

Complete national implementation	**Adoption by programs or partial national roll-out**	**Pilot stage or early phase in roll-out**
Bangladesh	Colombia	Afghanistan
Ghana	Laos	Algeria
India	Malawi	Benin
Kenya	Mozambique	Bhutan
Liberia	Nigeria	Burkina Faso
Rwanda	Sierra Leone	Cameroon
Tanzania	Solomon Islands	Congo Brazzaville
The Gambia	South Africa	Cote d'Ivoire
Uganda	Tajikistan	DRC
Zambia	Vietnam	Guinea Bissau
Zanzibar	Zimbabwe	Iraq
		Mexico
		Myanmar
		Namibia
		Nepal
		Niger
		North Korea
		Samoa
		Senegal
		South Sudan
		Sudan
		Timor Leste
		Togo
		Vanuatu

Table 3.2: Countries using DHIS2

Figure 3.7: Africa

Figure 3.8: East Africa

Figure 3.9: Rwanda

The level closest to the people is the Village. Here problems, priorities and needs of the people at a grass root level are identified and addressed. Above is the Cell level. Cells are managed by technicians and and a political team. Technical and key political matters are managed here. Further up in the hierarchy is the Sector level. The people participate here through their elected representatives. Sectors are collected in Districts which are the basic political-administrative unit in the country. Just under the national level the country is divided into five provinces. These serves mainly as advisor to the decentralized entities and coordinates development activities. [12]

This division is used to make areas more multi-ethnic and to decentralize power as an attempt to address problems that arose from the genocide in 1994.

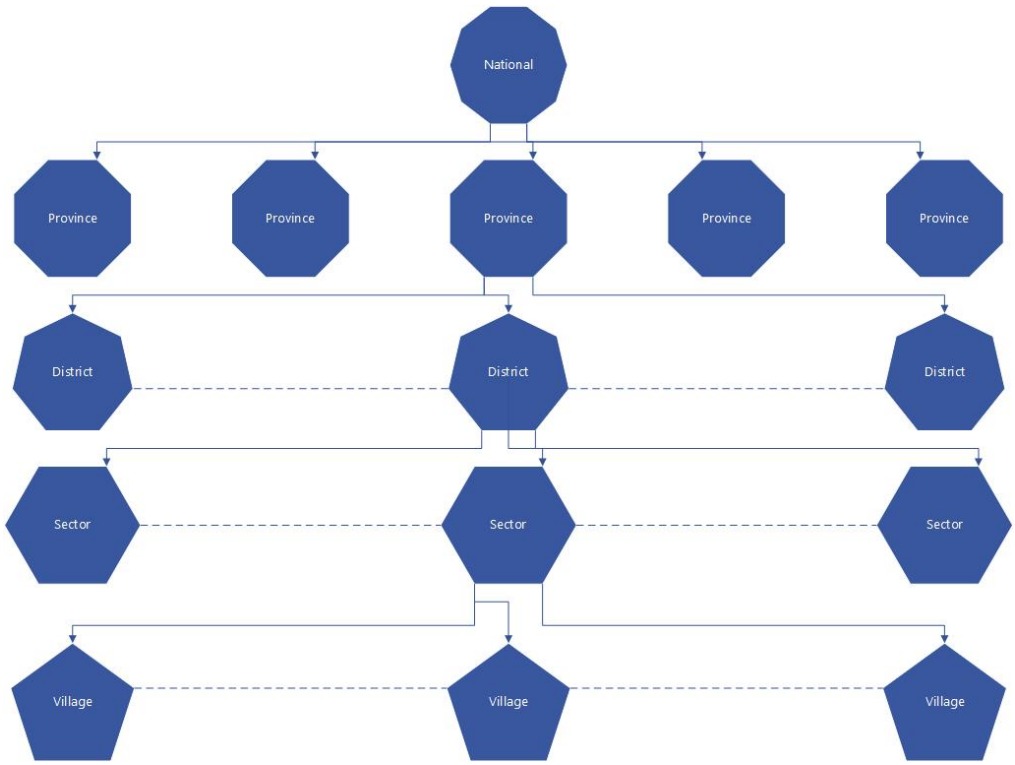

Figure 3.10: Rwandas Administrative Structure

Qualifications	
Read	Willing to volunteer
Write	Honest
20-50 years old	Reliable
Living in the village	Trusted by the community
Elected by the village members	

Table 3.3: CHW Qualifications

3.6 Health Management Information System in Rwanda

The Health Management Information Systems (HMIS) follows the administrative structure in Rwanda very closely.

3.7 Ministry of Health

3.8 Community Health Desk

The Community Help Desk (CHD) is in charge of managing community health activities. This includes planning processes, monitoring, implementing and evaluating.

[13]

3.8.1 Community Health Workers in Rwanda

The community health program started in 1995, endorsed by Ministry of Health (MOH), as a way to bring health care closer to the communities. The program was also a way to address the shortage of health care provider work force. In 1995, the number of CHW's was approximately 12000. Ten years later the number had grown to 45011. In 2013 there were 3 CHW's pr. village which is approximately 45000 CHW's. These are coordinated by the CHD.

Multi disciplinary	**Maternal**
Integrated community case management	Follow up of pregnant women and newborns
Malnutrition screening	Malnutrition screening
Community-based provision of contraceptives	Community-based provision of contraceptives
Preventive non-communicable disease (NCD)'s	Preventive NCD's
Preventive and behavior change activities	Preventive and behavior change activities
Household visits	Household visits
directly observed treatment (DOT) for tuberculosis (TB)	

Table 3.4: CHW Tasks

At each village there are 2 women and 1 man having the qualifications listed in table 3.3. The village CHW team has two roles. One man and one woman are multi disciplinary CHW's and the last woman is a maternal health CHW.

Some of their tasks are listed in table 3.4.

[13]

3.9 Cell Coordinators

Above the CHW's at the village level, there are two CHW's who are operating at a cell level with the purpose of strengthening CHW activities. One cell coordinator and one assistant cell coordinator. Their responsibilities are listed in table 3.5.

Cell Coordinator	Assistant Cell Coordinator
Visiting CHW's in order to monitor their activities on a monthly basis.	Monitor if the maternal health CHW has registers and that these registers are filled correctly.
Follow up and verify if CHW's has patient registers, if they are well kept and correctly filled out.	Follow up and see if the maternal health CHW refers pregnant women for Antenatal Care (ANC) visits at the Health Center (HC)
Monitor if drugs are distributed correctly, not expired and well kept.	Follow up and verify if the maternal health CHW has sent RapidSMS reports for pregnant mothers confirmed by health provider.
Compilation of reports of drugs that have been used by CHW in cell and requisition of drugs at health centers.	Verify if the maternal health CHW has Misoprostol drugs and that the drugs are not expired.
Supervision of the household that was recently attended by a CHW.	
Check if the CHW performs post-visit's for the children treated.	
Supervise CHW's on how well s/he is able to sensitize the community on family planning usage.	
Verification of reports brought for compilation if they have been sent by mobile.	

Table 3.5: CHW cell coordinator responsibilities at a cell level

Chapter 4

Research Methodology

4.1 Action Research

[11] [10]

4.2 Diagnosis

The diagnosis in the Action Research model is about identifying the nature of the problem situation, include all interrelated factors, develop a working theory about the situation and how it might be changed.

4.2.1 Situation Report

The CHD at the Ministry of Health would like to make a system that will automatically generate reorder quantities of essential drugs to the CHW. Based on SMS reporting from the CHW's, the system will predict how much of each essential drug that are needed for the next delivery.

Videre følger en fyldig status rapport av situasjonen imens jeg var i diagnose fasen

4.3 Planning

møte, møte, møte

4.4 Intervention

Beskrivelse av hva vi gjorde.

4.4.1 Use Cases

4.4.2 Configuring DHIS2

4.4.3 Algorithm

4.4.4 User Importer

4.4.5 The Essential Predictore

4.5 Evaluation

4.5.1 SMS demo

4.5.2 Algorithm Presentation

4.5.3 Situation Report

4.6 Reflection

Chapter 5

Case

5.1 Situation Report

The overall objective off all parties involved in this case was to configure and develop a system that could receive SMS-reports.

5.2 Diagnosis

5.2.1 Objectives

We started out with four simple objectives.

#1: Send SMS and email notifications based on rules.

#2: Send SMS and email reminder if a report is more than 4 days delayed.

#3: If user data does not map correctly user feedback should be provided.

#4: A functional SMS based reporting system.

This was the basis for our case.

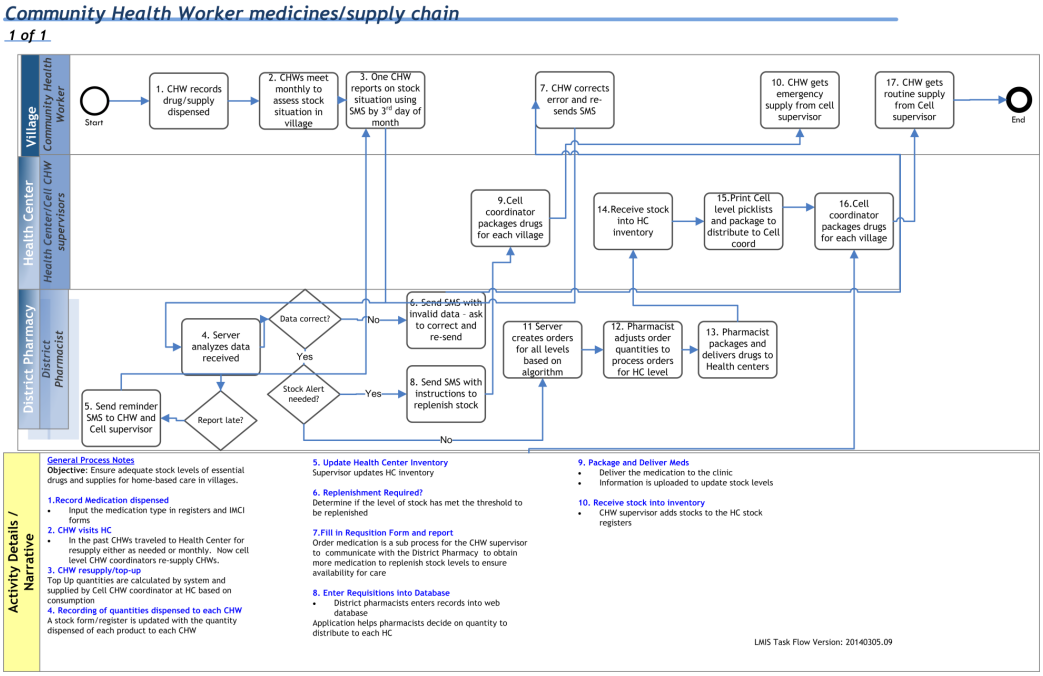

Figure 5.1: CHW Supply Chain in the Future

5.2.2 Use Cases

Based on the four objectives we made four use cases that was supposed to represent each one. Objective #1 would be represented with use case 5.1, objective #2 with 5.2, #3 with 5.3 and #4 with 5.4. These use cases worked as guidelines for our further work. They were not updated later on, because of the continuous updated requirements from CHD and other co-workers. That is one of the key characterizations of this project. The requirements kept on updating as more and more people got involved in the process. The more progress we made the less progress we made. As the project was coming more and more realized, more interest were made to the project, and more

Send SMS and Email Notifications	
Goal:	Create orders
Primary Actor:	System
Secondary Actor:	Cell CHW Supervisor HC CHW Supervisor District Pharmacist
Main Success Scenario:	1. CHW reports distributed and stock values. 2. System processes report. 3. System calculates essential drugs needed for each level. 4. System sends orders to cell, sector and district.
Extensions:	

Table 5.1: Textual Use Case: Send SMS and Email Notifications

Send SMS and Email Reminders	
Goal:	Send reminder
Primary Actor:	System
Secondary Actor:	CHW Cell CHW Supervisor
Main Success Scenario:	1. CHW misses report deadline. 2. 5 days goes by. 3. System sends reminder by email and SMS. 4. Another 5 days goes by. 5. System sends reminder by email and SMS.
Extensions:	

Table 5.2: Textual Use Case: Send SMS and Email Reminders

Send Report Feedback	
Goal:	Process SMS message
Primary Actor:	System
Secondary Actor:	Community Health Worker
Main Success Scenario:	1. CHW reports data incorrectly by SMS. 2. System receives SMS. 3. SMS triggers feedback message. 4. CHW corrects message and re-sends report. 5. System processes SMS. 6. System updates database.
Extensions:	

Table 5.3: Textual Use Case: Send Report Feedback

Report Using SMS	
Goal:	Update Database
Primary Actor:	Community Health Worker
Secondary Actor:	System
Main Success Scenario:	1. CHW reports stock and distributed values of essential drugs. 2. System receives SMS. 3. System processes SMS. 4. System updates database. 5. System sends confirmation SMS to CHW.
Extensions:	

Table 5.4: Textual Use Case: Report Using SMS

requirements were added. There were a kind of common understanding in the team. Once you got the picture, you didn't need to operate on a model anymore. Everyone kinda knew what needed to be done. The result of the diagnosis were essentially a clarification of what we were supposed to do and who are involved. The clients are CHD. A meeting took place and a list of contact information was exchanged. The users of the system are CHW's, Cell CHW Supervisors, HC CHW Supervisors and District Pharmacists. The basic idea is that the CHD would like to have HMIS make a system that enables CHW's to report using SMS and based on this have automatic generated orders sent to the HC's and District Pharmacists.

5.3 Planning

Our planning phase became somewhat glued together with the intervention. And continually altered. New problems were made visible by the interventions we made, and took us back to the planning phase. Making it very difficult to follow the action research model. In a perfect world, it is possible to plan everything to the point, but in our case new knowledge about the system was discovered along with our interventions and in turn, our plans had to be changed.

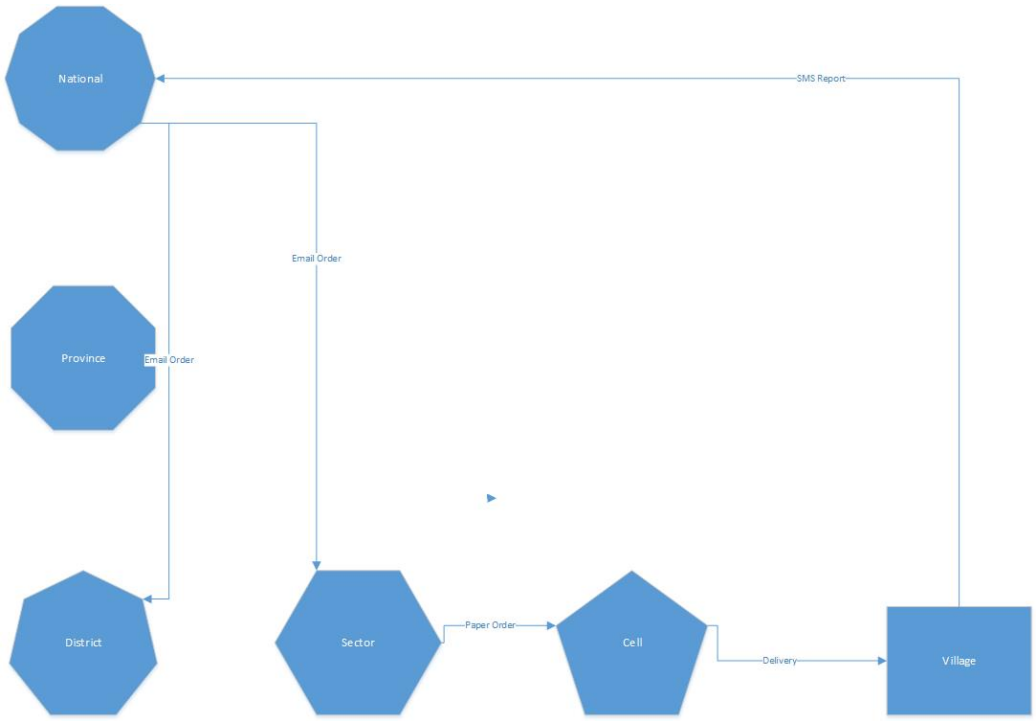

Figure 5.2: Flow of Orders

5.4 Intervention

5.4.1 Setting up the Test Environment

Our initial idea was to set up a DHIS2 instance for testing purposes. This made it possible for us to check if our objectives was in some way already met with the functionality of DHIS2. We knew that DHIS2 already supported SMS reporting, but it had never been tested. This was essentially what we did. Configured DHIS2 to support our case. Turned out that objective #3 and #4 was already met with just configuring DHIS2. One thing that we did not think about that became a problem later was the translation of the feedback messages. CHW's do not generally speak English, but the local language kinyarwanda. Fortunately, the translation of the messages was possible in the next version of DHIS2, so the objective was still met.

5.4.2 Setting up the mobile instance

We sat up the DHIS2 instance at the National Data Center (NDC). This is server that the CHW's will send their reports to. This process was very straight forward. The problem with having our instance running at a different location is that we have less control of our system. Now we have to go through another team to make certain changes to the system. Actually just slows down the

whole process. Setting up the mobile instance made our plans more real and allowed us to show our work in real life.

5.4.3 User Importer

The user importer was made in order to import user from a csv file. DHIS2 did not support automatically generating usernames and passwords for bulk users. Therefore we needed a program to do this for us. The down side of this approach is that all the users of the system are not included in the process of creating user accounts. This by passes the HISP philosophy of including local users in the system. Users may therefore have user accounts they are not aware of. Making the the users feel less ownership of the system. Despite of this we decided to take this approach.The amount of resources spent on manually register all the users would be to vast.

The user importer creates user accounts based on firstname, surname, village and phonenumber. After the user accounts are created they are able to send in SMS-reports based on the village they work from.

5.4.4 Re-Supply Algorithm

$$stk_n = stk_{n-1} + rcd_n - disp_n \tag{5.1}$$

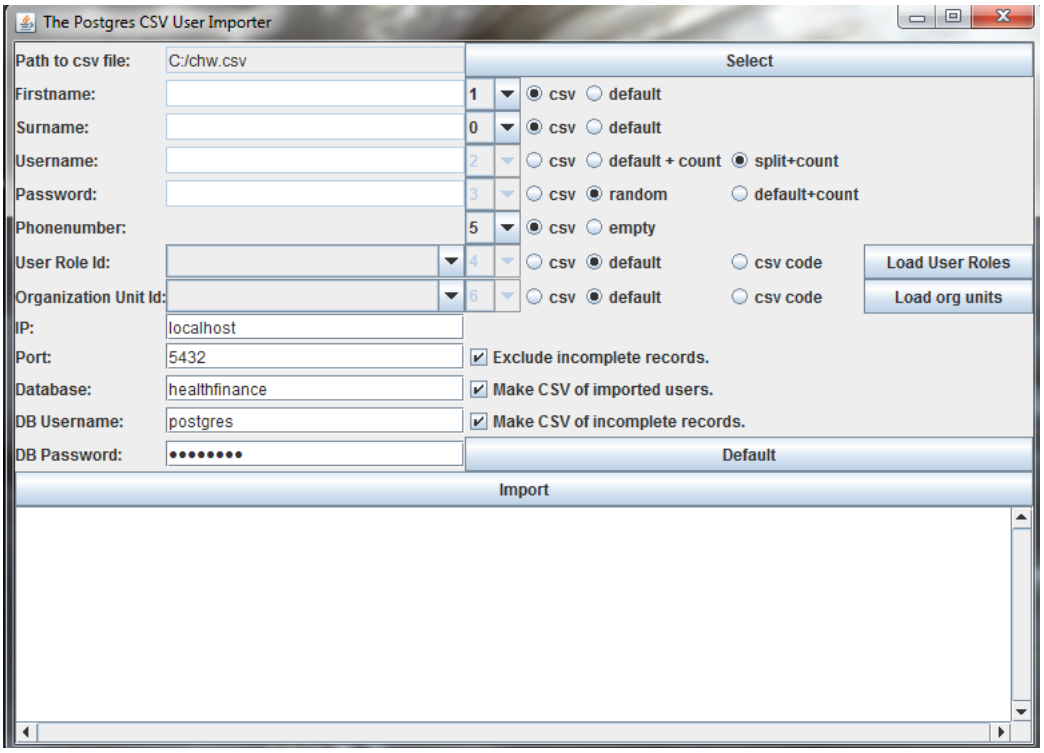

Figure 5.3: Screen Shot of the User Importer

$$
\begin{aligned}
reorder_n &= (amc_n \cdot 2) - stk_n && (5.2)\\
amc_n &= \frac{disp_{n-2} + disp_{n-1} + disp_n}{3} && (5.3)\\
disp_n &= stk_{n-1} + rcd_n - stk_n && (5.4)\\
disp_{n-1} &= stk_{n-2} + rcd_{n-1} - stk_{n-1} && (5.5)\\
disp_{n-2} &= stk_{n-3} + rcd_{n-2} - stk_{n-2} && (5.6)
\end{aligned}
$$

$\mathbf{reorder_n}$ This variable represents the quantity of how much is needed at the next re-supply of one village. n in this case represents the last month. If in May, it represents reorder quantity for the end of month of April.

$\mathbf{amc_n}$ Represents the average monthly consumption based on the last 3 months in one village. I in May, that would be the average monthly consumption based on February, March and April.

$\mathbf{disp_n}$ This variable is calculated based on the the values reported and is the number of items distributed by one village during one month.

$\mathbf{stk_n}$ The quantity in stock at the end of the month of one village. Usually reported within 1–5 days into the next month it represents. Stock in April is usually reported between 1st and 5th of May.

$\mathbf{rcd_n}$ This variable is the sum of items received in one village during the month it represents. If a CHW

receives 10 condoms 2nd of April, it should be reported the same day. If a village receives another 10 condoms the 13th of April, that should also be reported the same day it is received. rcd_n for April would then be the sum of those values, 20.

$$rcd_n = \sum_{k=1}^{j} rcd_{n,k} \tag{5.7}$$

. A more mathematical description in equation 5.7, where j represents the number of days in the month.

5.4.5 The Essential Predictore

In order to generate the threshold values to send reminders from we chose to make a small application to run the algorithm. The application updates the database directly. The funny thing is that this was the only way we knew how to get our result, despite the support we had. The developer team from Oslo has offer the competence we needed, but due to the time frame we decided that we needed to build this application with SQL and JAVA. The application was kind of split in two. One of the team members at HMIS had a strong familiarity with databases and I had some JAVA experience. The core of the application was made in SQL, then it was wrapped inside a JAVA-GUI.

The collaboration in this application is something worth taking note of. Neither one of the team member knew

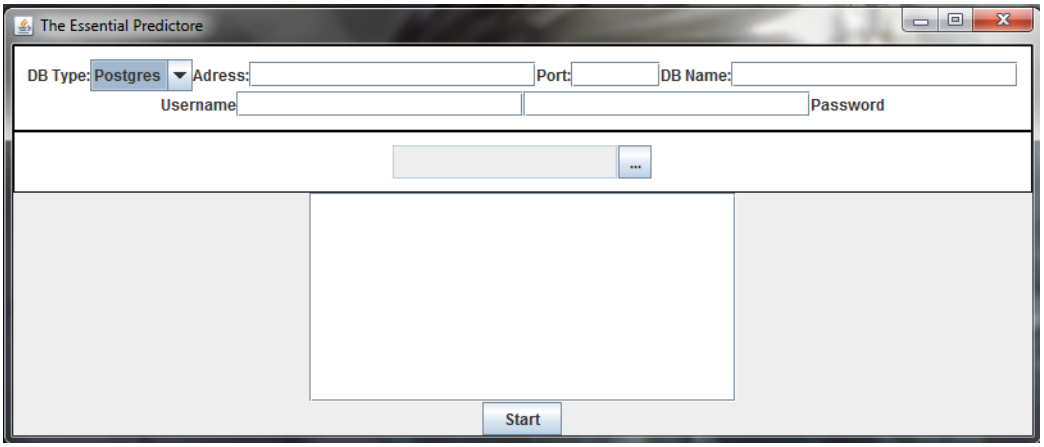

Figure 5.4: Screen Shot of the Essential Predictore

exactly what the other was doing. The application was in fact copy-pasted together after making the the GUI and SQL-functionality separately. The application realizes the re-supply algorithm in a JAVA application and works with DHIS2. So all the tools from DHIS2 could be taken advantage of.

Chapter 6

Discussion Of Results

Chapter 7

Conclusions

Bibliography

[1] Countries using dhis 2. http://www.dhis2.org/deployments, 2014. Accessed: 22-05-2014.

[2] Mikal Hem. Rwanda. http://snl.no/Rwanda#menuitem0, 2014. Accessed: 19-05-2014.

[3] The process of developing the dhis. http://www.mn.uio.no/ifi/english/research/networks/hisp/hisp-history.html, 2013. Accessed: 20-05-2014.

[4] Hisp. http://www.mn.uio.no/ifi/english/research/networks/hisp/index.html, 2014. Accessed: 20-05-2014.

[5] About hisp. http://hispindia.org/index.php/about-us, 2014. Accessed: 20-05-2014.

[6] Network of action. http://www.mn.uio.no/ifi/english/research/networks/hisp/network-of-action.html, 2013. Accessed: 20-05-2014.

[7] Hisp uio strategy, 2014. Accessed: 20-05-2014.

[8] Internet world stats. http://www.internetworldstats.com/stats.htm, 2012. Accessed: 24-05-2014.

[9] Sundeep Sahay Jørn Braa, Eric Monteiro. Networks of action: Sustainable health information systems across developing countries. *MIS Quarterly*, 2004.

[10] Briony J. Oates. *Researching Information Systems and Computing*. Sage Publications Ltd, 2006.

[11] Maris G. Martinsons Robert M. Davison and Ned Kock. Principles of canonical action research. *Info Systems*, 2004.

[12] Ministry of local government. http://www.minaloc.gov.rw/index.php?id=450, 2011. Accessed: 19-05-2014.

[13] National community health strategic plan, 2013. Accessed: 19-05-2014.

[14] Folkemengden. http://www.ssb.no/befolkning/statistikker/folkemengde, 2014. Accessed: 19-05-2014.

[15] Hutuer og tutsier. http://no.wikipedia.org/wiki/Hutuer_og_tutsier, 2013. Accessed: 19-05-2014.

[16] Rwanda. http://en.wikipedia.org/wiki/Rwanda, 2014. Accessed: 19-05-2014.

[17] Gross national income 2012, atlas method. http://databank.worldbank.org/data/download/GNI.pdf, 2012. Accessed: 19-05-2014.

[18] Gross national income per capita 2012, atlas method and ppp. http://databank.worldbank.org/data/download/GNIPC.pdf, 2012. Accessed: 19-05-2014.