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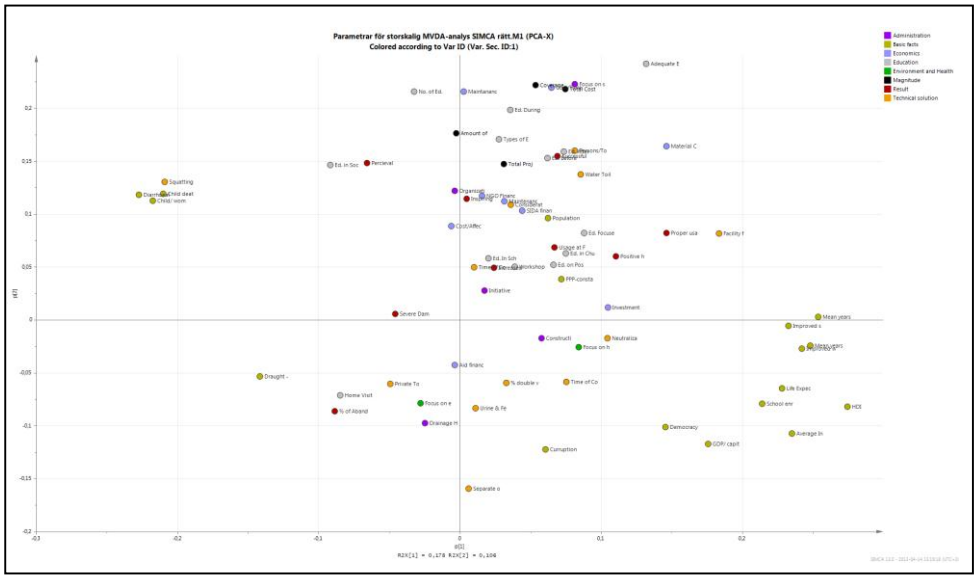

Implementing improved sanitation in developing areas

A study on correlations among indicators and what makes a project successful

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Cover:
Loading scatter from SIMCA

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Abstract

The main objective when implementing a sanitation system in developing areas is to protect and promote human health by providing a clean environment and breaking the cycle of disease. If this can be achieved, an aid project for improved sanitation can be described as successful. In order to know how to make a project as successful as possible, this study will evaluate the aspects of implementing a sustainable sanitation system.

The evaluation is done by statistically comparing sanitation projects with both quantitative and qualitative indicators. This comparison is based on a Principal Component Analysis (PCA) performed by the software program SIMCA to identify correlations among project characteristics. The analysis expresses interesting correlations that are important to take into consideration when conducting a sanitation project.

If the following correlations are considered when implementing a sanitation system, it is estimated to increase the chance of succeeding with a project. When introducing a sanitation project it is recommended to focus on direct benefits for the inhabitants, like reduced smell and easy maintenance. To emphasise the environmental aspects does not increase their motivation to use the facility. It is also important to educate the affected inhabitants before the implementation of the sanitation system, as this will help them to use the facility correctly. Furthermore it is necessary to consider how the sanitation system is maintained. The results show that the affected inhabitants prefer not to handle the emptying of the facilities themselves. The method of PCA has been evaluated based on the credibility of the results. It was concluded that analysing correlations among indicators can be valuable as a tool for designing sanitation projects.

Implementering av förbättrad sanitet i utvecklingsområden

En studie av korrelationer mellan indikatorer och vad som gör ett projekt framgångsrikt

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Sammanfattning

Huvudsyftet vid implementering av sanitatetssystem i utvecklingsområden är att främja och värna om människors hälsa genom att erbjuda en ren miljö och bryta befintliga sjukdomscykler. Om detta uppnås kan ett biståndsprojekt för förbättrad sanitet beskrivas som framgångsrikt. Denna studie utvärderar implementeringsaspekterna för ett hållbart sanitetsprojekt med målet att undersöka hur ett projekt blir så framgångsrikt som möjligt.

Studien är utförd genom att statistiskt jämföra sanitetsprojekt med både kvantitativa och kvalitativa indikatorer. Denna jämförelse baseras på en principalkomponentanalys (PCA) utförd av mjukvaran SIMCA för att identifiera korrelationer mellan aspekter inom projekt. Analysen resulterar i intressanta korrelationer som är viktiga att ta hänsyn till vid införandet av ett sanitetssystem.

Resultatet från följande korrelationer antas öka chanserna för att lyckas med ett sanitetsprojekt. Vid införandet rekommenderas ett fokus på de direkta fördelarna för invånarna; till exempel minskad lukt och enkel skötsel. Att lägga tyngd på miljöaspekter ökar inte invånarnas motivation för att använda anläggningarna. Vikt bör läggas på att utbilda de berörda invånarna inför införandet av ett nytt sanitetsprojekt då detta leder till att anläggningen används på rätt sätt. Det är även viktigt att ta hänsyn till hur anläggningen är underhållen. Resultaten visar att de berörda invånarna föredrar att inte sköta tömningen själv. Metoden med PCA har utvärderats baserat på trovärdigheten för resultaten. Slutsatsen dras att det är en användbar metod för att analysera korrelationer mellan indikatorer i sanitetsprojekt.

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1 Introduction

Water and sanitation are two of the most basic needs for human health and are necessary for every human on earth (Sustainable Saniation Alliance, 2013). Even so, close to one billion people around the world lack access to clean water and over two and a half billion do not have the possibilities to visit a toilet when managing their personal needs (Water Aid Sverige, 2013). For people in the wealthier parts of the world these life necessities are taken for granted and do not constitute a general issue (Lifewater international, 2013). This however, is not the case in all places. Inadequate access to clean water and safe sanitation does not only lead to enhanced risk of illness but also deprives people of their privacy and dignity and creates an unpleasant environment to live in (Water Aid Sverige, 2013).

There are 2.6 billion people around the world using what they have at hand, like riverbeds or plastic bags, to handle their everyday needs (Fogelberg & Sparkman, 2011). Some of these people do not practice methods that keep human excreta away from their food and drinking water and this insufficient sanitation results in nearly two million lost lives each year from curable diseases. In addition, poor sanitation and hygiene have many other serious consequences (UNICEF, 2013). Children, and girls in particular, are denied their right to education as a result of their schools lacking private and decent sanitation facilities.

In an attempt to reduce extreme poverty and its side effects, the world leaders were brought together in September year 2000 to adopt the United Nation Millennium Declaration (United Nations, 2013). This commitment has become known as the *Millennium Development Goals*, which aim to halve the proportion of people without access to safe water and adequate sanitation by the year 2015.

Under the last decades the issues with insufficient sanitation have been recognised and addressed by the rest of the world, which has resulted in a lot of work being done to improve sanitation situations where it is needed (World Health Organization, 2012). However, there is still a long way to go and the main problems to achieve the *Millennium Development Goals* are lack of priority to the sector of sanitation and lack of financial resources (World Health Organization, 2013). Implementation of sanitation projects, where toilet facilities are built, is one important step towards a better sanitation situation (World Health Organization, 2012). In these projects many aspects have to be taken into consideration in order to achieve a successful result. To manage a successful sanitation project, experience, knowledge and a source of motivation are important elements (UNICEF, 1997). It is also important to learn from previous mistakes and prevent that the same mistakes are being made (Sustainable Sanitation Alliance, 2013). It is therefore important to try to foresee some of the problems that might occur and what areas of implementation will require extra attention.

In order to determine how to make the implementation of a sanitation project as successful as possible this study will evaluate the phases and factors that are part of this process. The study will, by conduction of a Principal Component Analysis (PCA), show what factors correlate to each other. It will then be possible to evaluate the correlations and find the reasons behind them. Conclusions will be drawn, saying which parts of the project will require extra care. The findings can be of value when conducting a new sanitation project, for example show relations that are difficult to discover in advance. When knowing about these relations, attention can be paid to them and unnecessary mistakes can be avoided. This could help to implement successful sanitations systems and create a more sustainable situation regarding sanitation in various places around the world.

2 Aim and research questions

This study aims at assessing the importance of different aspects of sanitation projects in order to be as successful as possible. This will be done by statistically comparing selected aid projects for improved sanitation, to see possible correlations among chosen indicators. The comparison is based on a Principal Component Analysis (PCA) performed by the software program SIMCA to identify correlations among project characteristics. The analysis will make it possible to see interesting correlations to take into consideration when conducting a new aid project for improved sanitation.

The aim can be expressed in terms of the following research questions:

- What strong correlations can be found in the PCA and how can these correlations be explained?
- How can these correlations be combined to give recommendations for implementing a sanitation project?
- Is PCA a suitable method for analysing aid projects that focus on sanitation?

3 Background

This section gives a deeper understanding for the key subjects treated in this study. The first part contains the definitions that are relevant for this study. This is followed by a description of aid and a review over the consequences of lack of proper sanitation. Finally PCA is described to give further understanding of the method.

3.1 Definitions

It is important to define the concepts that will be used in a specific context (Prawitz, 2013). This is because it is essential to have a clear understanding of concepts when referring to them.

3.1.1 Sanitation

The term sanitation relates to systems promoting safe disposal of waste. In this study sanitation refers to the part of the system that takes care of human urine and faeces.

3.1.2 Sustainable sanitation

Sustainable sanitation is defined as a sanitation system which protects and promotes human health by providing a clean environment and breaking the cycle of disease (Sustainable Saniation Alliance, 2013). In order to be sustainable, a sanitation system has to be economically viable, socially acceptable, and technically and institutionally appropriate. It should also protect the environment and the natural resources.

3.1.3 Successful sanitation

If a sanitation project has turned out well or not is in this study evaluated according to the definition of sustainable sanitation previously declared. It is however difficult to say if a project is successful or not and usually a project can be considered successful in some aspects but not in others (UNICEF, 1997).

3.1.4 Developing areas

Developing areas are defined as geographical regions that do not fulfill certain criteria (DESA, 2012). Such criteria have for instance been defined by the United Nations Development Policy and Analysis Division and include gross secondary school enrolment ratio, under five mortality rates and percentage of population undernourished, among others.

3.2 Aid

Aid is defined as the transfer of funds for altruistic and humanitarian purposes (Lancaster, 2006). Aid can be given in various forms and amounts; from micro loans to individuals, to millions of dollars for reconstruction after a war or prevention of deceases. A large part of the aid comes from national governments and large international organisation like The United Nations or the World Bank, but Non-Governmental Organisations (NGOs) are also contributing. It is essential that the organisation is transparent considering its work, the money spent and how the money is distributed (Easterly & Pfutze, 2008). It can also be an issue that money is given to corrupt governments or inefficient channels.

In 2010 the total amount of development aid for sanitation and water was 7.8 billion US dollars (Eliasson & Stenbeck, 2009). Approximately one quarter of that money was given to the least developed areas of the world. Numerous of organisations like European Union and Wateraid spend large funds and a lot of effort on improvement of sanitation (European Commision, 2013) (WaterAid, 2013), but there is still an uneven distribution (Eliasson & Stenbeck, 2009). To reach the millennium goal regarding sanitation, decreasing the portion of the population not having access to improved sanitation by half to 2015, there is still a long way to go (millenniemålen.nu, 2011).

3.3 Consequences of insufficient sanitation

In addition to the health impacts, sanitation has a large influence on both the social and economic aspects of a society (Mara, et al., 2010). If improved sanitation is implemented the following consequences, among others, can be avoided.

3.3.1 Safety

There are fewer acceptable public latrines for women (Borba, et al., 2007). In some rural areas where open defecation is practiced, female inhabitants wait until dark to take care of their needs. Furthermore, women without access to homestead sanitation have enhanced risks of being raped or attacked, which are experienced when using public latrines or defecating in the bush (Mara, et al., 2010).

3.3.2 Economy

Diseases caused by poor sanitation leads to low productivity and consequently to poverty (Borba, et al., 2007). Poor people who get ill can lose their income and family members might have to spend their scarce resources, or need to stay at home from work or school, to care for their sick relatives. Improved sanitation can amount in resources, like fertilisers, to use as consumers or producers, leading to economic benefits (Mara, et al., 2010).

3.3.3 Education

Lack of proper sanitation in schools keeps young women out of education due to a need for a facility during menstruation, leading to negative consequences on their future opportunities to earn their living (Borba, et al., 2007). Health effects due to lack of proper sanitation also causes children to miss school (UNICEF, 2013). Consequently, the future ability to contribute to poverty alleviation in the household is deprived (Borba, et al., 2007).

3.3.4 Environment

The sanitary and environmental conditions in some developing urban and peri-urban areas have become a serious threat to public health and preservation of natural assets (Crennan & Berry, 2003). The lack of proper sanitation has led to pollution of water sources in many parts of the world which communities rely on for survival (Right to Water and Sanitation, 2006).

3.3.5 Health effects

Lack of proper sanitation is connected to the transmission of many common infectious diseases like cholera, typhoid, hepatitis and polio (Montgomery & Elimelech, 2007). As an example, typhoid fever is caused by the bacteria Salmonella typhi, which is passed in the faeces and urine of infected people (World Health Organization, 2013). Others are then infected by consuming food or water that is contaminated as a result of poor sanitation. Along with this example, the effects of substandard sanitation are manifold. The World Health Organization states that 10 percent of the people living in the developing world are infected with intestinal worms due to insufficient waste and excreta management (Carr, 2001).

3.3.5.1 Transmission of pathogens

Pathogens are agents causing disease (Alberts, et al., 2002). When pathogens are present in the environment they are a potential threat to human health (Carr, 2001). Their transmission has therefore been studied to more efficiently prevent humans from being infected. Many types of pathogens can be found in human excreta and they remain infectious for different amounts of time depending on the climate. It is crucial to prevent pathogens from contaminating the environment to decrease the risk of infection (Carr, 2001). Prevention can be obtained by using proper sanitation systems, which protects water resources and food from faecal contamination.

3.3.5.2 Pathogens in excreta

Not all bacteria in faeces are pathogenic (Niwagaba, 2009). In fact most species are non-pathogenic and are referred to as normal intestinal microbiota. Pathogens present in faeces are an indication of infection in that human. Depending on the health of the population, the excreta may contain a number of pathogenic bacteria, viruses and pathogenic protozoa. Most types of faecal pathogens give rise to gastrointestinal symptoms like diarrhoea, vomiting and stomach aches. If the immune system is weakened the non-pathogenic organisms can give rise to disease.

Urine has low content of pathogens and needs less treatment before it can be used as fertiliser or disposed (Carr, 2001). It is safe for crop fertilisation at homestead level after storing it for one month.

3.4 Pathogen inactivation

Human faeces have a higher risk of spreading diseases than urine, which is why a method for sanitising faeces is needed when constructing a sanitation system. (Winblad, 2004) Some of the main factors affecting the survival of pathogens are temperature, pH level, ammonia content and dehydration.

3.4.1 Thermal treatment

Inactivating microorganisms by thermal treatment is a well-known technique (Nordin, 2007). The heat source can be either external or internal, like in composting when the heat is generated by the material. Many functions in a cell are based on proteins, which can denature at temperatures above the organisms optimum (Mader, 2010). Denatured proteins have disrupted shapes and thus have lost their function as the function is determined by the shape (Kimball, 2012).

3.4.2 pH treatment

Treatment of pathogens using high pH levels can damage bacteria by breaking down their membrane (Mendonca, et al., 1994). To inactivate persistent pathogens, a pH of 12 during three months is recommended (Nordin, 2007). Such levels of pH can be obtained by addition of large amounts of ash to the waste. The efficiency of the pH treatment will be improved if high pH is combined with an increase in temperature.

3.4.3 Ammonia treatment

The effect of ammonia has been widely studied but the mechanism with which it helps sanitise waste is still not established (Nordin, 2007). One theory is that the small size and high solubility of the molecule enables it to penetrate the membrane of the pathogens. When this is done the molecules can reduce the intracellular proton concentration by taking up a proton. Protons are a central part of the metabolism of the cell, giving it energy to function (Lane, 2010).

3.4.4 Dehydration

Treating faeces by dehydration inhibits the growth of the pathogens as the availability of water is a critical factor for the growth of all cells (Todar, 2009). Water is the solvent where the molecules of life are dissolved as well as a source of oxygen and hydrogen, which are constituents of cell material. The method used in urine-diversion dehydration toilets (UDDTs) is dehydration which kills the viruses, bacteria and worm eggs in the faeces. It is important to keep urine and faeces separated to keep the moisture content in the faeces as low as possible (Wafler & Spuhler, 2010). Where double vault UDDTs is used, there is a risk of not storing the excreta for sufficiently long periods of time (Niwagaba, 2009). If the storage time is less than one year, a secondary treatment is necessary to ensure a sufficient decrease of pathogen content.

3.5 Indicators

In order to measure and follow the changes regarding sustainable development, the method of using indicators can be conducted (Palme, 2010). This method has been commonly used since the 1990's (Murray, et al., 2009) and the indicators can be formed to give a broad view of the situation by showing different functions for, in this case, sanitation projects (Palme, 2010).

Both quantitative and qualitative indicators are used in the study. The quantitative indicators are easier to measure and compare but the qualitative ones are as important and therefore alternative ways to compare these must be found (Lundin, et al., 1999). The indicators of this study have been divided into the following topics.

3.5.1 Basic facts

Factors like democracy rate, mean age and income per capita varies between different countries (Gapminder, 2008). It is important to know the characteristics of a community before starting a sanitation project as it will affect the outcome (UNICEF, 1997).

3.5.2 Scale

Sanitation projects vary in size regarding number of inhabitants affected, total cost, number of built toilets etcetera (Sustainable Sanitation Alliance, 2013). Project managers can measure progress by the number of toilets constructed or number of inhabitants covered (WSP, 2005).

3.5.3 Economics

The objective of looking at the budget of each project is to see how it affects their outcome (Water Aid, 2010). The design of the budget is important to ensure the right spending of the resources and effective implementation of each financial share. Budgets can also be evaluated by looking at volume and source of funding. It is important to consider the inhabitants' willingness to pay as an economical involvement will increase their concern for the project (UNICEF, 1997).

In order to make a more accurate comparison, the economic indicators have been *Purchasing Power Parity converted* (PPP-converted). This is done by using a factor to convert the domestic value of money to a common currency where all units have the same purchasing power (World Bank, 2013). The conversion factor was chosen according to the start-up year of each project.

3.5.4 Administration

The number of involved organisations will affect the outcome of the project and therefore it is sometimes better to have fewer actors as different directives can confuse the inhabitants (UNICEF, 1997).

Under the topic administration, involvement is a big and important part (Garfi & Ferrer-Martí, 2011). To make the inhabitants participate they have to be involved in several parts of the project (UNICEF, 1997) and not just in the manual work (Garfi & Ferrer-Martí, 2011). It is proved that only installing a technology without any participation from the inhabitants is a failing concept (UNICEF, 1997). If the inhabitants do not feel involved they tend to think that the facility belongs to the government and that the government is responsible for all the maintenance and operation (Muyibi, 1992).

3.5.5 Education

Adequate education should be involved in all stages of a project (Huuhtanen & Laukkanen, 2006). The inhabitants must not be forced to participate in the education but they need to be provided a chance to participate. There are many different forms of education like workshops, lectures and information through social media (Sustainable Sanitation Alliance, 2013). The education can also be held at different locations to reach different groups and ages for example in schools or churches (Muyibi, 1992).

When planning the education, the current knowledge of the inhabitants must be considered and a sufficient education is based on the interest and demand of the inhabitants (Huuhtanen & Laukkanen, 2006). At the same time a project's education about hygiene does not always contribute to a right usage of the facility (UNICEF, 1997). Many people already have the awareness about sanitation issues but fail to use the new facilities the right way as they do not feel involved. The inhabitants need to be convinced that improvement of their sanitation will enhance their life situation; otherwise the education does not matter (Huuhtanen & Laukkanen, 2006).

3.5.6 Technical solution

There is not a single recommended technology; it must be chosen out of the conditions of a project's location (UNICEF, 1997). The best way to choose a technology is to use local innovation and develop the already existing solutions (UNICEF, 1997). Problems due to bad construction and incorrectly used material can occur, which can lead to damages on the construction and must be taken into consideration (Muyibi, 1992).

The toilets can be arranged in different ways, from being installed in private households to public facilities (Water and Sanitation for All, 2013). A household facility tends to provide more privacy but is more expensive to build and operate. Public facilities are built in crowded areas (Water and Sanitation for All, 2013) and sometimes fail to be operated in a correct way as the persons in charge do not feel responsible for the facility (Sustainable Sanitation Alliance, 2013).

3.5.7 Environment and health

It is essential to consider the health impact when evaluating a sanitation system as it has a large effect on the residents in general (Black & King, 2009). If a person is transmitted with a disease due to lack of sanitation it affects the ability to work and take care of the family. It could in worst cases lead to death. Lack of sanitation and hygiene is one of the reasons why waterborne diseases continue to spread. It can also lead to a negative environmental impact (World Health Organization, 2013) as spreading of human excreta can reduce oxygen levels in rivers and effect plant and animal life in a negative way (WaterAid, 2013).

3.5.8 Result indicators

The result indicators consist of indicators from the topics mentioned above together with indicators concerning acceptance. Historically, a problem with sanitation projects is that the facilities have been abandoned (Muyibi, 1992). Therefore it is important that the technical solutions are accepted by the inhabitants (Huuhtanen & Laukkanen, 2006).

All result indicators are considered to either increase or decrease the degree of success in a project. They all have in common that they are not a part of how the projects are designed but rather consequences of choices made when doing so. Result indicators are important when conducting the PCA to be able to relate the other indicators to factors concerning the success degree of a project.

3.6 Statistical method and software program SIMCA

Dealing with a large set of data can make it difficult to grasp the full content of it (Eriksson, et al., 2006). Common statistical measures can be useful for large sets of data with only one or few variables. When there is data with many variables the most common statistical methods have a difficulty coping with it and presenting it in a comprehensive way. This is where Multivariate Data Analysis (MVDA) is useful. It presents the data in a comprehensive way so that trends and correlations can be seen. MVDA can separate the effects of the data from the noise. Noise is the disturbing factors in a data set and if it is not filtered it can mask the real effects of the dataset. MVDA is also good when there is missing data because it is capable of tolerating some amount of gaps in the data set.

In MVDA there are different analysing methods that can be used, for example Principal Component Analysis (PCA) or *partial least square projections to latent structures* (PLS). MVDA is typically used for market research, quality control and assurance in industries as well as process optimization and control (CAMO, 2013).

3.6.1 Principal Component Analysis, PCA

The method used in this study is *Principal Component Analysis* (PCA). It is the basis of MVDA and the method is used to find outliers and trends in a graphical way (Eriksson, et al., 2006). The method can find correlations between the observations and variables.

To perform the PCA, the software program SIMCA was used. It is a program which uses PCA to create a model of the dataset (Eriksson, et al., 2006). In order for SIMCA to interpret the data it needs to transform the variables to make them comparable (Eriksson, et al., 2006). They often vary a lot in range numerically, and the results would be misleading if the data was not transformed. Because of this the data is scaled. This is done by SIMCA, which uses the method of *unit variance scaling*. After scaling, SIMCA calculates which number of *principal components* is suitable to describe the model. Principal components span the cloud of observations and represent the model [See Figure 1].

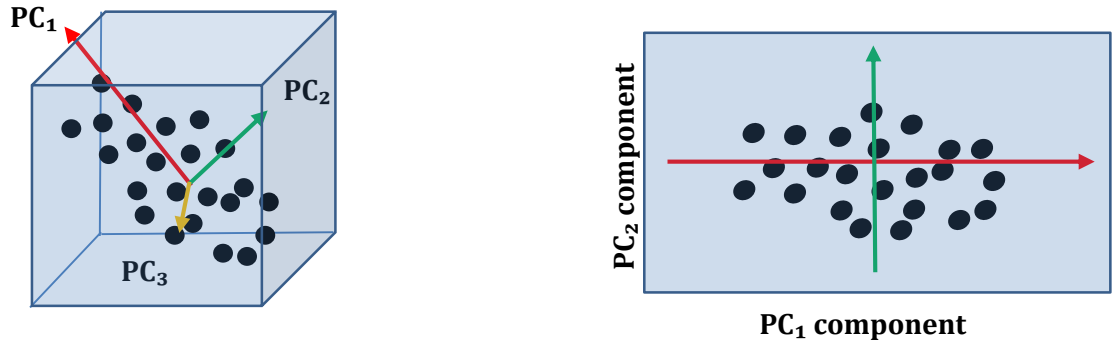


Figure 1. An illustration of how the principal components span the cloud of observations in three and two dimensions.

3.6.1.1 Transformation of variables

Skewness is a measure of how symmetric a dataset is (Eriksson, et al., 2006). If the variables have a high degree of skewness they need to be transformed. A variable is transformed in order for the model to be more predictive and easier to interpret. A transformation can also eliminate outliers.

After the transformation, SIMCA interprets the *principal components* and presents the model as plots (Eriksson, et al., 2006). SIMCA also presents plots, which can indicate if the model has statistical validity. The plot which presents the model is the *loading scatter* [see Figure 2]. The plots which are used to analyse the statistical validity of the model are *X/Y-overview* and *summary of fit* [See Figure 2].

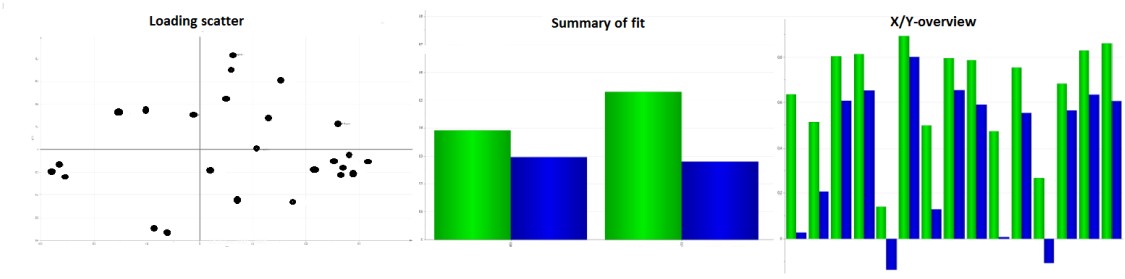


Figure 2. Schematic pictures of a *loading scatter*, a *summary of fit* and an *X/Y-overview.*

3.6.1.2 Statistical validity

In order to determine if the model has statistical validity the *X/Y-overview* and *summary of fit* diagrams were analysed.

The *X/Y-overview* plot shows the cumulated R^2 and Q^2 values for each indicator in the model. The R^2 value indicates how well the variation of the indicator is explained. The Q^2 value indicates how well the indicator values can be predicted. Indicators, which are modelled well, have high R^2 values (green bars) and high Q^2 values (blue bars) [see Figure 2].

The *summary of fit* plot displays two bars for each *principal component* in a model [See Figure 2]. The green bars represent the R^2 values, which show the percent of variation in the data set explained by the model. This value is a measure of how well the model fits the data. The blue bars show the percent of variation in the data set predicted by the model. The value indicates how well the model can predict new data. High R^2 and Q^2 values indicate a good model while low percentages are due to the data set containing too much noise.

4 Method

The method for this study is to compare a large amount of sanitation projects. This is done by selecting projects and identifying indicators that describe the characteristics of the project. The indicators from the projects are the data set in this study and form a matrix [see Appendix 2]. SIMCA then uses this matrix to perform a PCA. Correlations among the indicators were found and compared to correlations described in literature. The results were combined to form recommendations for future implementation of sanitation projects.

4.1 Project selection

Sanitation projects were found and chosen according to the limitations [see 5]. Most of the projects were taken from the Sustainable Sanitation Alliance (SuSanA) online library. Here, case studies conducted by different organisations are presented using the same template. This, in combination with that the case study reports are informative and give a wide perspective over the different aspects, makes them easy to compare. All projects are listed in Appendix 4.

4.2 Identifying indicators

In the next step indicators were identified with the aim to cover all aspects of each project [for definitions of indicators see Appendix 1]. 80 indicators were identified and divided into the following topics: basic facts, scale, economics, administration, education, technical solution, environment & health and results. The indicators are quantitative, qualitative or a binary choice and are presented as a number in the matrix. In the case of a qualitative indicator it is graded after a set scale.

In each project report as many of the indicators as possible were found and in the cases where a value could not be found, the project administration was contacted in order to fill the data gap. When contact information was missing or no reply was received the value was estimated or left blank. The indicators under the topics basic facts were found at Gapminder (2013).

4.2.1 Success indicator

To make a comparison between projects a *success indicator* was formed by combining the indicators that are considered as result indicators [for definitions of indicators see Appendix 1]. The result indicators are:

- Increased income (A)
- Perception of waste (B)
- Severe damage of structure (C)
- Positive health effects (D)
- Percentage of abandoned toilets (E)
- Percentage of usage at follow up (F)
- Percentage of proper usage (G)
- Inspiring others to build (H)

To see the definitions of the indicators, see Appendix 1. The results indicators were combined using the following formula:

$$Success\ rate = \left(A + \frac{B}{2} - C + D - \frac{E}{100} + F + \frac{G}{100} + H\right) * 10$$

The values used for each variable in the equation are found in Appendix 2. In the case where a value was not found, the value zero was used. The result indicators that are considered to have a negative impact on the success rate have been subtracted in the formula and the indicators with a positive impact have been added. The division was done so that the terms would give equal weight to the equation.

The formula was multiplied by ten to get a value easier overview. This generated a success rate for each project that varies between –40 and 80, where 80 is the most successful.

The success indicator was not used as a proof of which projects were the best, but more to see general trends and compare the projects relative each other. The quadrant containing the success indicator showed the direction of positively influencing characteristics of a project.

4.3 Loading scatter analysis

Variables which are positively correlated are grouped together in the *loading scatter* [see Figure 3]. It means that when one of the variables changes, there is a good chance that the correlated variables also change in the same way (Eriksson, et al., 2006). The variables can also be negatively correlated which can be seen as they are positioned in diagonally opposite quadrants of the origin. When the value of one variable increases, the values of the other will decrease.

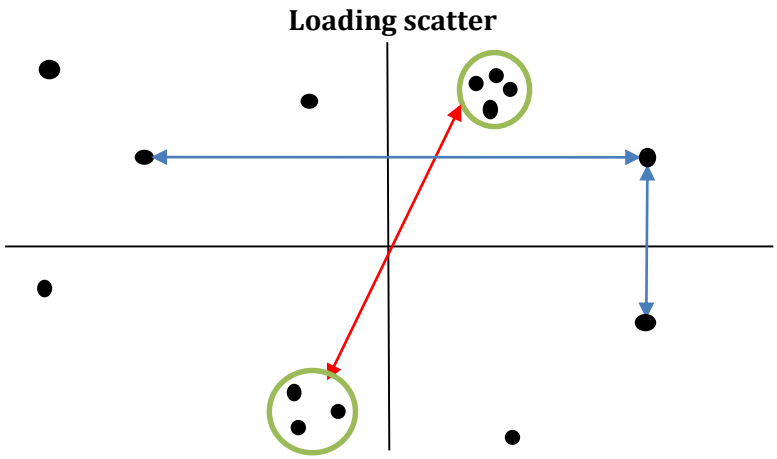


Figure 3. Schematic picture of a *loading scatter*. A green circle shows a group of indicators which are positively correlated and the red arrow shows groups of indicators which are negatively correlated. The blue arrow shows the direction of which indicators lie that are not correlated.

There is also information to be collected from the distance to the origin (Eriksson, et al., 2006). If a variable is positioned far from the origin it has a stronger impact on the model than a variable positioned closer to the origin. Outliers can be detected by analysing the *X/Y-overview* [se figure 2].

The PCA was performed several times with the groups of indicators combined in different constellations. This is because every time different indicators are involved there may be different correlations found (Eriksson, et al., 2006). There can be indicators that have too strong influence on the model. This can result in other indicators not contributing to the model. After each PCA, the model is evaluated to see if they have statistical validity. If this is not the case the model is discarded.

The following four models, with different sets of indicators, were included in the analysis:

1. All indicators
2. All indicators except the topic Basic Facts
3. All indicators except the topics Basic Facts, Economics and Scale
4. Basic Facts and Results

Models one, three and four contain three principal components while model number two was constructed with only two. The SIMCA program indicates a suitable number of principal components for each model.

Interesting correlations are chosen by analysing the plots and their credibility's are evaluated. When using more than two principle components in the SIMCA program, correlations can be analysed from different directions. Three of four models have three principle components, giving three views each on the cloud of observations. When choosing correlations to present in the analysis and the result, the correlations that also have contradicting ones from another angle have been excluded. However, strong correlations found in one direction that are less strong in others have been analysed.

These correlations are discussed in the result chapter [see 6]. The reason for each correlation is also evaluated. Finally the findings are combined to form recommendations that can be used when implementing a sanitation system.

5 Limitations

This study has the following limitations:

- The sanitation issues are regarding human excreta. In all projects one or many facilities are built where human excreta is collected and separated from human contact.
- The chosen projects are all in less developed areas in the world. A large proportion of the projects studied is performed in sub-Saharan Africa, where the lack of access to improved sanitation is the most severe (Thor Axel Stenström, 2011).
- The considered projects are small scale, where small scale is defined as 1 to 1 000 toilets built.
- The projects are, totally or partly externally funded and external organisations are involved in the process.
- The choice of projects has been limited to those who have project descriptions written in English or Swedish.

6 Results

The plots obtained from the simulations are presented in Appendix 3. It was possible to deduce several interesting correlations from the plots. These correlations are analysed and their validity is discussed. The conclusion of each correlation is used to form the recommendations for future implementation of sanitation systems.

6.1 Evaluation of correlations

In the following chapter, eight of the most frequent and interesting correlations are analysed. The correlations are described and a literature study is conducted to see if the correlation is previously known from literature. The reason for each correlation is analysed and the validity of the correlation is assessed. In the second part five validating correlations are presented with the aim to confirm the models but are not further analysed. All plots can be found in Appendix 3 and the definitions for the indicators are presented in Appendix 1.

6.1.1 Evaluation of interesting correlations

The following correlations have been chosen for further analysis because of their distinctness in the plots. They are also considered to be relevant for future sanitation projects.

6.1.1.1 Education and positive results

The models show general positive correlations among the indicators under the topic *education* and *results indicators*. The correlations are found in plot 1.1, 1.2, 1.3, 2.1, 3.1, 3.2 and 3.3. In the same plots a particular positive correlation could be found among the indicator *education before* and the *result* indicators. In all of the plots mentioned, mutual correlations among different types of education indicators could be found.

Conny Falk who previously worked in North Korea as an agricultural and technical advisor for a Swedish International Development Cooperation Agency (SIDA) project confirms that education before is essential for the success of a project (Falk, 2013). This can be explained by education before the construction phase is the first contact with the residents and a good way to start building trust.

Another explanation with the importance of education is the fact that it is hard to manage the problems if you do not know the reasons behind them (Boström, 2009). In some areas, there is insufficient knowledge about the connection between turbid water and diseases and without discussing this problem and its reasons, it is impossible to get a long-term result (Falk, 2013). For a positive long-term effect, education is important in order for the inhabitants to understand these difficulties (Boström, 2009).

The correlation can also be explained by the concept of self-help (Formgren & Friborg, 2012). For the residents to understand the whole concept of the building phase, education is needed in the start-up. By giving help in combination with education at a single occasion, the residents have the tools to help themselves next time.

A linkage between the correlations with successful projects and *education before* is worth considering. If education is missing in the start-up of a project, it is common that further education also is insufficient. (Falk, 2013). This could be explained by the mutual correlations among different education indicators.

The specific education locations; in church and on posters have the strongest positive correlations to the result indicators. Their correlations to the result indicators are evident in the plots 1.1, 1.2, 1.3 and 2.1. The church's role in providing information to the society is described by Greaves et al. (2009). They state that the strength of the local church is its ability to access the poor and marginalised, particularly in rural areas where other social institutions might not exist. It is also mentioned that the message of improved sanitation can be traced back to biblical texts, which church leaders use as sources of motivation. Another explanation to why the church is an important place for education is that it is an established community-based institution that already is familiar with the inhabitants. This can make it easier for education to reach the residents, both physically and psychologically. The same correlation is assumed to include other religious institutions as well.

The use of posters is discussed by the Emergency Response Unit and explains the efficiency by the ability to access large numbers of people at available and appropriate places (Red Cross, 2002). It is also important to present the information in a simple and accurate way.

For these reasons it is possible to believe that the positive correlation between *education* and s*uccess* shown in the PCA. This is especially true regarding education before implementation and for two types of education, in church and on posters. The relationships are frequently mentioned in the literature.

6.1.1.2 Internal emptying of the facilities and negative results

The models show negative correlation between the indicator *internal emptying of the facilities* and the *positive result* indicator. The correlation is found in plot 1.1 and 3.1.

In a report based on a case study with UDDTs, Roma et al. (2013) presents that eight percent of all problems the residents find as the most common are to empty their toilets. Furthermore the level of usage of ecological sanitation toilets is depending on how much the residents have to handle the excreta (Holden, et al., 2003). This is, according to Holden et al. (2003) one of the most important factors regarding the amount of toilets that are accepted and used. Technologies depending on the emptying of the facilities to function rely on the households or hired personnel to take care of it. If neither of this is done, problems with the facilities will occur which might lead to abandoned facilities.

Müllegger et al. (2012) claim that it is essential that the roles and responsibilities in a sanitation system are well defined and clear. The residents also need to feel responsibility and ownership for the sanitation facilities' operation and maintenance. At the same time 86 percent of the residents in a case study in Kenya say they are interested in a new technique if they do not have to be responsible for the operation and maintenance (Muchiri, et al., 2010). Reasons for the inhabitants not willing to empty the toilets can be lack of the practical knowledge and there is a need for sufficient education for the population to feel safe and confident on how to handle a filled toilet (Müllegger, et al., 2012).

In more developed areas of the world the majority of the population does not handle their own excreta. It is not difficult to understand why residents in developing areas would prefer that someone else did it as well. In larger projects a collective system for emptying the tanks might be a good solution. This would lead to the residents not having to manage the emptying themselves and can also lead to higher employment rate. This is however harder to perform in smaller projects where only a few facilities are built that might as well be located with large distances apart. Here it is more important for the residents to take responsibility for the emptying themselves and at the same time accept the system. One of the conclusions in the report of Roma et al. (2013) is that there is a need for the residents to understand the value of the waste. If this was the case and more knowledge was raised, the residents would be willing to be responsible for the emptying and thereby have a greater opportunity to use the dry excreta as fertilisers. With a higher knowledge

they would also know that totally dried excreta is safe to handle. If the residents would be willing to empty the tanks it would also lead to a higher feeling of responsibility which, according to Müllegger et al. (2012) will lead to positive results.

To conclude, a negative correlation between the indicator *internal emptying of the facilities* and positive results in the projects are considered as true. The correlation is frequently found in the literature and is mainly depending on the repulsion of handling excreta but also on inadequate education.

6.1.1.3 Construction by residents and an increased income

The models show a positive correlation between the indicator *construction by residents* and the result indicator *increased income*. The correlation among these indicators can be seen in the plots 1.2, 2.1, 3.1, 3.2 and 3.3. These relations all indicate that involving the resident in the construction part of the project is a good strategy for achieving a successful outcome of a sanitation project.

In many of the studied projects included in this analysis, the toilet facilities have been UDDTs. Faeces is separated, dried and commonly meant to be used as fertilisers to the surrounding farmland. This could be one explanation to the increase in income that has been seen. The extra nutrition generates an increase in harvests, which will increase income for the farmer as a result of bigger sales (Roma, et al., 2013).

It might seem of less importance who built the facility when the main thing is to reuse the waste as fertilisers. Possibly one explanation could be that the people building the facility have a greater possibility of designing the facility to suit needs and requests. These might be design matters like deciding the size of the faeces vaults or the placing of the urine container. Extra consideration in these matters could make it easier to handle the waste later on and will therefore be of interest for the person who will handle the waste. Even if there is no need for the waste as fertilisers in the household where the facility is located it might be somewhere else. Selling the waste is therefore another possible explanation to the increase of income in the household.

Worth mentioning here is that an economical contribution in form on an *investment cost* for the inhabitants in the project is another indicator that relate positively to the result indicator *increased income*. This relation can be seen in plot 1.1, 1.2 and 2.1. This has been observed in previous studies as well and the main reason might be that it will increase the sense of ownership of the facility which is an important part of reaching a successful result (Sustaniable Sanitation Alliance, 2010). An investment in form of an economical contribution as well as labour and engagement will lead to a better maintained and cared for facility. This will lead to a well functional facility that will have a longer life expectancy and generate an increase of income for the same reasons as mentioned previously.

This correlation is interesting and could make more households interested in installing a UDDT facility and being a part of constructing it. The increase in income is generally a result of bigger sales of an increase of harvest.

6.1.1.4 Construction by residents and positive health effects

The models show a correlation between *construction by residents* and *positive health effects*. The relations can be seen in the plots 1.2 and 3.3.

The correlation could be explained by the fact that inhabitants need to be part of designing and constructing the facility in order to get knowledge about the proper way for of using it. This implies that they have the knowledge about how to use the toilet when taking care of their personal needs, and also how to empty the faeces vaults and the urine container in a safe way. This will have a positive effect on the personal health of the residents as it will decrease and restrict the handling of

harmful waste. In a report from UN Habitat (2008) it is stated that community labour was a significant factor which made the project possible. It is also claimed to show the community's commitment to the success of the project as well as continued operation and maintenance. This supports the found correlation since the success of a sanitation project is strongly connected to improved health effects.

This correlation is interesting and could make more households interested in installing a facility and being a part of constructing it. The correlations among these indicators seem reasonable and are both a result of better knowledge before and during the construction of the facility.

6.1.1.5 Cost per toilet and positive results

The models show a negative correlation between *severe damage of structure* and *cost per toilet.* This negative correlation is showed in plot 2.1.

The correlation means that a higher cost per toilet results in a better, more sustainable and better functioning facility. In existing literature it is common to find that low-cost systems are an important factor for successful projects, one example of this is Montgomery and Elimelech's report on water and sanitation in developing countries where it is highlighted numerous of times that low-cost technologies and solutions are important to succeed (Montgomery & Elimelech, 2007)

It is important with cost-effective technologies but a common misconception is that the most inexpensive solution is always the most appropriate technology for the specific location (Garfi & Ferrer-Martí, 2011). Therefore it is important to notice that the least expensive solution does not always result in a successful project. An inexpensive solution can result in lower quality materials and careless handicraft, which can be summarised by the term "you get what you pay for".

It is also important to take into consideration that a sanitation project with a high cost per toilet totally funded by aid does not necessarily mean that the facilities are being well managed. The residents need to have the feeling of ownership towards a facility because if something is given for nothing, the problem of ownership will always occur (Austin, 2003). The residents should contribute with some sort of economic investment when implementing a new facility, in order to obtain commitment to proper care. Otherwise it could lead to facilities not managed well which eventually will lead to damage of the structure.

If the residents contribute with financial means, a possibility to install toilets with better quality to a higher cost per toilet is created. With this comes a higher cost for the residents which create the feeling of ownership and responsibility. This in turn leads to longer-lasting facilities. With these arguments presented, this correlation seems reasonable to take into consideration when implementing a sanitation project.

The models show a positive correlation between *cost per toilet* and the *positive health effects* indicator. The correlation is especially found in plot 1.2 and 2.1. The fact that the affected residents need to contribute to a sanitation project in order to increase the possibility for longer-lasting facilities, a good, sustainable and more functioning facility may well result in positive health effects. The negative connection between *positive health effects* and *severe damage of structure* can be found in plot 2.1. It is hereby showed that a higher cost results in better functioning and longer lasting facilities which results in improved health. Infectious diseases are easily spread if a facility is damaged, this is prevented if the facilities are managed well (Montgomery & Elimelech, 2007).

In conclusion, a high cost per toilet is likely to lead to be connected to better and more functioning facilities. It is however important to notice that a sanitation project has to be cost-effective because it is not just a large budget that contributes to a successful project.

6.1.1.6 The number of persons per toilet and positive results

From the models it could be evaluated that the indicator *persons per toilet* have a negative correlation with the indicator *severe damage on structure*. This negative correlation is found in plot 2.1 and 1.2. A positive correlation could also be seen between *persons per toilet* and *percentage of proper usage,* found in plot 2.1, 1.1, 1.2 and 1.3.

More persons per toilet do not always lead to a positive result. It is also dependent on what solution is implemented. If a sanitation project has to cover a large number of residents resulting in more persons per implemented toilet, a toilet block is often built (McFarlane, 2008). But research has shown that if a number of households share an individual toilet, this may reduce difficulties regarding maintenance because these toilets are often located within or beside homes, creating a distinct incentive for the households to maintain them resulting in longer lasting facilities. More residents sharing one toilet can also decrease the risk of not using the facility properly as cooperation and lessons from the well-informed are naturally handled. If someone uses the facility in the wrong way, it is important that the comprehending inhabitants notice this and shows them how to do it properly instead (Montgomery & Elimelech, 2007).

The models also show a negative correlation between *persons per toilet* and *abandoned toilets*. The correlation is found in plot 1.1, 1.2, 1.3 and 2.1. This correlation means that more persons per toilet can result in a lower percentage of abandoned toilets. With more residents using a facility, the risk of it being abandoned is lower given that the facility works properly. Something that cannot be evaluated from this indicator is if some inhabitants abandoned the toilets but some still used it. This correlation could also be explained by positive peer pressure from the community; that inhabitants help each other to use the facilities properly.

In conclusion more persons per toilet could result in better managed facilities if households share separate toilets instead of toilet blocks. Residents can also help each other out with proper usage, which could help to decrease the risk of not using the facility properly. The correlations among number of *persons per toilet* and the result indicators are plausible in some cases and can be good to take into consideration.

6.1.1.7 Focus on the environment and negative results

The models show negative correlations between *focus on environment and natural resources* and the indicators *usage at follow up* and *proper usage.* There is also a positive correlation to *percentage of abandoned toilets*. The correlations are found in plot 1.1, 1.2, 1.3, 2.1 and 3.2.

In a report that analyses the implementation of environmental aspects, it is stated that this process has been less successful than expected (Sele, 2003). The claim is that the competence of the workers was too low, making it difficult for them to execute their assignments. This theory might also be applied to the sanitation projects analysed in this study. If the aid organisations try to work on lowering the impact on the environment without having the right competences, the effort might not lead to any results and the invested resources are lost.

A report written by the organisation CARE states that initial establishment of natural resource management is time consuming (CARE, 1998). The effects of the management activities may also only be possible to detect after long periods of time. Additionally, future projects are advised to recruit younger people, as part of the project staff when implementing new ideas such as natural resource management. They are more likely to adapt to these technologies and can positively influence the older habitants. Yet another problem with efforts regarding focus on the environment is that the scale of the projects is often very small. This effects the ability for the participants to see immediate improvements, which might result in decreased motivation.

Further signs empowering this correlation are found in the article by Holden (2003). The research shows that inhabitants receiving aid for improved sanitation are mainly interested in social aspects like smell of waste and self-handling of excreta. Factors concerning the reuse of material are perceived as less important. Where the waste has been reused, the households have not been doing so intentionally but rather as a consequence of disposing excreta. It is recommended for future projects to put emphasis on social aspects when implementing the new technologies, letting the reuse come naturally as a consequence of proper usage of the toilets.

To use energy and materials in an economical and environmentally friendly way is an important part of establishing a sustainable sanitation solution (SuSanA, 2008). This concept is broadly known in the industrialised part of the world but is not as established in the less developed areas (Sudurmadi et al., 2001). It is possible that a too strong emphasis on these aspects can take time and financial resources from other parts of the project. The residents receiving the aid might for example value preventing infectious diseases higher. It might be that focusing on the aspects that are not of as much concern can make the households hesitant to the objective of the project. As a consequence, toilets can be abandoned and the motivation to learn how to use them can be influenced negatively. The aspect of keeping a sanitation project environmentally friendly does not seem to harm in itself. It is more probable that the emphasis on the environment when motivating the habitants can cause doubt and decrease their motivation. The measures seem more likely to succeed if motivated with social benefits, like less odour from the waste.

To conclude, the negative correlation between the indicator *focus on environment and natural resources* and *the success* of a project is considered true. The negative influence of the focus is mentioned in several other reports and is mainly due to inhabitants rather prioritising other aspects of the sanitation system. Other reasons can be lacking competences and the difficulty to see results from these efforts in small scale projects.

6.1.1.8 Home visits and abandoned toilets

A correlation has been found between *home visits* as an education step and *the percentage abandoned toilets*. The correlation is found in plot 1.1, 1.2, 1.3 and 2.1. A negative correlation is found in plot 3.3. The correlation is analysed because the positive correlation is stronger.

No correlation between home visits as education form in a sanitation project and abandoned toilets was found in the literature studied. However there is data saying that home visits contribute to the increase of awareness in the society (UNICEF, 1997). This indicates that the common perception is that home visits will lead to a better outcome and thereby more used toilets.

Home visits are a more intimate form of education where the staff of the project is visiting the residents. The reason that projects with home visits have less chance to succeed might depend on that the residents feel imposed by the visitors and thereby not tend to be willing to use the toilets. On the other hand, home visits can be considered as a personal form of education. This form should be successful, as the information about usage and cleaning can be given on site.

When nothing in the existing literature is making the correlation valid it is either a new correlation, an uncertain model or something else causing the correlation. In the models, more correlations can be found relating other indicators to home visits. Firstly, there is a correlation between home visits and the technique of separating urine and faeces. This correlation can be found in four of seven plots and the negative correlation is not found in any of them. This indicates that there is more common to conduct home visits in projects with this kind of technique that is considered harder to use (Riech, et al., 2012). It is harder to use because of the importance that urine and faeces fall into separate containers, not being mixed, that the faeces are covered with ashes and that nothing stays on the walls of the construction. It is possible that home visits are conducted in the projects with these kinds of toilets because they need more instructions for the right usage. This hypothesis is,

however, not truly valid since the correlation between home visits and abandoned toilets seems stronger than the correlation between separation of urine and faeces and abandoned toilets.

The indicator *adequate edu*cation is negatively correlated to *home visits*, a correlation which is also appearing in several plots. One explanation for this is that when doing home visits the organisation might not feel the need to perform other types of education. Examining this it is found that the mean value of the number of education forms chosen in the analysis (home visits, workshops, education in school, education in church, education in social media and education on posters) is 1,77 in general and 2,4 in the project where one of the education forms is home visits. This shows the opposite of the hypothesis; it is instead more common to use more types of education when one type is home visits.

If the found correlation is valid the implementers of a sanitation system should avoid focusing on home visits and conduct other forms of education that have a better proven effect. However there is nothing, apart from the models, that indicates that the correlation is valid since no proof was found in the existing literature, nor in the matrix or by studying other validating correlations in the PCA. Therefore this correlation needs more examination and the sources of errors must be taken into account.

6.1.2 Validating correlations

The following correlations are found in the models and are frequently mentioned in reports concerning aid projects for improved sanitation. The correlations serve to validate the models and make the results more credible. The validating correlations are not discussed in depth since they are considered obvious.

6.1.2.1 Positive health effects and focus on health and hygiene

The models show a correlation between the indicator *positive health effects* and the *focus on health and hygiene* indicator. The correlation is found in plot 1.2 and 1.3. No negative correlation was found. The relationship between the two indicators is considered validating for the models since the one is an evident consequence of the other.

6.1.2.2 Severe damages and the percentage of abandoned toilets

The models show a correlation between the indicator *severe damages* and the *percentage of abandoned toilets* indicator. The correlation is found in plot 1.2, 2.1, 3.1, 3.2, 3.3, 4.1, 4.2 and 4.3. No negative correlation was found. The observation by Kapur and Kumar (2012), that technology failure in the toilet construction is the single largest factor for non-use of toilets in India, agrees with the found correlation.

6.1.2.3 The maintenance cost and internal emptying of the facilities

The models show a negative correlation between the indicator *maintenance cost* and the *internal empting of the facilities* indicator. The correlation is found in plot 1.1, 1.2, 1.3 and 2.1. No positive correlation was found. This indicates that costs can be decreased when the inhabitants are involved in the project. The found correlation can be strengthened by the conclusion by Osumanu (2010) that an active involvement of the habitants can contribute to greater financial viability.

6.2 Recommendations when implementing a sanitation system

Based on the correlations found in the PCA and the strengthening facts from literature, suggestions on how to implement a successful sanitation project are presented. The following steps are recommendations to use when planning, building and finally operating and maintaining a sanitation facility.

6.2.1 Household preferences

When planning a project it is important to find out and consider what the inhabitants prioritise and what kind of system they want to have in their household/community. It is also important to present the concept to the inhabitants the right way. Emphasis should be put on the issues that are the most important for the inhabitants. When presenting the project, emphasis should not be put on the environmental aspect but on improved social aspects like lack of smell. These are issues that have direct impact in the everyday life of the inhabitants and will help getting them interested in installing the new toilet facility. The facility should still be environmental friendly but this should not be presented with the goal of motivating the inhabitants.

6.2.2 Education

An education plan should be developed during the planning phase of the project. Offering education before the construction has proven to be the most efficient for a successful outcome. Education performed in the local churches or other religious assembly halls is a good way of reaching out to the inhabitants of a community. Posters in the toilets facilities and on other places are recommended as an education form as they are always present, easily accessible for everyone and also presumably easy to understand due to the visual layout.

6.2.3 Economic aspects

Economic aspects that are important to address are how the budget is being allocated and who the financiers are, for example how much the users pay in relation to the external funders. Investing in the construction phase and especially on a high quality of the facility is recommended. It was seen in the study that higher cost per facility gave a better and more sustainable result over time. In addition to the material cost, money must be allocated to support the operation- and maintenance costs, which must not be overseen. It is also recommended that the community, household or owner of the new facility make an economical contribution to the project of some sort. The extent of the contribution is not the main thing but to create a sense of responsibility and ownership for the facility.

6.2.4 Health aspects

As discussed in the background episode, when using UDDTs it is important to maintain certain conditions in the faeces storage chamber to ensure a low enough containment of pathogens after the treatment period. One of the critical steps in waste treatment is the storage time and if its importance does not come through to the inhabitants, the pathogens can still be viral since the treatment is not fulfilled. This can lead to the risk of infection still being high; perhaps an even higher one than before the implementation if the residents treat the waste as harmless. Furthermore, the urine separation step of the UDDTs is an important message to deliver through education. If this is not done correctly, the waste will not be kept dry which is a crucial aspect of the treatment causing the pathogens to die off. Addition of ash to the waste before storage in a UDDT is another sensitive step in the excreta sanitising process. The amount of ash should be large according to the literature and this should be well described in the educational material. A sufficient amount of ash is necessary to ensure a pathogen inactivating pH level.

7 Discussion

Sources of error and possible improvements for the method have been looked at to assess the applicability of the method and to facilitate future studies using similar methods. These aspects are relevant for those intending to use the results of this study and those interested in applying the method to their work.

7.1 Project selection

During the process of developing the applied method, several possible sources of error were discovered. The sanitary situation is most severe in Africa, which has resulted in a large proportion of the analysed projects being performed there, as they were easier to find. The overrepresentation of projects executed in Africa might have affected the outcome of the analysis. Aspects that are important in these countries can be less important in other parts of the world where the conditions are different.

Regarding the follow-up phase, the time between the end of a project and the follow-up evaluation can vary. Some projects have reports from follow up-visits after a few months up to a year, while others have been visited and evaluated for several years. If the outcome of a project has been studied for several years it is more likely to find problems, for example on the construction, since more stress has been put on it. More extensive follow-ups also test the sanitation solution's applicability to the inhabitant's everyday life in the long run. Another aspect concerning the follow-up is that the person doing the evaluation can affect its outcome. It can be someone in connection to the organisation executing the project, which can lead to that the person will present the project in a beneficial way instead of reflecting the inhabitant's opinion. A person without connection to the executing organisation is more likely to give an unbiased view on the outcome of a project. These facts regarding the way the follow-up phase is proceeded, affects the result indicators.

7.2 Indicators

An aspect to consider is the fact that almost all of the included sanitation projects have chosen to implement UDDTs. This technology has several positive features but projects using them can differ from those using water toilettes. The need for education, economics, infrastructure and acceptance are some of the aspects that are affected by the choice of technical solution. The intention was to have an equal spread of used technologies in the projects; however this was not possible due to the difficulty of finding extensive enough reports concerning other choices than UDDTs. Due to the lack of spread, it was difficult to analyse how the technical solution affected the outcome of the projects.

The method of multivariate data analysis is mostly used for presenting data, measured in numbers. When analysing different aspects of aid projects, it is sometimes difficult to evaluate the projects by using numbers, especially considering qualitative indicators. To be able to use the program and construct the matrix it was however, necessary to do so. These estimated values are probably influenced by the person doing the evaluation. This issue is always relevant when dealing with qualitative measurements, not only for the method with PCA.

To be able to see which indicators are positively influencing the outcome of an aid project, some of them were elected to be result indicators. It is not certain that the ones chosen show a representative and complete picture of the result of an aid project for improved sanitation. If more information would have been available in the reports it might have been possible to include more aspects reflecting the outcome of the projects. The indicators used were chosen since information about them was possible to find for most of the projects. This is a reason why the results from the analysis should be used as pointers rather than stated facts. If the PCA method would be used for other aid projects than for sanitation, it is plausible that other result indicators would be preferable.

The indicator named success was created during this study and is simply a summation of all result indicators. All included terms are weighted equally since no assumption that some indicators mean more than others was made. This is relevant since the purpose of the analysis is to investigate if some indicators are more important than others. It is possible that a person more experienced in working with aid for sanitation would have designed this indicator differently based on previous experiences. In spite the fact that the success indicator is not being regarded as trustworthy it was interesting to try the concept. With this in mind the analysis was carried out without too much emphasis on the success indicator. More focus was put on the separate result indicators when studying the correlations in the plots.

The basic facts indicators taken from Gapminder could have been taken from the year that the project started to get more accurate values. However, in this study these indicators were approximated not to change much over a period of time in oppose to the economic indicators that may change more due to inflation. These economic factors were taken into account by the PPP conversion where both the start-up year of the project and the domestic value of the country were considered.

7.3 PCA

The studied project reports have had different aspects of the aid process emphasised. As an example, some are thoroughly describing the education plan of the projects while others have not mentioned education in the process but have highlighted the technical details. This has made it difficult to fill out some values in the data matrix. When scarce information has been presented in the study, this information has been used to estimate indicator values. Occasionally this has not been possible, leaving empty gaps in the matrix. When using the matrix in SIMCA, the program estimates these empty gaps. However, if a lot of values are missing, the program finds it more difficult to create reliable models. Four models were regarded as trustworthy and thus used in the analysis. Additional models with other combinations of indicators were also made but a large number of them ended up being too weak for further analysis. This was due to a too large number of missing values. The models used during the analysis were selected due to their better fit and trustworthiness according to the program's evaluation system displayed as *summary of fit* [see Appendix 3].

About one fourth of all indicators are two-option questions. This was later proven to be difficult for the program to evaluate, leading to less dynamic models. Adding more differentiated indicators would have been preferable. However, an answer to a two-option question is more likely be found in the project description and that is why this kind of indicators were used in this study. It would also have been preferable to have fewer indicators with a possibility to get the value zero. This is due to a decreased possibility to transform these indicators if their skewness would be too high. Transforming them can lead to a better model being produced.

The reasons previously discussed have led to some models having a *summary of fit* with lower values than would be desirable. Missing values, values including zero and indicators that are uncertain, affect the model and the uncertainty is shown in the summary of fit. Also, looking at the *XY overviews* for the different models can for a few indicators show weakness in how their values are explained and predicted.

After working with PCA as a tool for analysing aid projects for sanitation the method is considered to be a valuable alternative for evaluating and developing aid projects for improved sanitation. It is also believed that the method has good potential to give even more interesting results if the used data set is complete. If an organisation like SuSanA or SIDA would use this method, they would probably be able to collect all the relevant data and more easily contact the inhabitants involved in the projects. For further and improved studies, cooperation with established organisations is a suggestion for improvement as this will help collect more complete data.

It is anticipated that aid projects in other fields than sanitation can profit from an analysis with PCA. The method is easy to adapt by choosing other indicators. In spite of room for improvement, the method is recommended to be used as a complement to other approaches and as a possible way to discover unthought-of relations to improve the success rate of aid projects.

8 Conclusion

This study has resulted in several interesting correlations that should be taken into account when implementing a sanitation project. Some of them, those presented below, are considered to be more distinct and relevant. It is important to notice that this study on improved sanitation is regarding human excreta and the considered projects are all in less developed areas with a large proportion coming from sub-Saharan Africa. These projects are all small scale and are totally or partly external funded.

The relations among positive results and education in the initial phase of a project is explained by preparatory education leading to trust among the residents that has positive effects on the whole process. Education held in church, or other religious contexts, access all groups in the society and especially the poor inhabitants in the rural areas with few other social institutions. The information about hygiene in religious texts can also improve the church´s potential impact on the education. Regarding educational posters they are found as highly effective because of their ability to reach a large number of inhabitants and be placed on appropriate locations.

When regarding the correlations among internal empting of the facilities and negative results it is concluded that residents find it repulsive to handle their own excreta. This combined with poor perception of the value of waste makes projects with this type of maintenance less successful.

The linkage between focusing on environment and less successful projects has been clarified to mainly concern the residents' motivation for the project. Inhabitants are not motivated by environmental incitements but by social aspects like reduced smell or not having to handle excreta. Environmental aspects should with benefit be incorporated and focused on in the project but should not be the primary motivation for the inhabitants.

The method of PCA is not normally used for comparing qualitative indicators and especially not for developing aid projects. Consequently, some limitations of the method as it is used here have been discovered. In spite of this, the found results prove that the method can be useful and even more so if some improvements are made. The shortcomings of the set of data are most critical and greatly effect the method's credibility. Choosing better-suited indicators and having access to more data are considered to be necessary measures to improve the method and reach more certain results.

If a more thorough and better-suited set of data can be presented, this method of analysing correlations among indicators affecting a project outcome could be of great use when initiating a sanitation aid project. As been seen in this report several interesting correlations have been found. Correlations that are believed to be positive have in this study been proven to give opposite effect. By using the method of PCA, advice on how to succeed in a project can be given beforehand instead of basing experience on success and failure. In this way consequences from these misconceptions can be avoided. This can reduce the risk of failing with some parts of a project, which in turn reduce the risk of spreading infectious diseases. This will increase the chance for a better standard of living for millions of people.

Reference list

A. F. Mendonca, T. L. A. a. S. J. K., 1994. *Destruction of gram-negative food-borne pathogens by high pH involves disruption of the cytoplasmic membrane,* Pennsylvania: Department of Food Science, The Pennsylvania State University.

Alberts, B., Johnson, A. & Lewis, J., 2002. Introduction to Pathogens. In: *Molecular Biology of the Cell. 4th edition.* New York: Garland Science.

Austin, A., 2003. *Ecosan: An unsuccessful sanitation scheme at a rural school - Lessons learned from the project failure.,* Pretoria: s.n.

Barnes, R. R., 2009. *Planning for sustainable water and sanitation projects in rural, developing communities,* New South Wales: UNSW.

Black, M. & King, J., 2009. *The Atlas of Water.* Los Angeles: University of California Press.

Borba, M.-L., Smet, J. & Slijbesma, C., 2007. *Enhancing Livelihoods Through Sanitation,* Delft: IRC International Water and Sanitation Centre.

Boström, 2009. *Utrikeskorrespondenterna: Sveriges Radio.* [Online]
Available at:
http://sverigesradio.se/sida/gruppsida.aspx?programid=3304&grupp=6240&artikel=3309571
[Accessed 21 May 2013].

CAMO, S., 2013. *Multivariate Data Analysis: Powerful Statistics and Data Mining.* [Online]
Available at: http://www.camo.com/multivariate_analysis.html
[Accessed 16 May 2013].

CARE, 1998. *Lessons Learned in Water, Sanitation and Environmental Health,* s.l.: CARE Zambia.

Carr, R., 2001. Excreta-related infections and the role of sanitation in the control of transmission. In: *Water Quality: Guidelines, Standards and Health..* London, UK: IWA Publishing, pp. 90-113.

Consulting, P., 2012. *Multivariate Data Analysis: PTM Consulting.* [Online]
Available at: http://www.ptm-consulting.com/pharma-statistical-tools-multivariate-data-analysis.aspx
[Accessed 21 May 2013].

Crennan, L. & Berry, G., 2003. *Issues for community-based sustainable resource management and conservation: considerations for the Strategic Action Programme for the International Waters of the Pacific Small Island Developing States,* Apia: Project Coordination Unit, International Waters Programme.

DESA, 2012. *The criteria for identifying least developed countries.* [Online]
Available at: http://www.un.org/en/development/desa/policy/cdp/ldc/ldc_definitions.shtml
[Accessed 9 May 2013].

Easterly, W. & Pfutze, T., 2008. *Where does the money go? Best and worst practices in foreign aid,* Brookling: Brooklings Global Economy and Development.

Eliasson, J. & Stenbeck, P., 2009. *Wateraid Sverige-Nyheter- Fördubbla biståndet till vatten och sanitet.* [Online]
Available at: http://www.wateraid.se/cgi-bin/nyheter.cgi?sok=1&mall=nyhet.shtml&falt=1&varde=001
[Accessed 21 May 2013].

ENVIS Centre on Hygiene, Sanitation, Sewage Treatment Systems and Technology, 2011. *Pathogens in Human Excreta.* [Online]
Available at: http://www.sulabhenvis.nic.in/Database/sanitation_humanexcreta_2131.aspx
[Accessed 18 04 2013].

Eriksson, L. et al., 2006. *Multi- and Megavariate Data Analysis Principals and Applications.* 2nd ed. Umeå: Umetrics.

European Commision, 2013. *Water and Sanitation.* [Online]
Available at: http://ec.europa.eu/europeaid/what/environment/water-energy/
[Accessed 06 May 2013].

Falk, C., 2013. [Interview] (23 04 2013).

Fogelberg, K. & Sparkman, D., 2011. *Flushing Away Bolivia's Sanitation Crisis.* [Online]
Available at: http://www.waterforpeople.org/media-center/in-the-media/flushing-away-bolivias-sanitation-crisis.html
[Accessed 15 May 2013].

Formgren & Friborg, 2012. *Ledaren: Corren,* Linköping: Corren.se.

Gapminder, 2008. *Gapminder World,* s.l.: s.n.

Garfi, M. & Ferrer-Martí, L., 2011. Decision-making criteria and indicators for water and sanitation projects in developing countries. *Water Science & Technology,* 64(1), pp. 83-101.

Gleick, P., 2009. *Water Conflict.* [Online]
Available at: http://worldwater.org/chronology.html
[Accessed 21 May 2013].

Greaves, F., Yardley, S. & Hoek, E. v., 2009. *The role of the church in improving access to sanitation.* Addis Ababa, s.n.

Holden, R., Terreblanche, R. & Muller, M., 2003. *Factors which have influenced the acceptance of ecosan in South Africa and development of a market strategy.* s.l., IWA, pp. 167-174.

Huuhtanen, S. & Laukkanen, A., 2006. *A Guide to Sanitation and Hygiene for those Working in Developing Countries,* Tampere: Tampere Polytechnic - University of Applied Sciences Publications.

Kaliba, A. R., 2002. *Participatory Evaluation of Community-Based Water and Sanitation Programs: The Case of Central Tanzania,* Manhattan: Kansas State University.

Kapur, D. & Kumar, P., 2012. *Formative Research on Sanitation and Hygiene Behaviours. Current Status, Knowledge, Attitudes, Barriers and Enablers: Primary Research Findings,* Dhaka: Asia Regional Sanitation and Hygiene.

Kimball, J. W., 2012. *The Rules of Protein Structure.* [Online]
Available at:
http://users.rcn.com/jkimball.ma.ultranet/BiologyPages/D/DenaturingProtein.html
[Accessed 3 May 2013].

Lancaster, C., 2006. *Foreign Aid : Diplomacy, Development, Domestic Politics.* Chicago: University of Chicago Press .

Lane, N., 2010. *Why are cells powered by proton gradients?,* s.l.: Nature Education.

Lifewater international, 2013. *Sanitation.* [Online]
Available at: http://www.lifewater.org/resources-information/programs/sanitation/
[Accessed 21 May 2013].

Lundin, M., Molander, S. & Morrison, G. M., 1999. A set of indicators for the assessment of temporal variations in the sustainability of sanitary systems. *Wat. Sci. Tech.,* pp. 253-242.

Mader, S. S., 2010. *Food Pathogens and Temperature.* [Online]
Available at: http://highered.mcgraw-hill.com/sites/007352543x/student_view0/chapter6/food_pathogens_and_temperature.html
[Accessed 18 04 2013].

Mara, D., Lane, J., Scott, B. & Trouba, D., 2010. *Sanitation and Health.* [Online]
Available at:
http://www.plosmedicine.org/article/info%3Adoi%2F10.1371%2Fjournal.pmed.1000363
[Accessed 14 May 2013].

McFarlane, C., 2008. Sanitation in Mumbai's informal settlements: state, 'slum', and infrastructure. *Environment and Planning A,* 40(1), pp. 88-107.

Mendonca, A. F., Amoroso, T. L. & Knabel, S. J., 1994. *Destruction of gram-negative food-borne pathogens by high pH involves disruption of the cytoplasmic membrane,* Pennsylvania: Department of Food Science, The Pennsylvania State University.

millenniemålen.nu, 2011. *Fler har tillgång till drägligt dricksvatten men saknar fortfarande toaletter.* [Online]
Available at: http://www.millenniemalen.nu/sakra-en-miljomassigt-hallbar-utveckling/fler-har-tillgang-till-rent-vatten/
[Accessed 06 May 2013].

Mollah, K. A., Nishida, K., Kondo, N. & Yamagata, Z., 2009. Children's Health Deficits due to Diarrhoea: Effects of Water Suppl and Sanitation Systems in Slums with Different Water Logging Conditions. *Journal of Water and Environment Technology,* pp. 277-291.

Montgomery, M. A. & Elimelech, M., 2007. Water and Sanitation in Developing Countries: Including Health in the Equation. *Environmental Science & Technology,* 41(1), pp. 17-24.

Muchiri, E., Mutua, B. & Müllegger, E., 2010. Private sector involvement in operation a sanitation system with urine diversion dry toilets in Nakuru, Kenya. *Sustainable Sanitation Practice,* pp. 21-25.

Müllegger, E., Freiberger, E. & etal, 2012. *Operation and maintenance of sustainable sanitation systems,* s.l.: Sustainalbe Sanitation Alliance.

Murray, A., Ray, I. & Nelson, K. L., 2009. An innovative sustainability assessment for urban wastewater infrastructure and its application in Chengdu, China. *Journal of Environmental Management,* pp. 3553-3560.

Muyibi, S., 1992. Planning Water Supply and Sanitation Projects in Developing Countries. *Journal of Water Resources Planning and Management,* pp. 351-355.

Niwagaba, C. B., 2009. *Treatment Technologies for Human Faeces and Urine,* Uppsala, Sweden: Swedish University of Agricultural Sciences.

Nordin, A., 2007. *Ammonia Based Sanitation Technology,* Uppsala: Swedish university of Agricultural Sciences.

OECD, 2011. *Development aid: Total official and private flows.* [Online]
Available at: http://www.oecd-ilibrary.org/development/development-aid-total-official-and-private-flows-2011_aid-off-pvt-table-2011-1-en;jsessionid=aoanqlidh63ph.x-oecd-live-02
[Accessed 06 May 2013].

Osumanu, I. K., 2010. *Community involvement in urban water and sanitation provision: The missing link in partnerships for improved service delivery in Ghana,* Wa, Ghana: Department of Environment and Resource Studies, University for Development Studies.

Page, L., 2012. *SOIL's EcoSan Toilet Design Goes Global.* [Online]
Available at: http://www.oursoil.org/soils-ecosan-toilet-design-goes-global/
[Accessed 14 May 2013].

Palme, U., 2010. On Prerequisites for the Application of Sustainable Development Indicatiors in Urban Water Management. *Sustainability,* pp. 92-116.

Prawitz, D., 2013. *Nationalencyklopedin.* [Online]
Available at: http://www.ne.se/lang/definition
[Accessed 14 05 2013].

Red Cross, 2002. *Water and Sanitation,* Geneva, Switzerland: International Federation of Red Cross and Red Crescent Societies.

Riech, C., von Münch, E. & Hoffman, H., 2012. *Technology Review of Urine-diverting dry toilets (UDDTs),* Eschborn: Deutsche Gesellschaft für Internationale Zusammenarbeit.

Right to Water and Sanitation, 2006. *Right to Sanitation.* [Online]
Available at: http://www.righttowater.info/right-to-sanitation/
[Accessed 14 May 2013].

Roma, E. et al., 2013. *User perceptions of urine deversion dehydration toilets: Experiences from a cross-sectional stydy in eThekwini Municipality,* London: London School of Hygiene and Tropical Medicine.

Sele, M., 2003. *Norwegian Aid & Sustainable Development - Focus on environment in NORAD and decentralised management of natural resources in rural development.,* Oslo: Department of Political Science, University of Oslo.

Shah, A., 2012. *Foreign Aid for Development Assistance.* [Online]
Available at: http://www.globalissues.org/article/35/foreign-aid-development-assistance
[Accessed 06 05 2013].

SIDA, 2013. *Missionärer, folkrörelser och "u-hjälp".* [Online]
Available at: http://www.sida.se/Svenska/Bistand--utveckling/Detta-ar-svenskt-bistand/Svensk-bistandshistoria/
[Accessed 06 May 2013].

Stenström, T. A., Seidu, R., Ekane, N. & Zurbugg, C., 2011. *Microbial Exposure and Health Assessments in Sanitation Technologies and Systems,* Stockholm, Sweden: Stockholm Environment Institute.

Sudurmadi et al., S., 2001. *A survey of perception, knowledge, awareness, and attitude in regard to environmental problems in a sample of two different social groups in Jakarta, Indonesia,* s.l.: The Department of Public Health, Gunma University School of Medicine, et al..

SuSanA, 2008. *Towards more sustaiable sanitation solutions, Version 1.2,* s.l.: Sustainable Sanitation Alliance.

Sustainable Saniation Alliance, 2013. *Introduction of Sustainable Saniation.* [Online]
[Accessed 11 April 2013].

Sustainable Sanitation Alliance, 2013. *About SuSanA.* [Online]
Available at: http://www.susana.org/lang-en/about-susana
[Accessed 11 April 2013].

Sustainable Sanitation Alliance, 2013. *Case Studies.* [Online]
Available at: http://www.susana.org/lang-en/case-studies
[Accessed 01 April 2013].

Sustainable Sanitation Alliance, 2013. *SuSanA case study book on sustainable sanitation projects from Sub-Sahara Africa published.* [Online]
Available at: http://www.susana.org/lang-en/news/latest-news/593-susana-case-study-book-on-sustainable-sanitation-projects-from-sub-sahara-africa-published
[Accessed 12 April 2013].

Sustaniable Sanitation Alliance, 2010. *UDDTs implemented via CBOs and Water Services Trust Fund, Nyanza, Western and other provinces, Kenya,* s.l.: Sustaniable Sanitation Alliance.

Svensson, 2012. [Online]
Available at:

http://www.mynewsdesk.com/se/pressroom/jak_medlemsbank/news/view/oekad-konkurrens-om-vattnet-hur-tryggar-vi-livsmedelsfoersoerjningen-45644

The World Bank, 2012. *What we do.* [Online]
Available at:
http://web.worldbank.org/WBSITE/EXTERNAL/EXTABOUTUS/0,,contentMDK:20103838~menuPK:1696997~pagePK:51123644~piPK:329829~theSitePK:29708,00.html
[Accessed 14 May 2013].

Thor Axel Stenström, R. S. N. E. a. C. Z., 2011. *Microbial Exposure and Health Assessments in Sanitation Technologies and Systems,* Stockholm, Sweden: Stockholm Environment Institute.

Todar, K., 2009. *Nutrition and Growth of Bacteria.* [Online]
Available at: http://textbookofbacteriology.net/themicrobialworld/nutgro.html
[Accessed 6 May 2013].

UN Habitat, 2008. *Impact Assessment Study for the Community-based Water and Sanitation Project,* s.l.: UN Habitat.

UNICEF, 1997. *A Sanitation Handbook.* New York: UNICEF.

UNICEF, 2010. *Good quality aid.* [Online]
Available at: http://www.unicef.org.uk/UNICEFs-Work/What-we-do/Issues-we-work-on/International-aid/Good-quality-aid/
[Accessed 06 May 2013].

UNICEF, 2013. *Water, Sanitation and Hygiene.* [Online]
Available at: http://www.unicef.org/wash/index_3951.html
[Accessed 23 April 2013].

United Nations, 2013. *Background.* [Online]
Available at: http://www.un.org/millenniumgoals/bkgd.shtml
[Accessed 14 May 2013].

VP., S., 1999. *Bacterial energetics at high pH: what happens to the H+ cycle when the extracellular H+ concentration decreases?,* Moscow, Russia: Department of Bioenergetics, A. N. Belozersky Institute of Physico-Chemical Biology, Moscow State University.

Wafler, M. & Spuhler, D., 2010. *UDDT.* [Online]
Available at: http://www.sswm.info/category/implementation-tools/water-use/hardware/toilet-systems/uddt
[Accessed 05 07 2013].

Wafler, M. & Spuhler, D., 2010. *UDDT | SSWM.* [Online]
Available at: http://www.sswm.info/category/implementation-tools/water-use/hardware/toilet-systems/uddt
[Accessed 14 May 2013].

Water Aid Sverige, 2013. *Water Aid Sverige Utmaningen.* [Online]
Available at: http://www.wateraid.se/utmaningen.shtml
[Accessed 25 April 2013].

Water Aid, 2010. *Budget advocacy for the water and sanitation sector in Nepal: A primer for civil society organisations,* Kupondole: Water Aid.

Water and Sanitation for All, 2013. *Providing Sanitation Services.* [Online]
Available at: http://web.mit.edu/urbanupgrading/waterandsanitation/levels/provide-san-serv.html
[Accessed 02 April 2013].

WaterAid, 2013. *Sanitation.* [Online]
Available at: http://www.wateraidamerica.org/what_we_do/the_need/sanitation.aspx
[Accessed 01 April 2013].

WaterAid, 2013. *WaterAids arbete.* [Online]
Available at: http://www.wateraid.se/wateraids-arbete.shtml
[Accessed 06 May 2013].

Winblad, U. a. S.-H. M., 2004. *Ecological Sanitation - Revised and Enlarged Edition,* Stockholm: Stockholm Environmental Institute.

World Bank, 2013. *PPP conversion factor (GDP) to market exhange rate ratio.* [Online]
Available at: http://data.worldbank.org/indicator/PA.NUS.PPPC.RF
[Accessed 01 April 2013].

World Health Organization, 2012. *GLAAS 2012 REPORT, UN-Water Globlan Analysis and Assessment of Sanitation and Drinking Water,* Switzerland: s.n.

World Health Organization, 2013. *Water Sanitation Health, Sanitation challegne: Turning commitment into reality.* [Online]
Available at:
http://www.who.int/water_sanitation_health/hygiene/envsan/sanitchallenge/en/index10.html
[Accessed 01 April 2013].

World Health Organization, 2013. *Water Sanitation Hygiene.* [Online]
Available at: http://www.who.int/water_sanitation_health/hygiene/en/index.html
[Accessed 10 May 2013].

WSP, 2005. *Scaling-up Rural Sanitation in South Asia,* s.l.: Water and Sanitation program.

Appendix 1 Definitions of indicators

Basic Facts[1]	
Continent	Continent where the project was conducted
Country	Country where the project was conducted
PPP-constant	Purchasing Power Parity-constant taken from the Worldbank[2] website according to the year the project started
GDP per capita	Gross Domestic Product in EUR
Life expectancy	The average number of years a new born child would live if current mortality patterns were to stay the same[3]
Average income	Gross Domestic Product/Capita in PPP$
Corruption perception index	A measure of how corrupt a country is with focus on the public sector (1-10)
Children per woman	Total fertility rate per woman
Democracy score	A summary measure of a country's democratic and free nature (-10 to 10)
Diarrhoeal deaths	Diarrhoeal deaths in children 1-59 month (per 1000 births)
Child deaths	All causes of death in children 1-59 month (per 1000 births)
Drought	Total number of people getting affected, injured or killed in drought
Improved water source	Proportion of the population using improved drinking water sources
Population density	Population density per square kilometre
School enrolment	The percentage of students completing the last year of primary school
Mean years in school, men	Average number of years of school attended by men between 25 and 34 years old, including primary, secondary and tertiary education
Mean years in school, women	Average number of years of school attended by women between 25 and 34 years old, including primary, secondary and tertiary education
HDI	Index used to rank countries by level of "human development" on a scale from 0 to 1, containing three dimensions: health level, educational level and living standard (0-1)
Improved sanitation	Proportion of the population using improved sanitation facilities

[1] (Gapminder, 2013), http://www.gapminder.org/
[2] (The World Bank, 2013), http://data.worldbank.org/indicator/PA.NUS.PPPC.RF?page=1
[3] (Gapminder, 2013) http://www.gapminder.org/data/

Scale	
Total project time	Total project time in months
Amount of toilets	Total amount of toilets implemented
Number of inhabitants covered	Total number of inhabitants covered by the project
Total cost	Total cost of the project, EUR
Total cost, PPP	Total cost of the project, PPP-dollar

Economics	
Cost per toilet	Total cost divided by number of toilets, EUR
Cost per toilet	Total cost divided by number of toilets, PPP-dollar
Total cost per affected person	Total cost divided by number of affected inhabitants, EUR
Total cost per affected person	Total cost divided by number of affected inhabitants, PPP-dollar
Material cost per toilet	Total material cost divided by number of toilets, EUR
Material cost per toilet	Total material cost divided by number of toilets, PPP-dollar
Maintenance cost per toilet	Maintenance cost per toilet and month, EUR
Maintenance cost per toilet	Maintenance cost per toilet and month, PPP-dollar
Maintenance cost	Maintenance cost per month, EUR
Investment cost	Total investment cost paid by the inhabitants, EUR
Investment cost per toilet	Total investment cost paid by the inhabitants divided by number of toilets, EUR
Investment cost per toilet	Total investment cost paid by the inhabitants divided by number of toilets, PPP-dollar
Cost paid by aid	Percentage of total cost funded by aid organisations
SIDA-financed	Percentage of total cost funded by SIDA
NGO-financed	Percentage of total cost funded by NGO's

Education	
Number of types of education	Number of different types of education used during the project
Number of education sessions	Number of education sessions performed
Education before	Has education been performed in the preparatory phase? (Yes=1, No=0)
Education during	Has education been performed in connection to the building phase? (Yes=1, No=0)
Education after	Has education been performed after the project was ended? (Yes=1, No=0)
Adequate education	How sufficient the education was; estimated in a scale from 1 to 5
Home visits	Has education been performed using home visits? (Yes=1, No=0)
Workshops	Has education been performed using workshops? (Yes=1, No=0)
Education in school	Has education been performed in schools? (Yes=1, No=0)
Education in church	Has education been performed in churches or other religious contexts? (Yes=1, No=0)
Education in social media	Has education been performed in social media? (Yes=1, No=0)
Education on posters	Has education been performed on posters? (Yes=1, No=0)
Education focuses on children	Does the education focus on children? (Yes=1, No=0)

Administration	
Number of involved organizations	Number of different organizations involved throughout the process
Initiative from residents	Was the initiative to start the project taken by the residents? (Yes=1, No= 0)
Construction by residents	Did the residents contribute with labour in the construction phase? (Yes=1, No= 0)
Drainage handled internally	Internal emptying of the facilities? (Yes=1, No=0)
Focus on socio-cultural & institutional	A mean value of the evaluations from SuSanA, numbered between -1 and 1. 1 means it is a strong point of the project. "Involve the sociocultural acceptance and appropriateness of the system, perceptions, gender issues and compliance with legal and institutional frameworks"[4]

Technical solution	
Time of construction	In months
Time of construction per toilet	Total time of construction, in months, divided by total number of toilets
Persons per toilet	Average persons per toilets
Percentage double vault toilets	Percentage of double vault UDDTs of all toilets in project
Water toilet	Are the facilities water toilets? (Yes=1 No=0)
Private toilets	Percentage of private toilets of all toilets in project
Separate or in blocks	Are the toilets placed separately (=1) or in complexes? (= 0)
Squatting or sitting	Are the toilets designed for squatting (=1) or sitting (=0)?
Urine & faeces separation	Is urine and faeces separated? (Yes=1 No=0)
Consideration of design	Have the inhabitants influenced the choice of design of the facility? (Yes=1 No=0)
Facility for hand wash	Is a facility for hand wash built? (Yes=1 No=0)
Neutralization steps	Number of steps to decontaminate the faeces, for example drying

[4] Sustainable Sanitation Alliance (2008), towards more sustainable sanitation solutions.

Environment and Health	
Focus on environmental and natural resources	A mean value of the evaluation score from SuSanA, numbered between -1 and 1. 1 means it is a strong point of the project. "Involve the resources needed in the project as well as the degree of recycling and reuse practiced and the effects of these" [5]
Focus on health & hygiene	A mean value of the evaluation score from SuSanA, numbered between -1 and 1. 1 means a strong point of the project. "Include the risk of exposure to pathogens and hazardous substances and improvement of livelihood achieved by the application of a certain sanitation system"[5]

Result	
Increased income	Have the toilets resulted in an increased income for the inhabitants? (Yes=1 No=0)
Perception of waste	How the waste from the toilets are perceived, (-2 to 2) where -2=really dangerous , 2= totally safe
Severe damage	Have severe damages occurred on the construction? (Yes=1 No=0)
Positive health effects	Have positive health effects been documented after building of construction? (Yes=1 No=0)
Percentage of abandoned toilets	Percentage of abandoned toilets at follow up
Inspiring others to build	Have the project inspired other people to build own facilities? (Yes=1 No=0)
Usage at follow up	Percentage of inhabitants that uses the facilities at follow up
Proper usage	Percentage of inhabitants that uses the facility the right way
Successfulness	A combination of the results parameters, where a higher value indicates a more successful project (-40 to 80)

[5] Sustainable Sanitation Alliance (2008), towards more sustainable sanitation solutions.

Appendix 2 Matrix used in the PCA

			Basic facts																
Project	Continent	Country	PPP-constant	GDP/ capita	Life Expectancy	Average Income	Curruption perception index	Child/ woman	Democracy score	Diarrhoeal deaths children	Child deaths	Draught - affected	Improved water source	Population density	School enrolement	Mean years in school- men	Mean years in school- women	HDI	Improved sanitation
				EUR	Year	GDP/Capita PPP				per 1000 born	per 1000 born		%	per square km	%				%
1	South America	Peru	0,5	2275,35	74	7859	3,5	2,5	9	1,1	22	0	84	22	102	12	11	0,712	69
2	Africa	Ethiopia	0,3	693	59	900	2,7	4,4	1	23	90	6400000	42	72	52	3,6	2	0,348	18
3	Africa	Tanzania	0,4	330,33	56	1180	2,6	5,6	-1	11	73	0	53	47	90	6,7	6,3	0,448	10
4	Africa	Namibia	0,7	2121,47	62	5339	4,5	3,2	6	2,5	24	0	92	2,7	78	8,5	9	0,613	31
5	South America	Bolivia	0,4	982,5	67	4171	2,8	3,3	7	7,9	51	0	86	9	95	10	9,1	0,656	27
6	Africa	Botswana	0,4	3226,3	53	13240	5,8	2,7	8	2,1	26	0	96	3,4	97	7,3	8,3	0,626	61
7	Africa	Burkina Faso	0,4	220,2	55	1343	3,1	5,8	0	30	149	0	75	60	45	2,9	1,4	0,321	17
8	Africa	Chad	0,45	1344	50	1746	1,7	6,1	-2	42	175	0	50	8,3	34	4,1	1,3	0,316	12
9	Africa	Egypt	0,3	4710	73	6117	3,1	2,8	-3	1,1	26		99	78	97	9,9	8,3	0,633	95
10	Africa	Ethiopia	0,3	693	59	900	2,7	4,4	1	23	90	6400000	42	72	52	3,6	2	0,348	18
11	Africa	Ethiopia	0,3	693	59	900	2,7	4,4	1	23	90	6400000	42	72	52	3,6	2	0,348	18
12	Africa	Kenya	0,5	368,1	57	1496	2,1	4,7	7	25	84,7	1400004	57	70	83	9,5	9	0,493	32
13	Africa	Kenya	0,5	368,1	57	1496	2,1	4,7	7	25	84,7	1400004	57	70	83	9,5	9	0,496	32
14	Africa	Kenya	0,5	368,1	57	1496	2,1	4,7	7	25	84,7	1400004	57	70	83	9,5	9	0,493	32
15	Africa	Kenya	0,5	368,1	57	1496	2,1	4,7	7	25	84,7	1400004	57	70	83	9,5	9	0,493	33
16	Africa	Kenya	0,5	368,1	57	1496	2,1	4,7	7	25	84,7	1400004	57	70	83	9,5	9	0,493	34
17	Africa	Mozambique	0,4	402	50	1000	2,7	4,8	5	14	83	500000	47	28	59	4,5	2,7	0,304	17
18	Africa	Rwanda	0,4	957,6	55	1124	4	5,3	-3	22	72	0	66	380	70	5,5	4,6	0,411	55
19	Africa	Tanzania	0,4	330,33	56	1180	2,6	5,6	-1	11	65	0	53	47	90	6,7	6,3	0,448	10
20	Africa	Uganda	0,4	274,89	52	1173	2,5	6,3	-1	20	99	750000	69	130	58	7,1	5,4	0,43	34
21	Africa	Tanzania	0,4	330,33	56	1180	2,6	5,6	-1	11	73	0	53	47	90	6,7	6,3	0,448	10
22	Asia	Cambodia	0,3	454,3	63	1950	2,1	2,5	2	5,9	49		60	78	87	6,2	4,6	0,513	31
23	Africa	Ethiopia	0,3	177,1	59	900	2,7	4,4	1	23	65	6400000	42	72	52	3,6	2	0,348	18
24	Asia	Philippines	0,4	1088,01	68	3441	2,4	3,2	8	2,2	68	0	92	311	92	9,8	11	0,636	74
25	Asia	Bangladesh	0,3	429,66	69	1596	2,4	2,3	5	5,4	20	0	81	1010	48	5,7	4,4	0,491	54
26	Asia	Philippines	0,4	1088,01	68	3441	2,4	3,2	8	2,2	68	0	92	311	92	9,8	11	0,636	74
27	Asia	Philippines	0,4	1088,01	68	3441	2,4	3,2	8	2,2	68	0	92	311	92	9,8	11	0,636	74
28	Asia	Bangladesh	0,3	429,66	69	1596	2,4	2,3	5	5,4	20	0	81	1010	48	5,7	4,4	0,491	54
29	Europe	Armenia	0,4	1170,4	74	5347	2,6	1,7	5	0,38	18	0	97	103	92	12	12	0,712	90
30	Asia	Philippines	0,4	1088,01	68	3441	2,4	3,2	8	2,2	68	0	92	311	92	9,8	11	0,636	74
31	Asia	India	0,3	645,26	65	3163	3,3	2,7	9	7,6	31	0	90	362	96	8	5,4	0,527	32
32	Asia	India	0,3	645,26	65	3163	3,3	2,7	9	7,6	31	0	90	362	96	8	5,4	0,527	32
33	Africa	Mali	0,3	209,44	51	1117	2,7	6,4	7	34	133	0	60	12	51	2,6	1,3	0,346	21
34	Africa	Uganda	0,4	274,89	52	1173	2,5	6,3	-1	20	99	750000	69	130	58	7,1	5,4	0,43	34

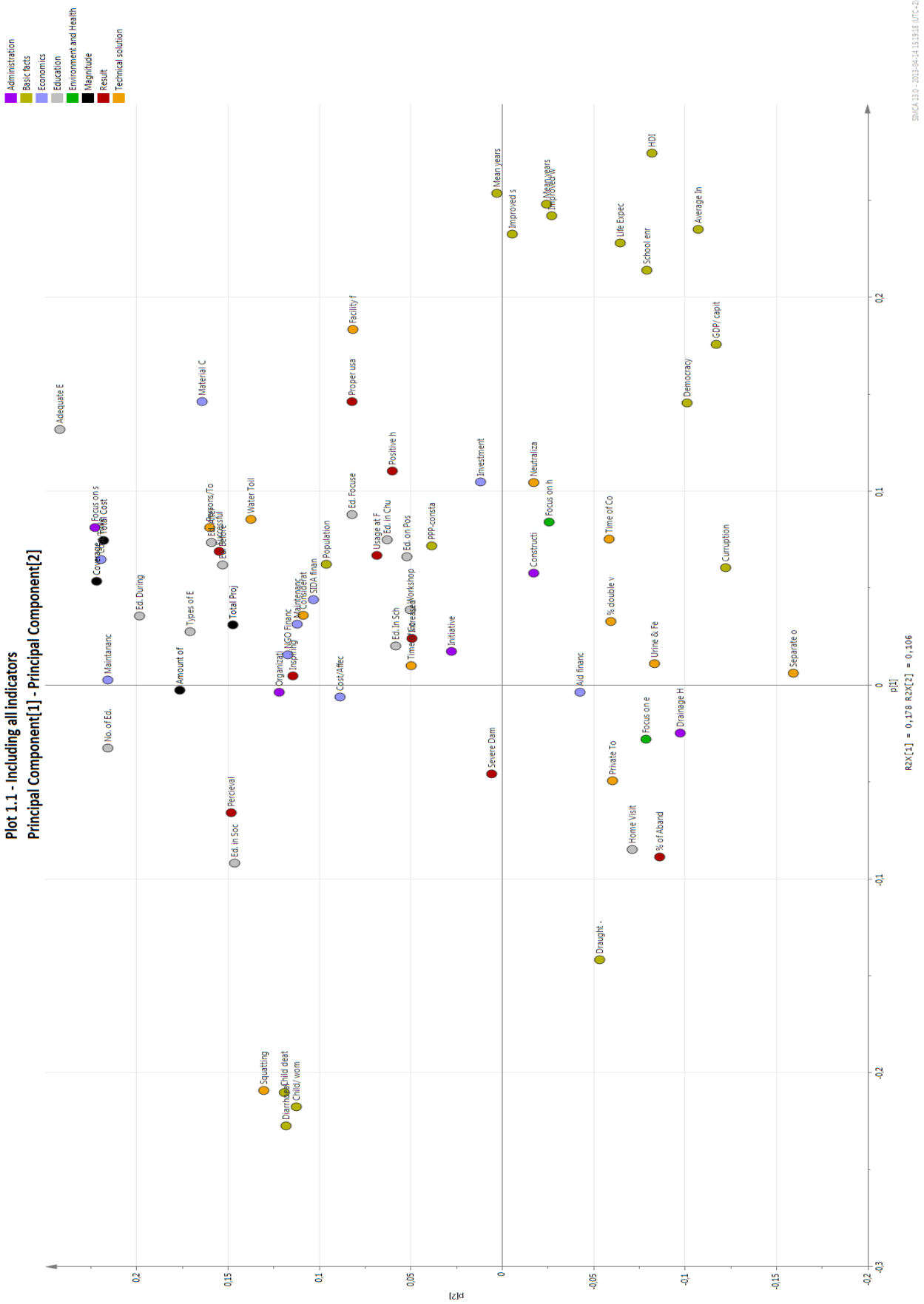
			Magnitude					Economics														
Project	Continent	Country	Total Project Time	Amount of Toilets	Coverage	Total Cost	Total Cost, PPP	Cost/Toilet	Cost/Toilet, PPP	Cost/Affected Person	Cost/Affected Person, PPP	Material Cost/Toilet	Material Cost/Toilet, PPP	Maintenance Cost/Toilet	Maintenance Cost/Toilet, PPP	Maintanance Cost	Maintanance Cost, PPP	Investment Cost/Toilet	Investment Cost/Toilet, PPP	Aid Financed	SIDA Financed	NGO Financed
			Month			EUR	PPP-dollar	EUR	PPP	EUR	PPP	EUR	PPP	EUR/month	PPP/Month	EUR/month	PPP/month	EUR	PPP	%	%	%
1	South America	Peru	21	2	53	5000	3246,8	455	295	94,3	61,23	455	295,5	0	0,0	0	0,0	0	0,0	100	0	0
2	Africa	Ethiopia	41	9	33	347	135,2	38,6	15	10,5	4,09	33,41	13,0					0	0,0	100	0	0
3	Africa	Tanzania	25	8	36	3300	1285,7	316,6	123	92	47,79	273,3	142,0	4,875	2,5	39	20,3	0	0,0	100	0	0
4	Africa	Namibia	1	21	140	17000	15454,5	776	705	15	13,64	554	503,6	0	0,0	0	0,0	315	286,4	98	0	0
5	South America	Bolivia	60	897	4500	13300000	6909090,9	1450	753	289	150,13	713	370,4	0,58	0,3			163	84,7	88	88	0
6	Africa	Botswana	42	42	252			156	81	26	13,51	93	48,3	2,33	1,2						0	0
7	Africa	Burkina Faso	43	933	7000	1497120	777724,6	1604,6	834	213,9	111,12			0,24	0,1	220	114,3	70	36,4	71	13,8	0
8	Africa	Chad	16	102	500	36000	21039,0	360	210	72	42,08	35	20,5	0	0,0	0	0,0	35	20,5	90	0	90
9	Africa	Egypt	84	400	2750	300000	116883,1	715	279	110	42,86	600	233,8	3	1,2	214	83,4	100	39,0	90	0	90
10	Africa	Ethiopia	25	30	400	21600	8415,6	720	281	54	21,04	179	69,7	1,7	0,7	50,3	19,6				0	90
11	Africa	Ethiopia	30	30	177	2600	1013,0	87	34	15	5,84	87	33,9	0	0,0	0	0,0	65	25,3	25	0	25
12	Africa	Kenya	48	984	20000	600000	389610,4	610	396	30	19,48	522	339,0	0	0,0	0	0,0	390	253,2	25	40	25
13	Africa	Kenya	36	5	300	40000	25974,0	8000	5195	133	86,36	7500	4870,1	424	275,3	16	10,4	0	0,0	100	30	100
14	Africa	Kenya	43	263	35000	137286	89146,8	522	339	3,9	2,53	394	255,8	0,1	0,1	0,5	0,3	100	64,9	90	30	0
15	Africa	Kenya	30	21	223	8473	5501,9	403	262	38	24,68	243,7	158,2	1,1	0,7	2	1,3	211,8	137,5	90	0	0
16	Africa	Kenya	30	4	75	2000	1298,7	500	325	26,7	17,34	375	243,5	3,3	2,1	13,2	8,6	0	0,0	100	0	0
17	Africa	Mozambique	8	585	4000	315210	163745,5	538,82	280	78,8	40,94	458	237,9					0	0,0	100	0	0
18	Africa	Rwanda	7	24	2800	19200	9974,0	500	260	6,86	3,56	500	259,7					0	0,0	100	0	0
19	Africa	Tanzania	21	4	56	1753	910,6	438,25	228	31,3	16,26	410	213,0							100	0	100
20	Africa	Uganda	48	47	400	70000	36363,6	1489,36	774	175	90,91	333	173,0	0,89	0,5	41,7	21,7	0	0,0	100	0	100
21	Africa	Tanzania	49	8	36	3300	1714,3	412,5	214	91,7	47,64	150	77,9	2	1,0	16	8,3	0	0,0	100		
22	Asia	Cambodia	10	14				30,8	12			26,95	10,5					0	0,0	100	0	100
23	Africa	Ethiopia	2	1	10	325	126,6	325	127	32,5	12,66	171	66,6	0	0,0	0	0,0	0	0,0	100	0	0
24	Asia	Philippines	10	3	28													0	0,0			
25	Asia	Bangladesh	48	16	1800	5120,5	1995,0	320	125	3	1,17			2,17	0,8	34,65	13,5	0	0,0	100	0	100
26	Asia	Philippines										410	213,0	0	0,0	0	0,0				0	
27	Asia	Philippines	8	40	220	10000	5194,8	272	141	46	23,90	280	145,5	0,42	0,2	0,5	0,3	0	0,0	40	0	0
28	Asia	Bangladesh	19	100	6360	44593	17373,9	445,9	174	7,01	2,73	294,4	114,7	0	0,0	0	0,0	0	0,0	100	0	100
29	Europe	Armenia	8	10	376	28740	14929,9	287,4	149	76,4	39,69	2011,8	1045,1					862,2	447,9	70	0	0
30	Asia	Philippines	19	23	1000	9000	4675,3	391,3	203	9	4,68	300	155,8					0	0,0	100	0	100
31	Asia	India	30	21	630	16500	6428,6	785,7142857	306	26,19047619	10,20			0	0,0	0	0,0	0	0,0	100	0	0
32	Asia	India	24	9	100	2650	1032,5	294,4444444	115	26,5	10,32			0	0,0	0	0,0	0	0,0	100	0	0
33	Africa	Mali	18	11	25	3850	1500,0	350	136	154	60,00	350	136,4	0	0,0	0	0,0	0	0,0	100	0	0
34	Africa	Uganda	18	10	165	20000	10389,6	2000	1039	121,2121212	62,97			4,16667	2,16450	41,66667	21,6	0	0,0	100	0	0

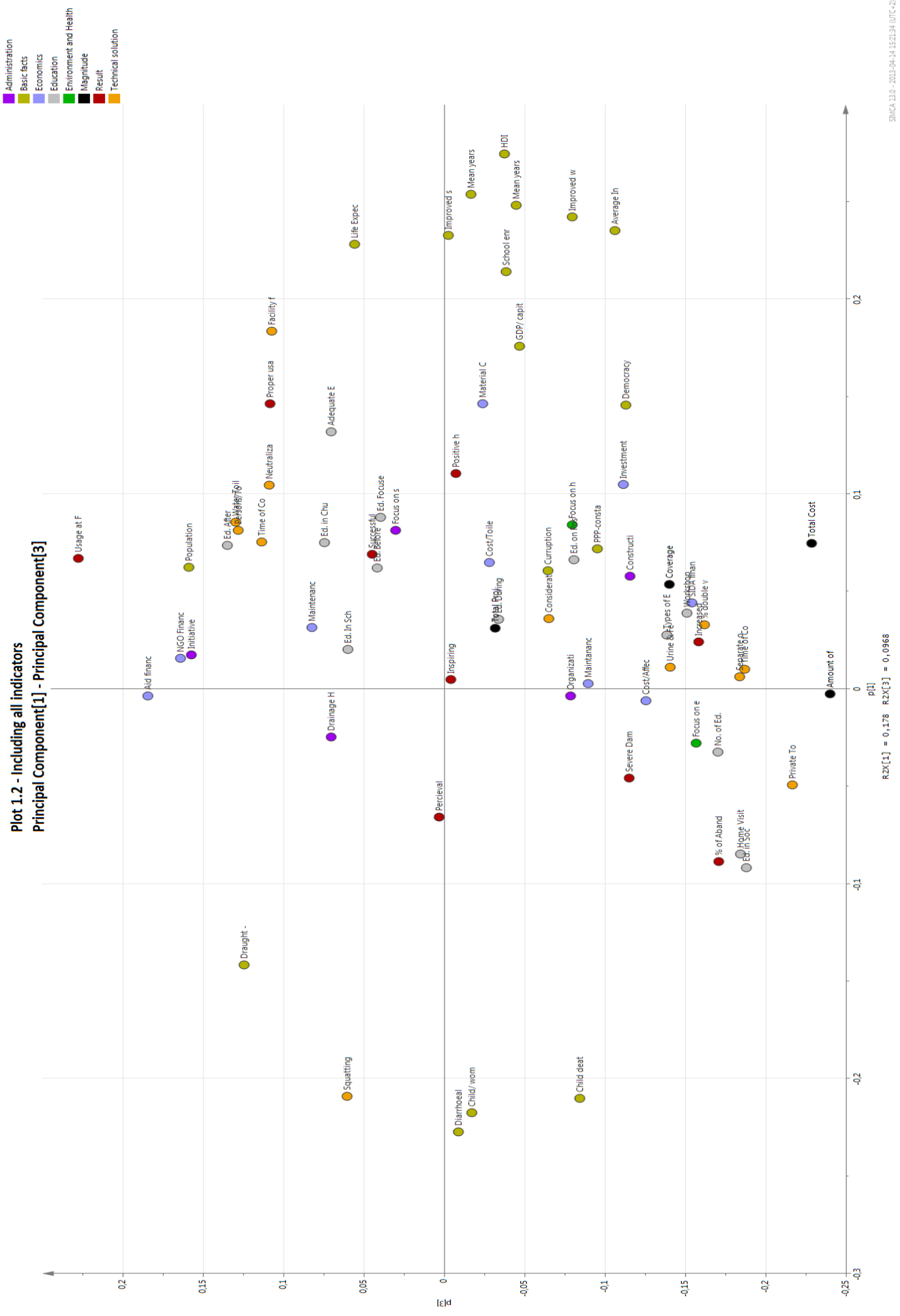
			Administration					Education													
Project	Continent	Country	Organizations Invovled	Initiative from Residents	Construction by residents	Drainage Handled Internally	Focus on socio-cultural & institutional	Types of Ed.	No. of Ed. Sessions	Ed. Before	Ed. During	Ed. After	Adequate Ed.	Home Visits	Workshop	Ed. In School	Ed. in Church	Ed. in Social media	Ed. on Posters	Ed. Focuses On Children
				Yes/No	Yes/No	Yes/No	-1,0,1						Scale 1-5 (1=really bad, 5=really good)	Yes/No	Yes/No	Yes/No	Yes/No	Yes/No	Yes/No	Yes/No
1	South America	Peru	0	1	1	1	0	1	1	0	0	1	2	0	0	1	0	0	0	1
2	Africa	Ethiopia	4	0	1	1	0	0	0	0	0	0	2	0	0	0	0	0	0	0
3	Africa	Tanzania	2	0	0	1	0	1	1	0	0	1	2	1	0	1	0	0	0	0
4	Africa	Namibia	2	0	0	1	0	0	0	0	0	0	2	0	0	0	0	0	0	0
5	South America	Bolivia	3	0	1	1	1	1	1	0	1	0	4	0	0	0	0	0	1	0
6	Africa	Botswana	7	0	1	1	-1	4		1	1	0	3	1	1	0	0	0	0	0
7	Africa	Burkina Faso	6	0	1	0	1	10	100	0	1	1	5	1	1	0	0	1	1	0
8	Africa	Chad	2	0	1	1	0	1	1	1	1	0	2	1	0	0	0	0	0	0
9	Africa	Egypt	7	0	1	1	1	5	2	1	1	1	5	0	0	1	1	0	0	1
10	Africa	Ethiopia	5	1	0	1	1	1	1	1	1	1	4	0	0	1	0	0	0	0
11	Africa	Ethiopia	7	0	0	1	0	0	0	0	0	0	2	1	1	1	0	0	0	1
12	Africa	Kenya	9	0	1	1	1	4		1	1	0	4	1	1	1	0	0	0	1
13	Africa	Kenya	6	0	0	1	1	1	2	1	1	1	5	0	0	0	0	0	0	0
14	Africa	Kenya	7	0	0	1	0	2	2	0	1	1	3	0	1	1	0	0	0	1
15	Africa	Kenya	3	0	0	0	0	2	3	0	1	1	3	0	1	1	0	0	0	1
16	Africa	Kenya	3	0	1	1	0	1	2	1	1	1	4	0	1	1	1	0	0	1
17	Africa	Mozambique	3	0	1	1	1	6		1	1		2	0	1	1	0	1	0	0
18	Africa	Rwanda	5	0	0	1	0	5			1	1	3	0	0	1	0	0	1	1
19	Africa	Tanzania	4	0	0	1	1						2	0	0	1	0	0	0	0
20	Africa	Uganda	4	1	0	1	0,67	2		1	1	1	5	0	0	1	0	0	0	1
21	Africa	Tanzania	3	0	1	1	0	2		0	1	1	3	1	1	0	0	0	1	0
22	Asia	Cambodia	8	0	0	1		2		0	1	0	4	0	0	1	0	0	1	0
23	Africa	Ethiopia	1	1	1	1	0	5	1	0	1	0	4	1	0	0	0	0	0	0
24	Asia	Philippines	2	0	1	1		4	1	0	1	1	4	1	1	0	0	0	1	0
25	Asia	Bangladesh	4	1	1	1	1	3	10	1	1	1	5	0	1	0	0	0	0	0
26	Asia	Philippines	6	0		1	1													
27	Asia	Philippines	3	0	1	1	1	3		1	1	0	3	1	1	0	0	0	0	0
28	Asia	Bangladesh	3	0	1	0	0,5	2	6	0	0	1	3	0	1	0	0	0	0	0
29	Europe	Armenia	5	0	0	0	0	6	20	1	1	1	5	0	1	1	0	0	1	1
30	Asia	Philippines	2	1	1	1	1	4	10	1	1	1	4	0	1	1	0	0	1	1
31	Asia	India	5	0		1	1				1		4			1				
32	Asia	India	3	0		1	0													
33	Africa	Mali	5	0	0	1	-1						1							
34	Africa	Uganda	3	0	0	1	0						4	0	1	0	0			

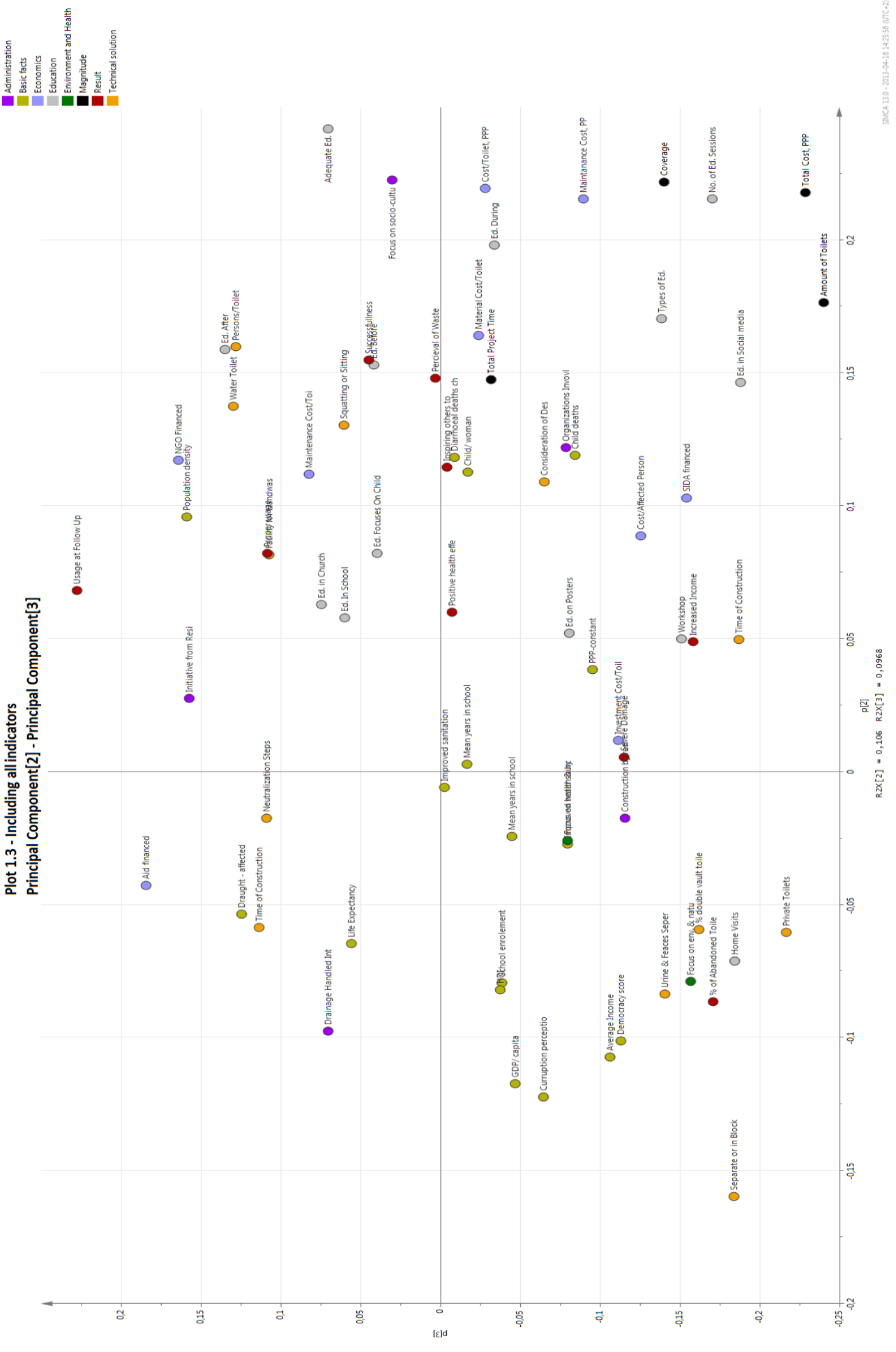
			Technical solution												Environment and Health	
Project	Continent	Country	Time of Construction	Time of Construction/ Toilet	Persons/ Toilet	% double vault toilets	Water Toilet	Private Toilets	Separate or in Blocks	Squatting or Sitting	Urine & Feaces Separation	Consideration of Design	Facility for Hand wash	Neutralization Steps	Focus on env. & natural resources	Focus on health & hygiene
			Month	Month		%	Yes/No	%	1=Seperate 0=Blocks	1=Squatting 0=Sitting	Yes/No	Yes/No	Yes/No		medelvärde av -1,0,1	-1,0,1
1	South America	Peru	16	0,5	3,8	100	0	0	1	0	1	1	1	3	1	1
2	Africa	Ethiopia			3,7	0	0	0	1	1	0	0	0	1	1	1
3	Africa	Tanzania	15	1,875	4,5	100	0	0	1	1	1	1	0	1	1	1
4	Africa	Namibia	1	0,05	6,7	0	0	0	1	0	1	1	1	2	1	0,5
5	South America	Bolivia	51	0,32	5	0	0	100	1	0	1	1	1	1	1	1
6	Africa	Botswana	38	0,9	6	100	0	100	1	0	1	1	0	1	1	1
7	Africa	Burkina Faso	18	0,02	7,5	100	0	98,8	1		1	1	0	1	1	0,25
8	Africa	Chad	16	0,25	5	0	0	100	1	1	0	1	0	1	0	1
9	Africa	Egypt	14	14	6,5	0	1	95	1		0	1	1	3	0	1
10	Africa	Ethiopia	12	0,4	13	100	0	0	0	1	1	1	1	1	1	0
11	Africa	Ethiopia	25	0,8	5,9	0	0	100	1	1	1	1	0	1	1	0
12	Africa	Kenya	14	1	22	100	0	75	1	1	1	1	1	1	1	1
13	Africa	Kenya	12	2,4	60	0	1	0	0	1	0	1	1	3	0	1
14	Africa	Kenya	34	0,13	133,1	100	0	0	0	1	1	0	1	1	1	0,33
15	Africa	Kenya	12	0,6	10,6	100	0	0	0	1	1	1	1	1	1	0,67
16	Africa	Kenya	3	0,6	18,8	33	0	0	0	1	1	1	1	1	1	0
17	Africa	Mozambique	8	0,014	6,80	100,00	0	98	1	1	1	1	0	1	1	1
18	Africa	Rwanda	3	0,125	117,0	0,0	0	0	0	1	1	0	1	1	1	-0,33
19	Africa	Tanzania	1	0,25	14	0	0	0	0	1	1			1	1	1
20	Africa	Uganda	12	0,255	8,5	0	0	0	0	1	1	0,5		1	1	1
21	Africa	Tanzania	15	1,875	4,75	100	0	100	1	0	1	0		1	1	1
22	Asia	Cambodia	6	0,43		0	0	100	1		1	0,5	1	1		
23	Africa	Ethiopia	1	1	10	100	0	100	1	1	1	0	0	2	0	0
24	Asia	Philippines	6	2	9,33	100	0	100	1	0	1	0	1	1		
25	Asia	Bangladesh	12	0,75	112,5	0	1	0	0	0	0	1	1	1	0	1
26	Asia	Philippines				100	0	0	1	0	1	0	1	2	1	1
27	Asia	Philippines	8	0,4	5,5	100	0	100	1	0	1	1	1	1	1	1
28	Asia	Bangladesh	12	0,12	63,6	100	0	100	1	1	1	1	0	1	0	1
29	Europe	Armenia	5	0,5	37,6	100	0	0	0	0	1	1	1	1	0,67	0,67
30	Asia	Philippines	6	0,26	43,5	100	0	56,5	1	0	1			1	1	0,67
31	Asia	India	11	0,523809524	30	100	0	0	0	1	1			1	0	0,67
32	Asia	India			11,1111	89	0	89	1	1	1	0		2	0,66	0,33
33	Africa	Mali	12	1,090909091	2,27273	100	0	100	0,5	1	1			1	1	0,666666667
34	Africa	Uganda	6	0,6	16,5	0	0	0	0	1	0,5	1	1	2	0,33	0,33

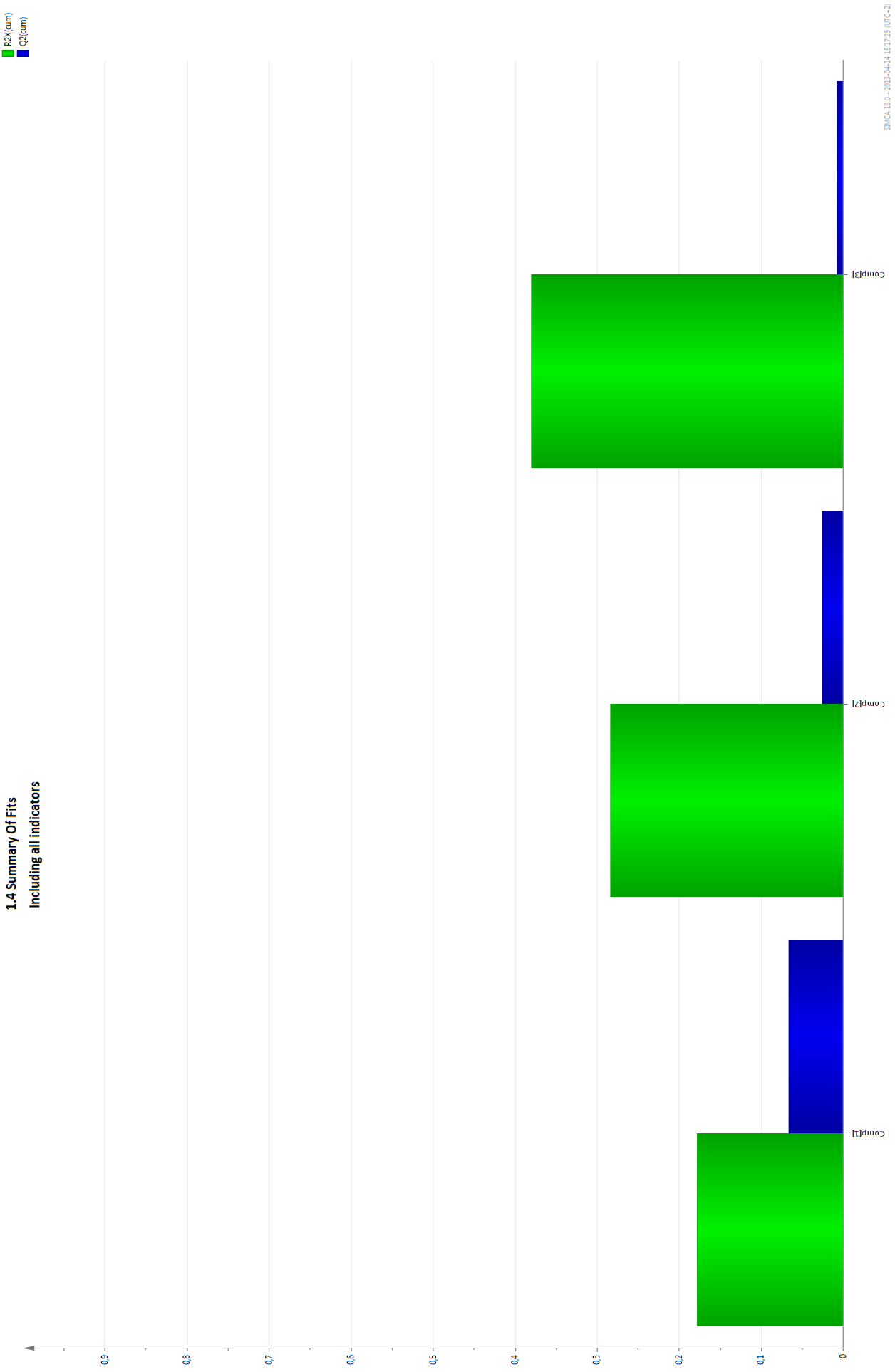
			Result								
Project	Continent	Country	Increased Income	Perception of Waste	Severe Damage	Positive health effects	% of Abandoned Toilets	Inspiring others to build	Usage at Follow Up	Proper usage	Successfulness
			Yes=1/No=-1	Scale -2-2 (-2=Really Dangerous 2= Totally Safe)	Yes=1 /No=-1	Yes=1 /No=-1	%	Yes=1/No=-1	%	%	Scale -40 - 80
1	South America	Peru	1	0	-1		0	-1	100	80	28,0
2	Africa	Ethiopia	-1	-1	-1	1	0	-1	100	70	12,0
3	Africa	Tanzania	1	0	-1		0	1	100	80	48,0
4	Africa	Namibia	-1	-1	-1		0	-1	100	100	5,0
5	South America	Bolivia		1	-1	1	30	-1	70	100	29,0
6	Africa	Botswana		0	-1	1	40	1	60	80	40,0
7	Africa	Burkina Faso	1	2	-1	1	4,2	1	95,8	95	68,7
8	Africa	Chad	-1	2		1					10,0
9	Africa	Egypt	-1	0	-1	1	0	1	99	80	37,9
10	Africa	Ethiopia	-1	2	-1	-1			100	80	18,0
11	Africa	Ethiopia	-1	2						70	7,0
12	Africa	Kenya	1	2				1			30,0
13	Africa	Kenya	1	0	1		0	1	100	90	29,0
14	Africa	Kenya	-1	0	1		30	-1	23	60	-24,7
15	Africa	Kenya	-1	-1	-1		0		90	90	13,0
16	Africa	Kenya	-1	1	-1	1	25		100	100	32,5
17	Africa	Mozambique		0	1		5	1	30	33	5,8
18	Africa	Rwanda		0	1		8,3	1	90		8,2
19	Africa	Tanzania		1	-1		0	1		75	32,5
20	Africa	Uganda		2	-1	1	0	1	100	100	60,0
21	Africa	Tanzania		2	-1		0	1	100		40,0
22	Asia	Cambodia		1	-1			1			25,0
23	Africa	Ethiopia	-1	1	-1		0	1	100	95	34,5
24	Asia	Philippines		0	1		1	1	50	80	12,9
25	Asia	Bangladesh	-1	2	-1	1	0	-1	100	90	29,0
26	Asia	Philippines	1	0		1					20,0
27	Asia	Philippines	-1	1	1			1			-5,0
28	Asia	Bangladesh	-1	-1,5	-1		6	-1	94	90	0,3
29	Europe	Armenia	-1	0,5	-1	1	0	1	100	100	42,5
30	Asia	Philippines	1	2	-1		0	1	100	100	60,0
31	Asia	India		2	-1		0		100	90	39,0
32	Asia	India		1	-1		0			80	23,0
33	Africa	Mali	1	1	1	-1	90,9	-1	32	32	-17,7
34	Africa	Uganda	-1	2	-1	1	0		100		30,0

Appendix 3
Loading scatter plots, summary of fit- and X/Y-overview diagrams




Plot 1.2 - Including all indicators
Principal Component[1] - Principal Component[3]
Administration
Basic facts
Economics
Education
Environment and Health
Magnitude
Result
Technical solution
Usage at F
Aid financ
Population
NGO Financ
Initiative
Draught -
Squatting
Drainage H
Maintenanc
Ed. In Sch
Ed. In Chu
Adequate E
Facility f
Proper usa
Neutraliza
Time of Co
Ed. After
Life Expec
Ed. Focuse
Focus on s
Percieval
Diarrhoeal
Child/ worm
Child deat
Severe Dam
Inspiring
Positive h
Material C
Cost/Toile
Total Piping
Considerat
Curruption
Organizati
Maintananc
Cost/Affec
Focus on h
PPP-consta
Constructi
Investment
Democracy
Improved s
Mean years
HDI
Mean years
School enr
GDP/ capit
Improved w
Average In
Total Cost
Amount of
Private To
Focus on e
No. of Edi.
% of Aband
Home Visit
Coverage
Increased
% double v
Separate C
Time of Co
p[3]
p[1]
R2X[1] = 0,178 R2X[3] = 0,0968
SIMCA 13.0 - 2013-04-14 15:21:34 (UTC+2)


Plot 1.3 - Including all indicators
Principal Component[2] - Principal Component[3]
Administration
Basic facts
Economics
Education
Environment and Health
Magnitude
Result
Technical solution
p[3]
p[2]
R2X[2] = 0,106 R2X[3] = 0,0968
Usage at Follow Up
Aid financed
Initiative from Resi
Drainage Handled Int
Draught - affected
Time of Construction
Neutralization Steps
Life Expectancy
Population density
NGO Financed
Ed. In Church
Ed. In School
Maintenance Cost/Toi
Squatting or Sitting
Ed. Focuses On Child
Adequate Ed.
Focus on socio-cultu
Ed. After
Persons/Toilet
Water Toilet
Positive health effe
Improved sanitation
Mean years in school
Mean years in school
School enrolement
GDP/ capita
Curruption perceptio
Average Income
Democracy score
Urine & Feaces Seper
Focus on env. & patu
% double vault toile
% of Abandoned Toile
Home Visits
Separate or in Block
Private Toilets
Percieval of Waste
Child/ woman
Material Cost/Toilet
Total Project Time
Cost/Toilet, PPP
Ed. During
Consideration of Des
Organizations Invovl
Child deaths
Ed. on Posters
PPP-constant
Investment Cost/Toil
Construction
Cost/Affected Person
SIDA financed
Workshop
Increased Income
Time of Construction
Ed. in Social media
Maintanance Cost, PP
Types of Ed.
Coverage
No. of Ed. Sessions
Total Cost, PPP
Amount of Toilets


1.4 Summary Of Fits
Including all indicators
R2X(cum)
Q2(cum)
Comp[1]
Comp[2]
Comp[3]
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
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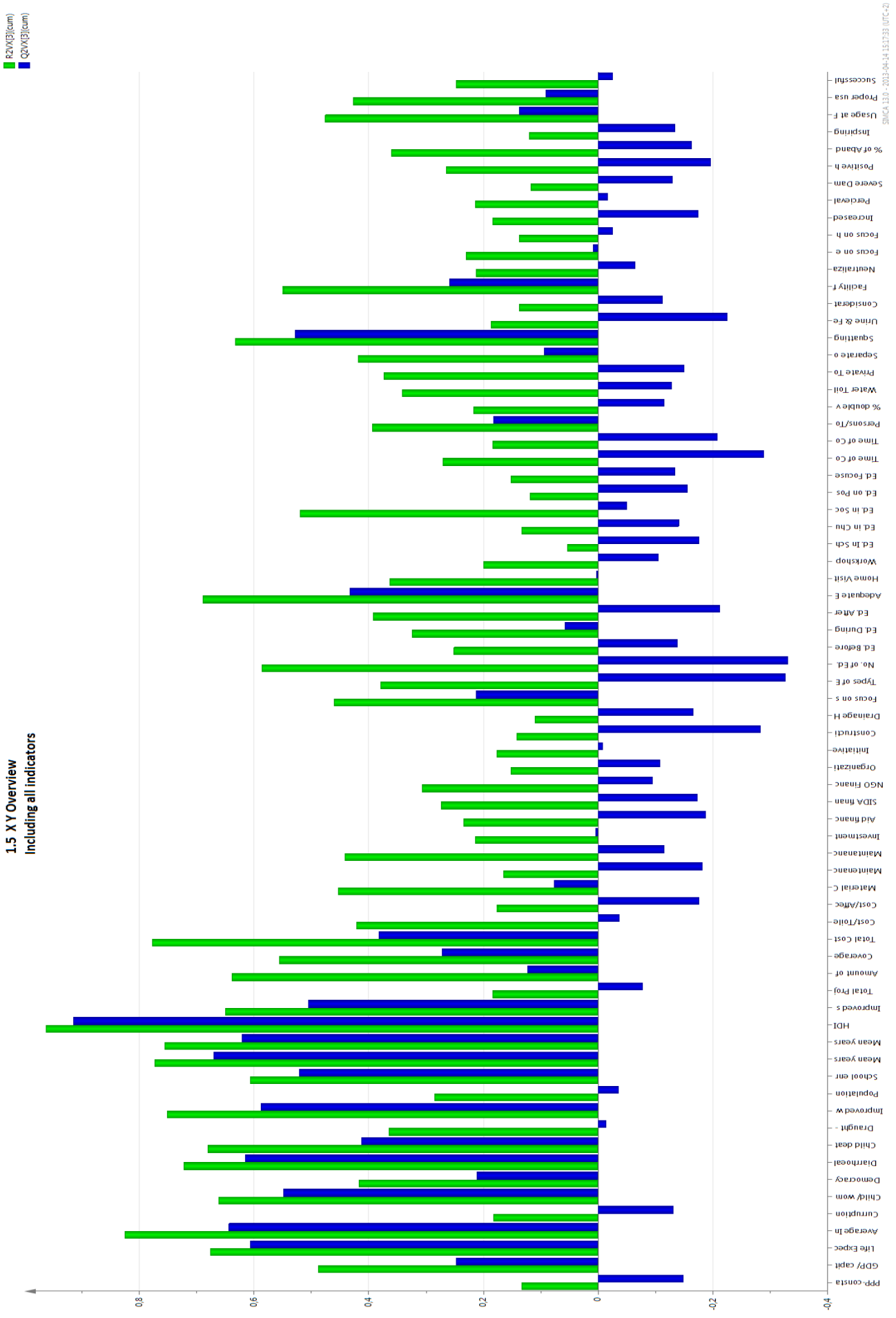
1.5 X Y Overview
Including all indicators
R2(V)[3](cum)
Q2(V)[3](cum)
SIMCA 13.0 - 2013-04-14 15:17:38 (UTC+2)
ppp-consta
GDP/ capit
Life Expec
Average In
Curruption
Child/ wom
Democracy
Diarrhoeal
Child deat
Draught -
Improved w
Population
School enr
Mean years
Mean years
HDI
Improved s
Total Proj
Amount of
Coverage
Total Cost
Cost/Toile
Cost/Affec
Material C
Maintenanc
Maintenanc
Investment
Aid financ
SIDA finan
NGO financ
Organizati
Initiative
Constructi
Drainage H
Focus on s
Types of E
No. of Ed.
Ed. Before
Ed. During
Ed. After
Adequate E
Home Visit
Workshop
Ed. In Sch
Ed. In Chu
Ed. In Soc
Ed. on Pos
Ed. Focuse
Time of Co
Time of Co
Persons/To
% double v
Water Toil
Private To
Separate o
Squatting
Urine & Fe
Considerat
Facility f
Neutraliza
Focus on e
Focus on h
Increased
Percieval
Severe Dam
Positive h
% of Aband
Inspiring
Usage at F
Proper usa
Successful
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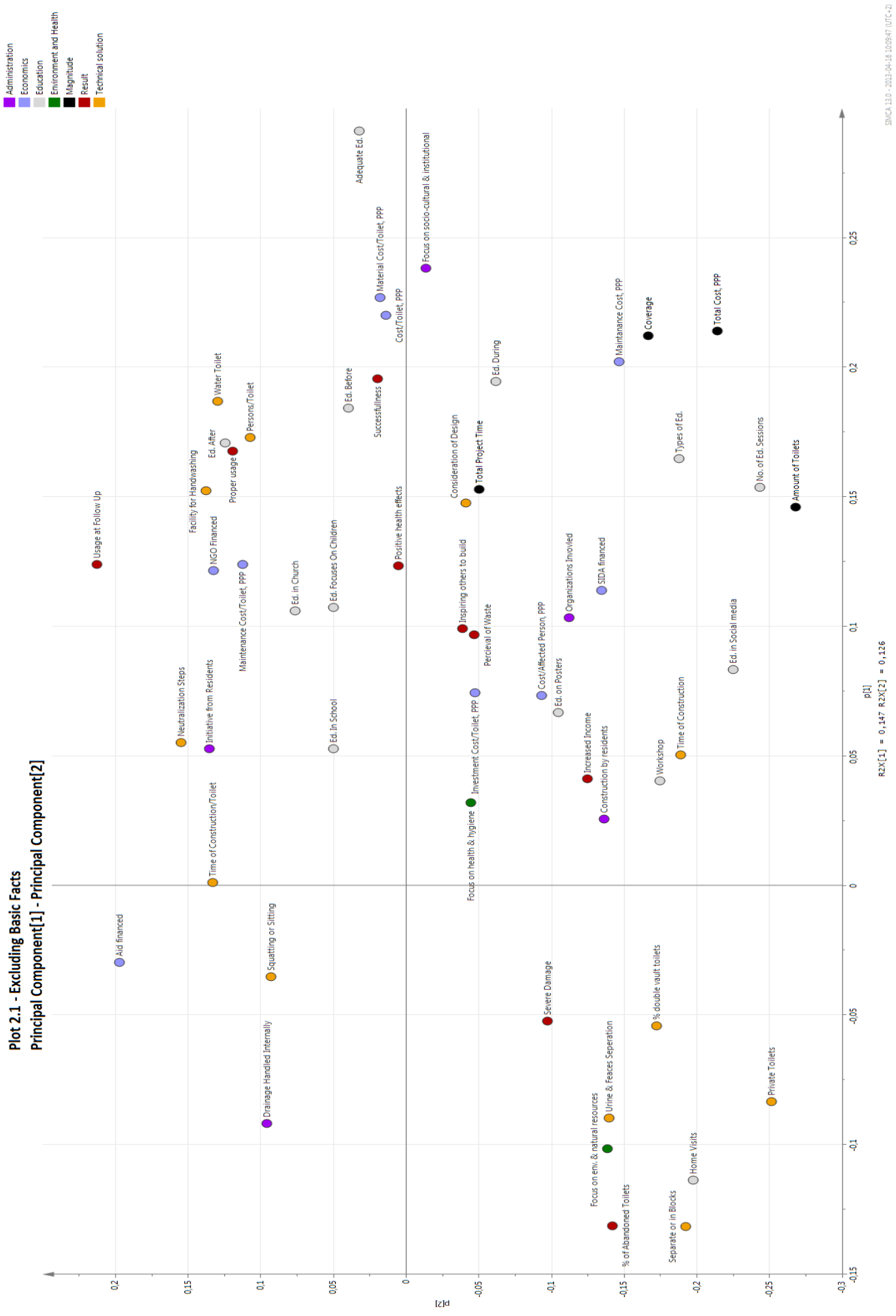
0.6
0.4
0.2
0
-0.2
-0.4


Plot 2.1 - Excluding Basic Facts
Principal Component[1] - Principal Component[2]
Administration
Economics
Education
Environment and Health
Magnitude
Result
Technical solution
Usage at Follow Up
Aid financed
Neutralization Steps
Initiative from Residents
Time of Construction/Toilet
Facility for Handwashing
NGO Financed
Maintenance Cost/Toilet, PPP
Squatting or Sitting
Drainage Handled Internally
Ed. After
Water Toilet
Proper usage
Persons/Toilet
Ed. in Church
Ed. Focuses On Children
Ed. In School
Ed. Before
Positive health effects
Successfullness
Adequate Ed.
Material Cost/Toilet, PPP
Cost/Toilet, PPP
Focus on socio-cultural & institutional
Consideration of Design
Total Project Time
Ed. During
Inspiring others to build
Percieval of Waste
Investment Cost/Toilet, PPP
Focus on health & hygiene
Organizations Involved
SIDA financed
Maintanance Cost, PPP
Coverage
Total Cost, PPP
Types of Ed.
No. of Ed. Sessions
Amount of Toilets
Cost/Affected Person, PPP
Ed. on Posters
Increased Income
Construction by residents
Workshop
Time of Construction
Ed. in Social media
Severe Damage
% double vault toilets
Focus on env. & natural resources
Urine & Feaces Seperation
% of Abandoned Toilets
Separate or in Blocks
Home Visits
Private Toilets
p[2]
p[1]
R2X[1] = 0,147 R2X[2] = 0,126
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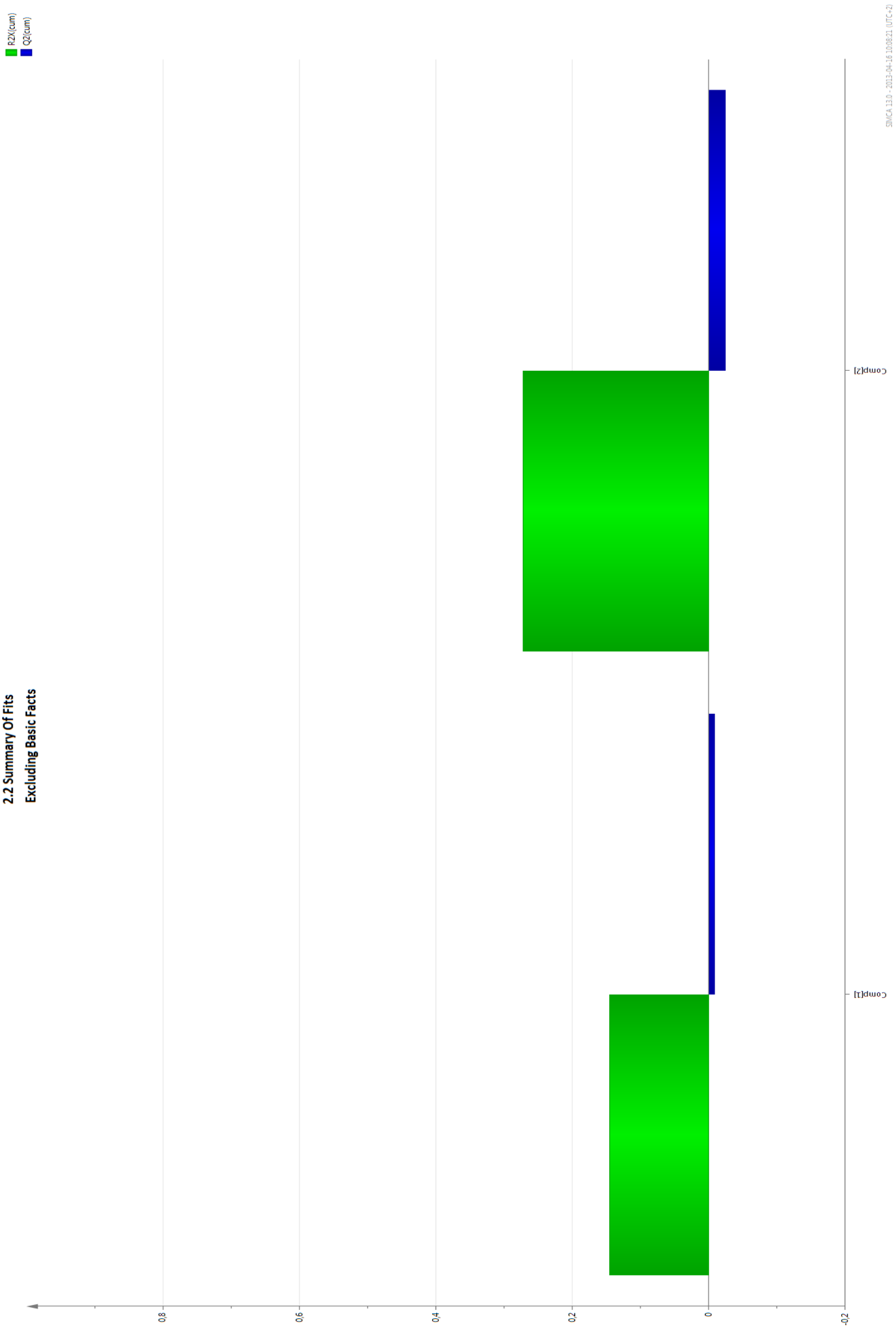
R2X(cum)
Q2(cum)
2.2 Summary Of Fits
Excluding Basic Facts
0.8
0.6
0.4
0.2
0
-0.2
Comp[1]
Comp[2]
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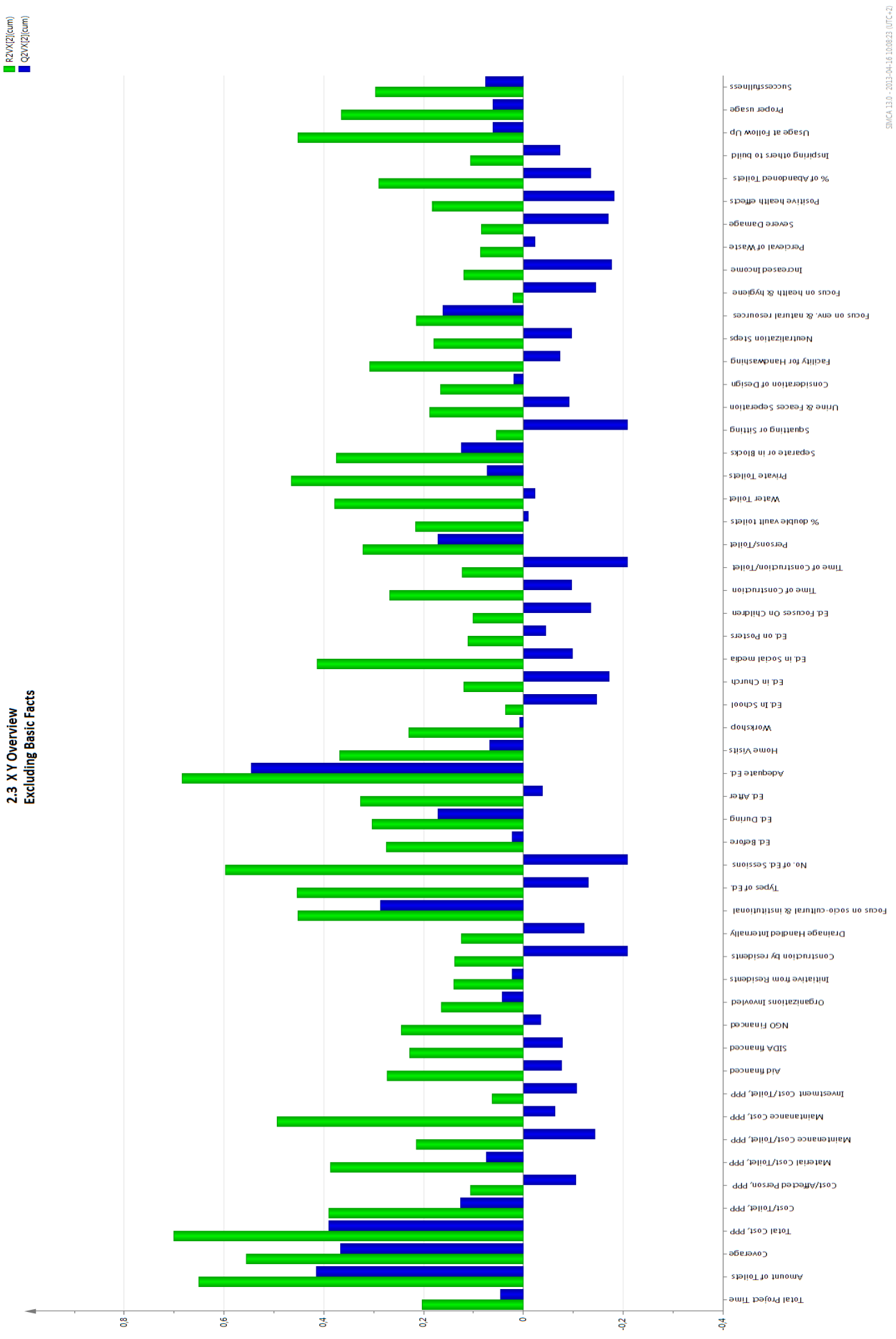
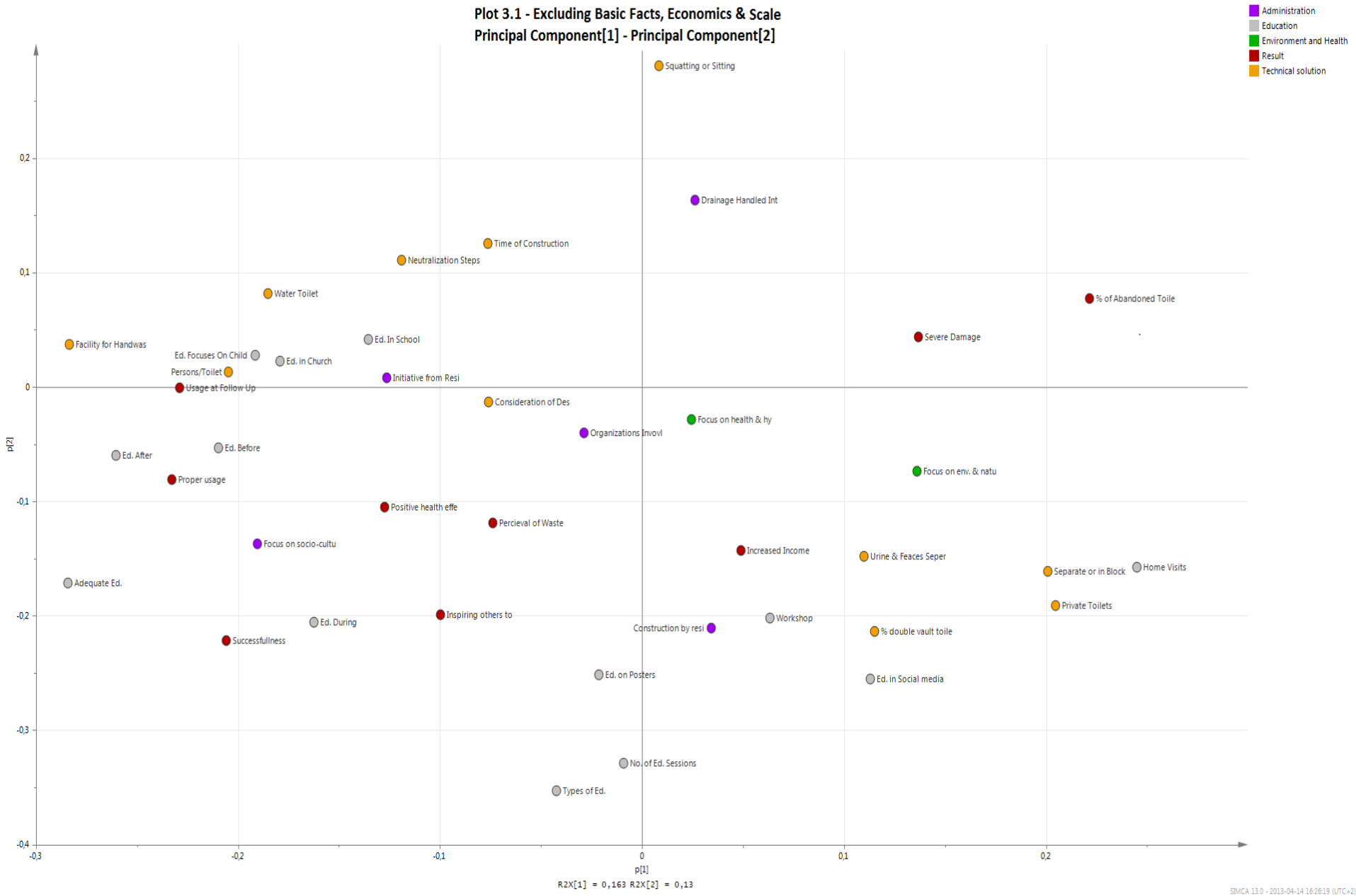

2.3 X Y Overview
Excluding Basic Facts
R2VX(2)(cum)
Q2VX(2)(cum)
Total Project Time
Amount of Toilets
Coverage
Total Cost, PPP
Cost/Toilet, PPP
Cost/Affected Person, PPP
Material Cost/Toilet, PPP
Maintenance Cost/Toilet, PPP
Maintenance Cost, PPP
Investment Cost/Toilet, PPP
Aid financed
SIDA financed
NGO Financed
Organizations Involved
Initiative from Residents
Construction by residents
Drainage Handled Internally
Focus on socio-cultural & institutional
Types of Ed.
No. of Ed. Sessions
Ed. Before
Ed. During
Ed. After
Adequate Ed.
Home Visits
Workshop
Ed. In School
Ed. In Church
Ed. in Social media
Ed. on Posters
Ed. focuses On Children
Time of Construction
Time of Construction/Toilet
Persons/Toilet
% double vault toilets
Water Toilet
Private Toilets
Separate or in Blocks
Squatting or Sitting
Urine & Feaces Seperation
Consideration of Design
Facility for Handwashing
Neutralization Steps
Focus on env. & natural resources
Focus on health & hygiene
Increased Income
Percieval of Waste
Severe Damage
Positive health effects
% of Abandoned Toilets
Inspiring others to build
Usage at Follow Up
Proper usage
Successfullness
0.8
0.6
0.4
0.2
0
-0.2
-0.4
SIMCA 13.0 - 2013-04-16 10:08:23 (UTC+2)


Plot 3.1 - Excluding Basic Facts, Economics & Scale
Principal Component[1] - Principal Component[2]
Administration
Education
Environment and Health
Result
Technical solution
Squatting or Sitting
Drainage Handled Int
Time of Construction
Neutralization Steps
Water Toilet
% of Abandoned Toile
Severe Damage
Facility for Handwas
Ed. In School
Ed. Focuses On Child
Ed. in Church
Persons/Toilet
Initiative from Resi
Usage at Follow Up
Consideration of Des
Focus on health & hy
Organizations Invovl
Ed. After
Ed. Before
Focus on env. & natu
Proper usage
Positive health effe
Percieval of Waste
Focus on socio-cultu
Increased Income
Urine & Feaces Seper
Separate or in Block
Home Visits
Adequate Ed.
Private Toilets
Ed. During
Inspiring others to
Workshop
Construction by resi
% double vault toile
Successfullness
Ed. on Posters
Ed. in Social media
No. of Ed. Sessions
Types of Ed.
p[2]
p[1]
0,2
0,1
0
-0,1
-0,2
-0,3
-0,4
-0,3
-0,2
-0,1
0
0,1
0,2
R2X[1] = 0,163 R2X[2] = 0,13
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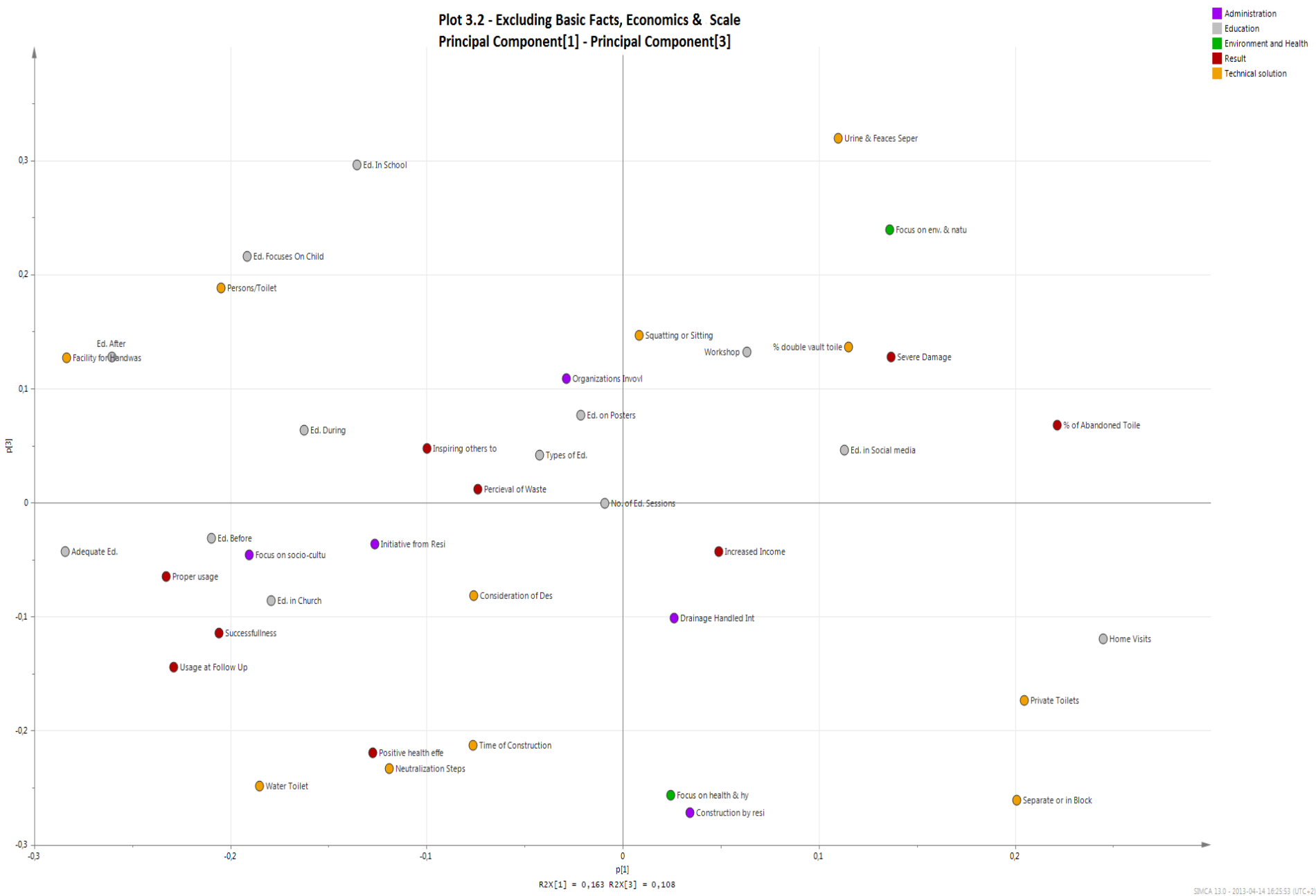
Plot 3.2 - Excluding Basic Facts, Economics & Scale
Principal Component[1] - Principal Component[3]
Administration
Education
Environment and Health
Result
Technical solution
Urine & Feaces Seper
Ed. In School
Focus on env. & natu
Ed. Focuses On Child
Persons/Toilet
Squatting or Sitting
Ed. After
Facility for Handwas
Workshop
% double vault toile
Severe Damage
Organizations Invovl
Ed. on Posters
% of Abandoned Toile
Ed. During
Inspiring others to
Types of Ed.
Ed. in Social media
Percieval of Waste
No. of Ed. Sessions
Ed. Before
Adequate Ed.
Initiative from Resi
Focus on socio-cultu
Increased Income
Proper usage
Consideration of Des
Ed. in Church
Drainage Handled Int
Home Visits
Successfullness
Usage at Follow Up
Private Toilets
Time of Construction
Positive health effe
Neutralization Steps
Water Toilet
Focus on health & hy
Separate or in Block
Construction by resi
p[3]
p[1]
0,3
0,2
0,1
0
-0,1
-0,2
-0,3
-0,3
-0,2
-0,1
0
0,1
0,2
R2X[1] = 0,163 R2X[3] = 0,108
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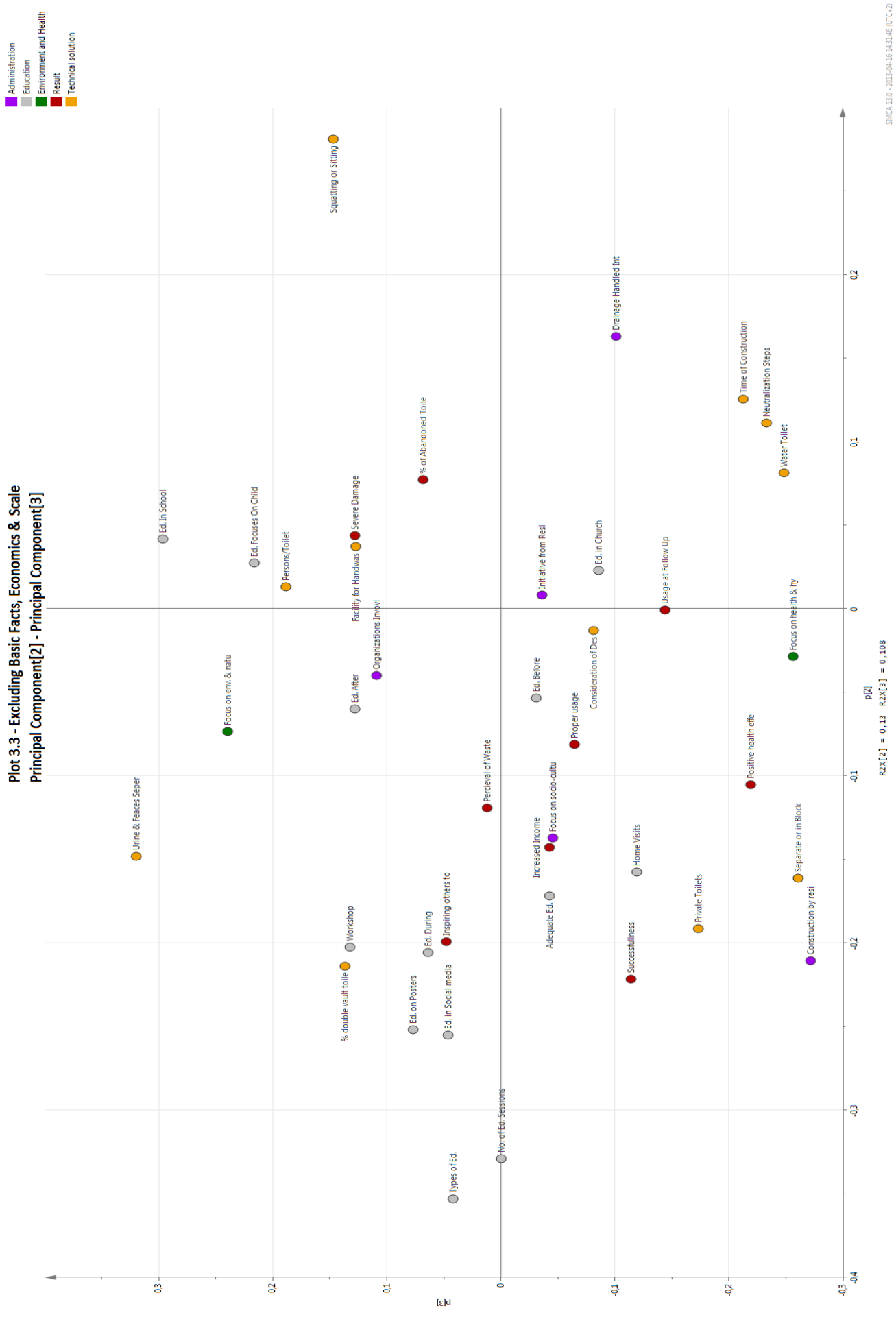
Plot 3.3 - Excluding Basic Facts, Economics & Scale
Principal Component[2] - Principal Component[3]
Administration
Education
Environment and Health
Result
Technical solution
Squatting or Sitting
Ed. In School
Ed. Focuses On Child
Persons/Toilet
Severe Damage
Facility for Handwas
% of Abandoned Toile
Focus on env. & natu
Ed. After
Organizations Involvl
Urine & Feaces Seper
% double vault toile
Workshop
Ed. on Posters
Ed. During
Ed. in Social media
Inspiring others to
Types of Ed.
No. of Ed. Sessions
Percieval of Waste
Ed. Before
Increased Income
Adequate Ed.
Focus on socio-cultu
Proper usage
Initiative from Resi
Ed. in Church
Consideration of Des
Drainage Handled Int
Usage at Follow Up
Home Visits
Successfullness
Private Toilets
Positive health effe
Time of Construction
Neutralization Steps
Water Toilet
Focus on health & hy
Separate or in Block
Construction by resi
p[3]
p[2]
R2X[2] = 0,13 R2X[3] = 0,108
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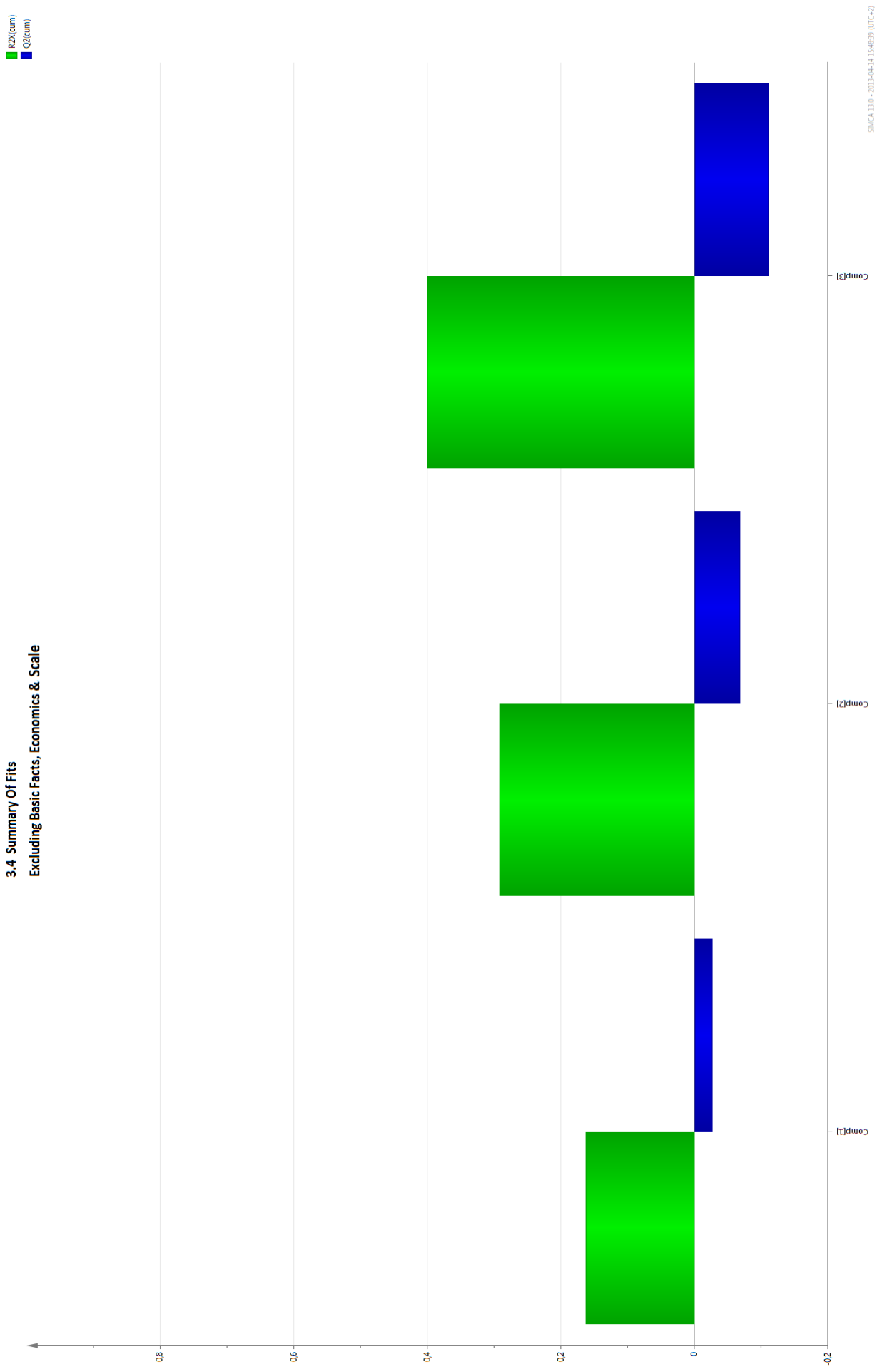
3.4 Summary Of Fits
Excluding Basic Facts, Economics & Scale
R2X(cum)
Q2(cum)
Comp[3]
Comp[2]
Comp[1]
0,8
0,6
0,4
0,2
0
-0,2
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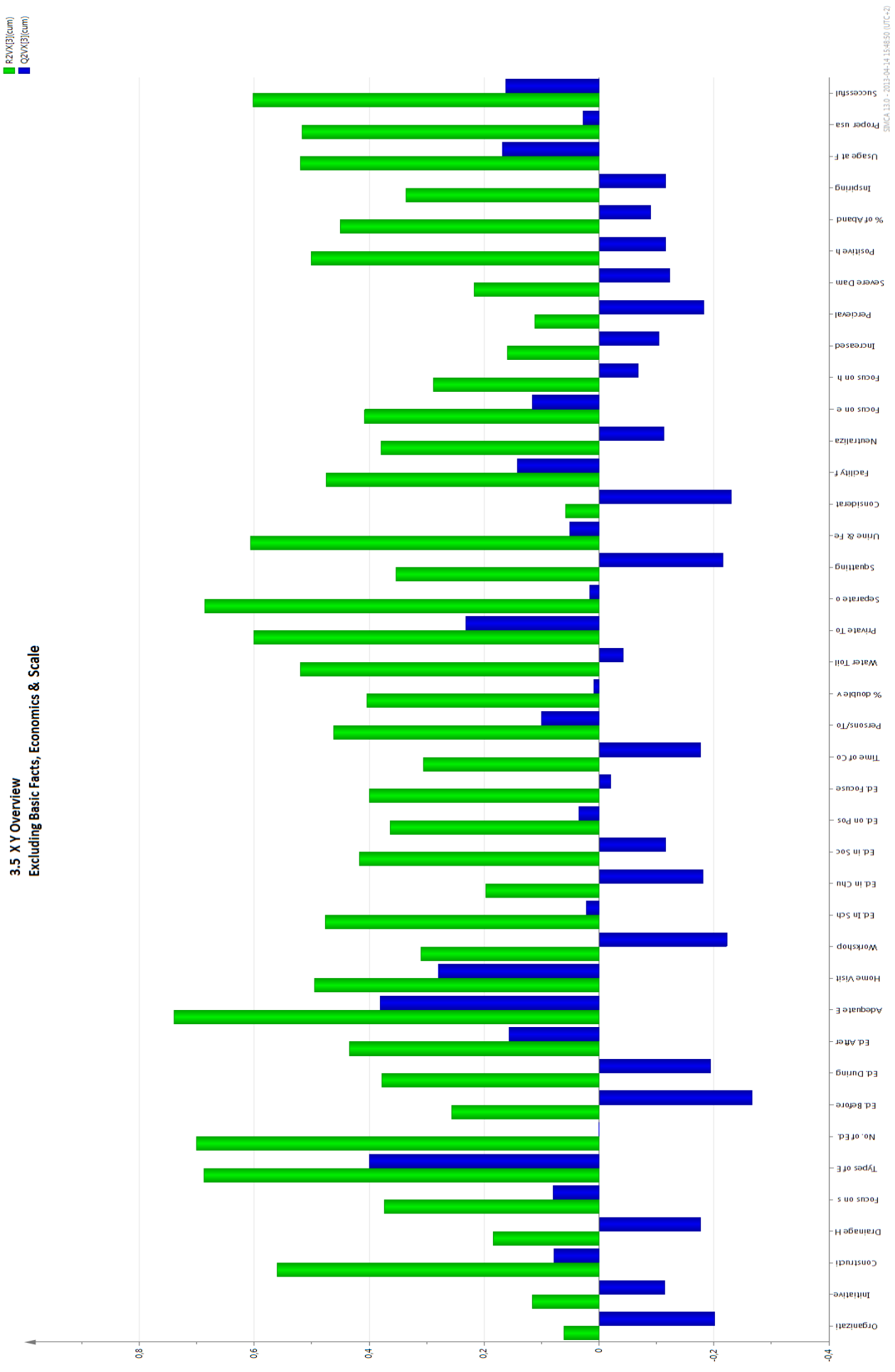
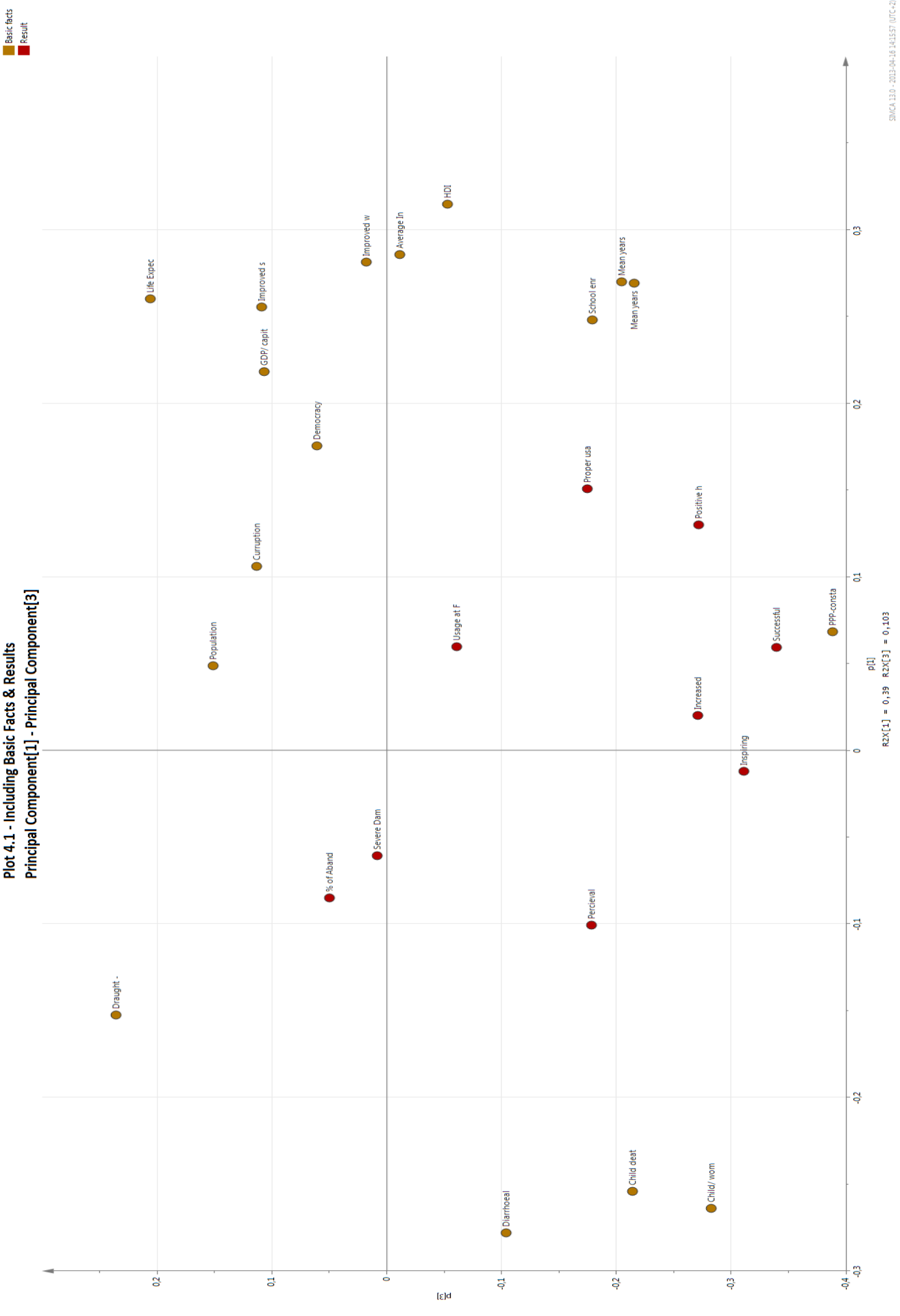
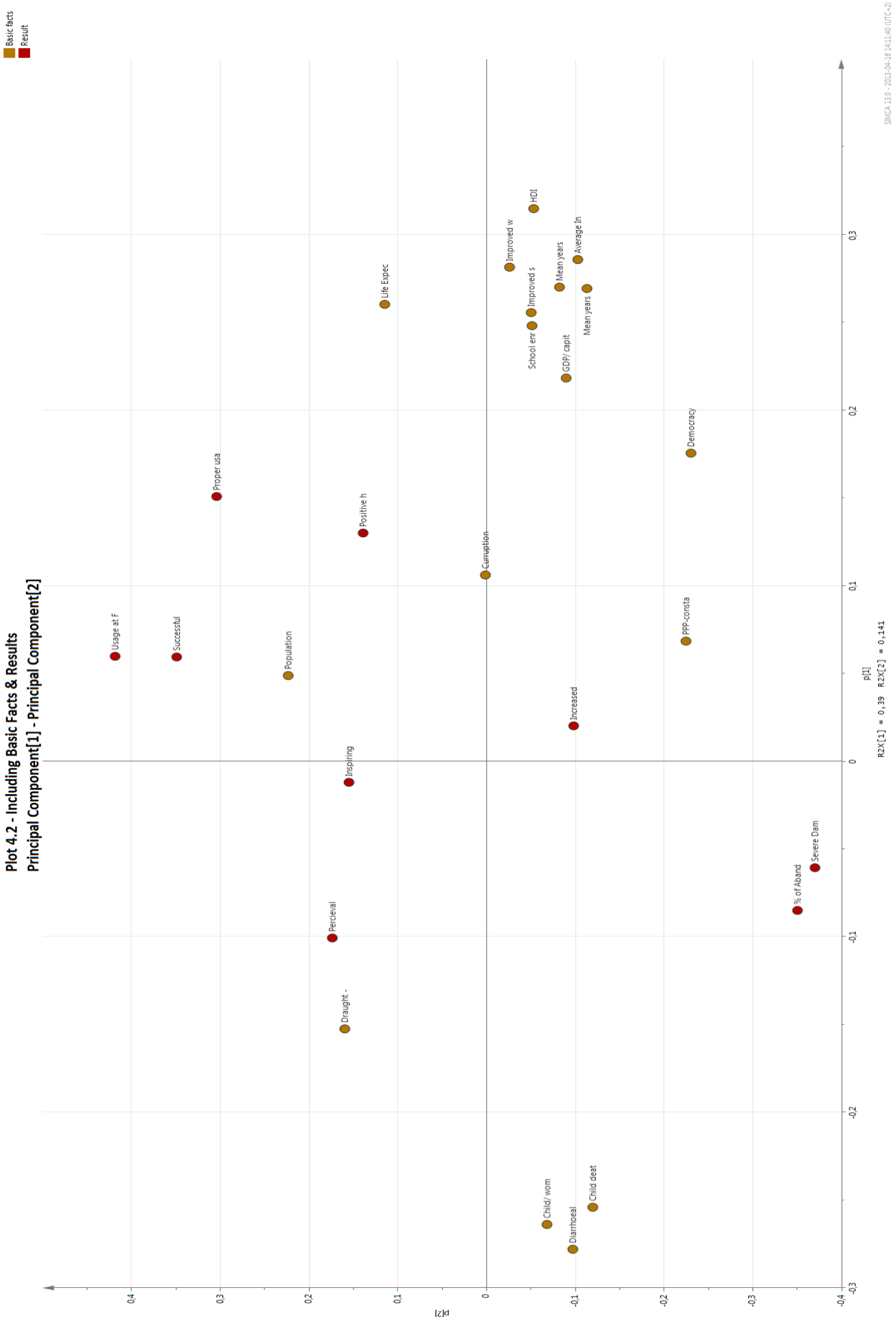

3.5 X Y Overview
Excluding Basic Facts, Economics & Scale
R2VX[3](cum)
Q2VX[3](cum)
SIMCA 13.0 - 2013-04-14 15:48:50 (UTC-2)
Organizati
Initiative
Constructi
Drainage H
Focus on s
Types of E
No. of Ed.
Ed. Before
Ed. During
Ed. After
Adequate E
Home Visit
Workshop
Ed. In Sch
Ed. In Chu
Ed. In Soc
Ed. on Pos
Ed. Focuse
Time of Co
Persons/To
% double v
Water Toil
Private To
Separate o
Squatting
Urine & Fe
Considerat
Facility f
Neutralize
Focus on e
Focus on h
Increased
Perceival
Severe Dam
Positive h
% of Aband
Inspiring
Usage at F
Proper usa
Successful
0,8
0,6
0,4
0,2
0
-0,2
-0,4


Plot 4.1 - Including Basic Facts & Results
Principal Component[1] - Principal Component[3]
Basic facts
Result
Life Expec
Improved s
GDP/ capit
Improved w
Average In
HDI
Democracy
School enr
Mean years
Mean years
Corruption
Proper usa
Positive h
Population
Usage at F
Successful
PPP-consta
Increased
Inspiring
Severe Dam
% of Aband
Percieval
Draught -
Child deat
Child/ wom
Diarrhoeal
p[1]
p[3]
R2X[1] = 0,39 R2X[3] = 0,103
SIMCA 13.0 - 2013-04-16 141557 (UTC+2)


Basic facts
Result
Plot 4.2 - Including Basic Facts & Results
Principal Component[1] - Principal Component[2]
Usage at F
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Proper usa
Population
Positive h
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Percieval
Draught -
Life Expec
Corruption
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School enr
Mean years
Average In
Mean years
GDP/ capit
Democracy
PPP-consta
Increased
Child/ wom
Diarrhoeal
Child deat
% of Aband
Severe Dam
p[2]
p[1]
R2X[1] = 0,39 R2X[2] = 0,141
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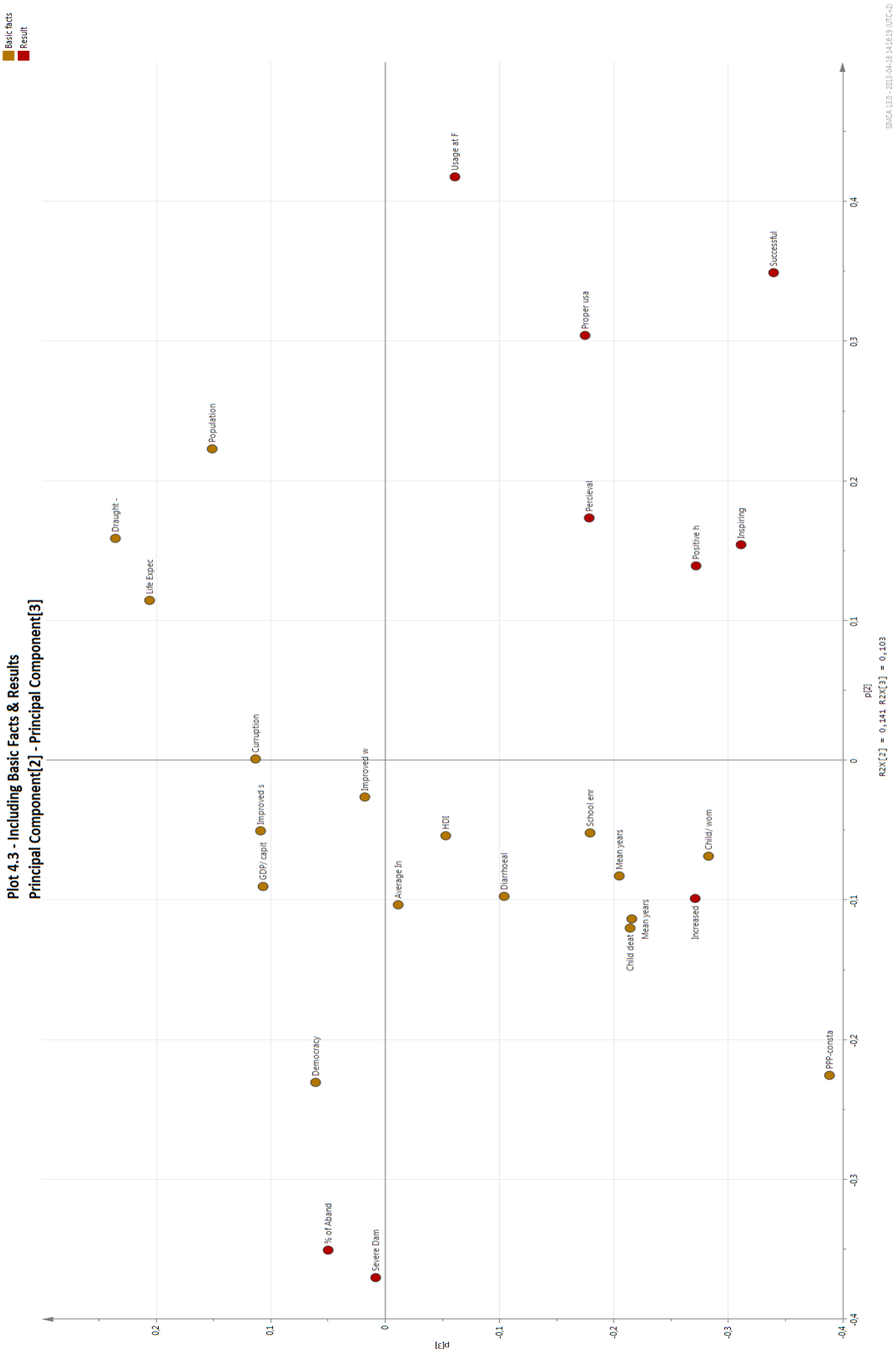
Basic facts
Result
Plot 4.3 - Including Basic Facts & Results
Principal Component[2] - Principal Component[3]
Draught -
Life Expec
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Curruption
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Usage at F
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Mean years
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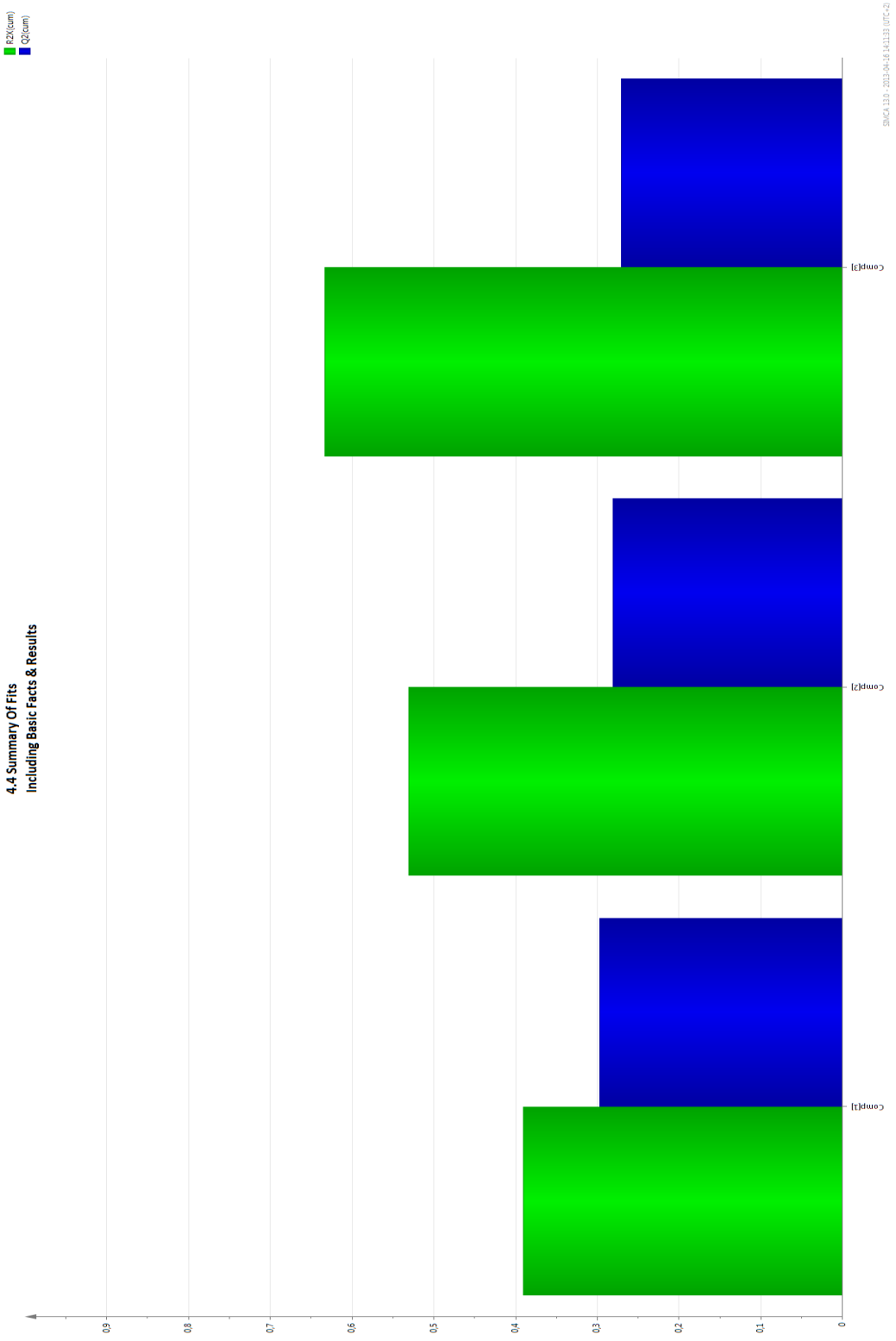
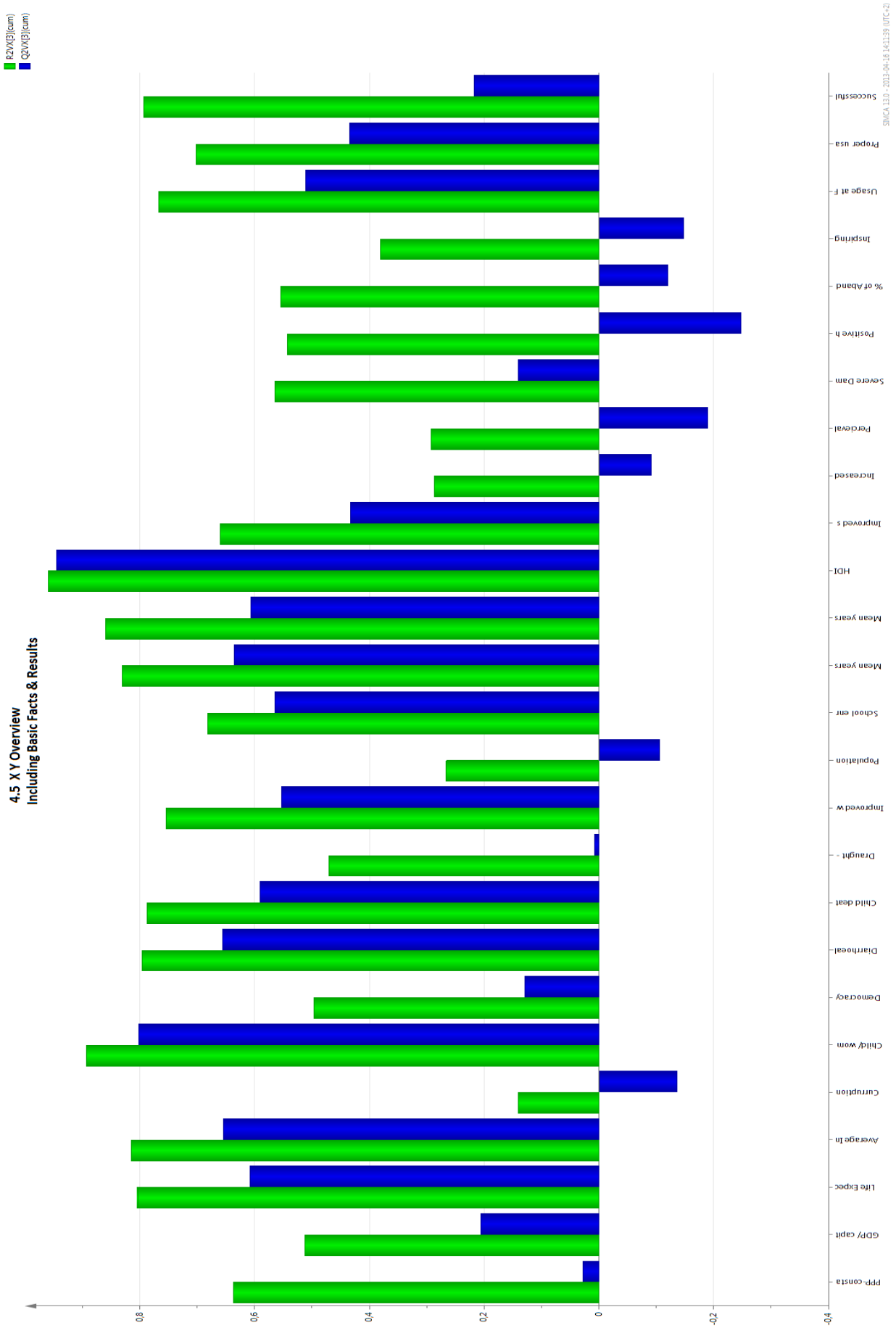
Mean years
Increased
Child/ worm
Positive h
Inspiring
Successful
PPP-consta
p[3]
p[2]
R2X[2] = 0,141 R2X[3] = 0,103
SIMCA 13.0 - 2013-04-16 14:16:19 (UTC+2)


R2X(cum)
Q2(cum)
4.4 Summary Of Fits
Including Basic Facts & Results
Comp[3]
Comp[2]
Comp[1]
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9


R2VX[3](cum)
Q2VX[3](cum)
4.5 X Y Overview
Including Basic Facts & Results
SIMCA 13.0 - 2013-04-16 14:11:39 (UTC+2)
PPP- consta
GDP/ capit
Life Expec
Average In
Corruption
Child/ wom
Democracy
Diarrhoeal
Child dead
Draught - -
Improved w
Population
School enr
Mean years
Mean years
HDI
Improved s
Increased
Percieval
Severe Dam
Positive h
% of Aband
Inspiring
Usage at F
Proper usa
Successful
0,8
0,6
0,4
0,2
0
-0,2
-0,4

Appendix 4 References to project reports included in the PCA

Project	*Reference*
1	Hoffmann, H., Rüd, S., & Schöpe, A. (2009). *Blackwater and greywater reuse system.* Sustainable Sanitation Alliance.
2	Shewa, W. A., & Geleta, B. G. (2010). *Arborloo for household sanitation.* Arba Minch: Sustainable Sanitation Alliance.
3	Senzia, M. (2011). *UDDTs for peri-urban households, Arusha, Tanzania.* Sustainable Sanitation Alliance.
4	Kleemann, F., & Berdau, S. (2011). *Otji toilets for peri-urban informal households in Omariri, Namibia.* Sustainable Sanitation Alliance.
5	Suntura, J. C., & Sandoval, B. I. (2012). *Large-scale ecological sanitation in peri-urban area, El Alto city, Bolivia.* Sustainable Sanitation Alliance.
6	Werner, C., Klingel, F., Bracken, P., Schlick, J., Lorenz, S., & Khawaja, N. (2010). *Rural urine diversion dehydration toilets (after 6 years), Hanahai and Paje villages, Botswana - Draft.* Sustainable Sanitation Alliance.
7	Fall, A., & Coulibaly, C. (2011). *URban urine diversion dehydration toilets and reuse, Ouagadougou, Burkina Faso.* Sustainable Sanitation Alliance.
8	Patinet, J. (2011). *Household pit latrines with urine diversion.* Sustainable Sanitation Alliance.
9	Stuber, N., Riad, M., Husselman, H., & Fahrlaender, F. (2012). *Community-managed wastewater treatment system, El-Moufty, Kafr El-Sheikh, Egypt.* Sustainable Sanitation Alliance.
10	Yeboah, B. A. (2012). *Urine-diverting dry toilets at Adama University, Adama, Ethiopia.* Sustainable Sanitation Alliance.
11	Shewa, W. A., & Geleta, B. G. (2010). *Fossa alterna for household sanitation, Arba Minch, Ethiopia.* Sustainable Sanitation Alliance.
12	Rieck, C. (2010). *UDDTs implemented via CBOs and Water Services Trust Fund, Nyanza, Western and other provincess, Kenya.* Sustainable Sanitation Alliance.
13	Rieck, C. (2010). *Public toilet with biogas plant and water kiosk, Naivasha, Kenya.* Sustainable Sanitation Alliance.
14	Kraft, L., & Rieck, C. (2011). *Urine diversion dehydration toilets for rural schools in Kenya.* Sustainable Sanitation Alliance.
15	Muchiri, E. W., Raude, J., & Mutua, B. (2010). *UDD toilets and greywater treatment at Secondary School, Nakuru, Kenya.* Sustainable Sanitation Alliance.
16	Muchiri, E., & Mutua, B. (2010). *UDD toilet at a church and nursery school, Nakuru, Kenya.* Sustainable Sanitation Alliance.
17	Fogde, M., Macário, L., & Porsani, J. A. (2011). *Household UDDTs in flood-response resettlement project, Guara-Guara, Sofala province, Mozambique.* Sustainable Sanitation Alliance.
18	Dusingizumuremyi, E. (2010). *Urine diversion dehydration toilets in rural scholls, Huye and Ngorerero, Rwanda.* Sustainable Sanitation Alliance.
19	Senzia, M. (2011). *UDDTs for teachers at a primary school, Arusha, Tanzania.* Sustainable Sanitation Alliance.
20	Müllegger, E., & Schlick, J. (2009). *UDD toilets at a rural secondary school, Kalungu, Uganda.* Sustainable Sanitation Alliance.
21	Senzia, M. (2011). *UDDTs for teachers at a primary school, Arusha, Tanzania.* Sustianable Sanitation Alliance.
22	Phat Sanday Floating Communities on the Tonle Sap Lake, Cambodia. (2010). *Floating Community ecological sanitation project on the Tonle Sap Lake.* Korea International Cooperation Agency.

23 Khandaker, H., & Badrunnessa, G. (2006). Bangladesh - CBO management of slum neighbourhood sanitation services: the Aynal's Bastee Case, Dhaka, Bangladesh. *The Value of Environmental Sanitation - Case studies*, 79-87.

24 Philippines - Tingloy ecosan pilot project. (2006). *The Value of Environmental Sanitation - Case studies*, 89-103.

25 Saywell, D., & Hunt, C. (1999). Kumasi Strategic Sanitation Project. *Sanitation Programmes Revisited*, 14-27.

26 Holmer, R. J., Factura III, H. S., Miso, A. U., Sol, G. Y., Santos, C. A., Elorde, E. G., . . . Montes, A. A. (2009). *UDD toilets with reuse in allotment gardens, Cagayan de Oro. Philippines.* Sustianable Sanitation Alliance.

27 Lipkow, U. (2009). *Urine-diversion dehydration toilets in rural areas, Bayawan City. Philippines.* Sustianable Sanitation Alliance.

28 Delepière, A. (2011). *Household UDDTs after cyclone disaster, Padma & Rohitra villages, Barisal Division, Bangladesh.* Sustainable Sanitation Alliance.

29 Deegener, S., Samwel, M., & Anakhasyan, E. (2009). *UDD toilets in rural school, Hayanist, Armenia.* Sustianable Sanitation Alliance.

30 Sayre, E. V., & Münch, E. v. (2009). *Rural community and school UDD toilets in Misamis Oriental Libertad, Initao and Manticao, Philippines.* Sustianable Sanitation Alliance.

31 Macwan, M., Wafler, M., & Heeb, J. (2009). *Sanitation improvements at Navsarjan Boarding Schools, Gujarat, India - draft.* Sustianable Sanitation Alliance.

32 Dawa, S., Kreutzer, G., & Panesar, A. (2009). *Improved traditional composting toilets with urine diversion, Leh, Jammu and Kashmir State, India - draft.* Sustianable Sanitation Alliance.

33 Werner, C., Klingel, F., Bracken, P., Schlick, J., Freese, T., & Rong, W. (2009). *Peri-urban urine diversion dehydration toilets (abandoned).* Sustianable Sanitation Alliance.

34 Müllegger, E., Schlick, J., & Werner, C. (2009). *Improved sanitation at Kanawat Health Center, Kanawa, Uganda.* Sustianable Sanitation Alliance.