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A Novel Research Approach to solving Zimbabwe's Water Pollution and Sanitation Problem

"In rural areas there is no rain. People go to caves to cook beer to please the ancestors and ask for rain. When the beer evaporates, people are happy. Ancestors have drunk, and they can revive rain! In Zimbabwe there are caves, rivers, buildings and animals. People in Zimbabwe have a good culture. They go to church with a heart and children go to school. Many years ago there were no telephones. People beat drums, and used fire and wood. When smoke rose up, people knew something wrong had happened and came to help."

-Brighton Chovunita, 12 years
Zimbabwe
Asael et al, 2011

Brighton Chovunita is one of the 1.4 million Zimbabweans who faced food shortages in 2012 (Kuwuya, 2012). Food insecurity has burdened the life of many in Zimbabwe, as Brighton described, many citizens of rural Zimbabwe pray for the rain to come. Inadequate access to safe drinking water is increasing in the developing world. United Nations' secretary-general Kofi Annan states, "Access to safe water is a fundamental human need and, therefore, a basic human right. Contaminated water jeopardizes both the physical and social health of all people. It is an affront to human dignity." Zimbabwe is in a critical condition. Lack of clean water or any water at all is burdening Zimbabwe's education system, food security, and the health of its people. Klaus Topher, the chief of the UN Environment Program states that, "without adequate clean water, there can be no escape from poverty." With an escalating impoverished population, Zimbabwe's water problem must be fixed.

Getting Creative in a Rural Setting: The Life of the Murgawes, the people in Jiria, Muchetu, and Farmers

Due to the crippled economy and abominable food insecurity, an estimated 3 million Zimbabweans, over 20% of the population, have left the country in 2013 (The International Fund for Agricultural Development, 2013). The rise of unemployment is causing male migration into industrialized cities, leaving women as the heads of the households (United Nations, 1997). A study states that these households are often the most disadvantaged (The International Fund for Agricultural Development, 2013). The Mugarwes, the people of Jiria, and Muchetu all represent typical families from different areas in Zimbabwe. The Mugarwes, a family of six, live in the dirt lanes of Chitungwiza (Journal of Public Health in African, 2012). They bake one loaf of bread and split it among the six of them. Everyone gets two slices except the youngest child, who at the age of two, only receives one. When bread is not available, villagers will resort to crickets and beetles as a food source. The cooking procedure is quite simple: remove the shells off of the insects and throw them into a hot pan. In fact, Zimbabweans have gotten quite creative with their food, scavenging for any possible food sources. In the small village of hut filled Jiria, people compete for the hacha, a small foul smelling fruit (Decapua, 2008). If the villagers fail to rise early to gather the fruit, they will not eat that day (Peace and Collaborative Development Network (PCDN), 2008). In Bengina, Muchetu feeds her 2-year-old daughter animal feed that she describes as a conglomeration of wheat, soy bean, sand, and "green stuff." It is not delicious, but she is still thankful that they have something to put in their stomachs (Dugger, 2008). A United Nations survey revealed that 7 out of 10 people had nothing to eat or only had a single meal the day prior (Dugger, 2008).

It is clear that many of the citizens need food aid. Especially a farmer who is usually poorer than the average citizen. The Zimbabwe Vulnerability Assessment Committee reports that rural citizens in the dry

south western region of Zimbabwe are the most vulnerable to food insecurity (James, 2012). They don't have any alternative sources, to farming. Instead, farmers survive off of mice, wild fruit, white ants, and black beetles (Dugger, 2008). Farmers in Mashonaland, Zimbabwe that receive land are unable to utilize it because they do not have the necessary agricultural support (Dugger, 2008). The typical annual harvest includes corn, cotton, maize, tobacco, and sorghum (Kuwuya, 2012). Due to the lack of resources, harvests have been reduced by 1/3 from previous yields (USAID b, 2007). Despite these circumstances, farmers have not failed to be creative. In order to preserve water, farmers create terraces in the land (Bellamy, 2006) that increase crop yield by as much as 50% (Welton et al, 2012). To reduce runoff, other farmers put mulch in the ground to keep water from evaporating (Reece et al, 2012).

The distressing food status plays a role in the children's education, and therefore the future capacity to improve society (International Federation of Red Cross, 2012). In the rural communities of Zimbabwe, there are 300,000 children who drop out of school annually to spend time gathering food for their family (Mutenga, 2012). The passing rate is 28.9% for primary school education and 40% for secondary school. Due to the lack of water, poor housing, and electrical shortages, trained teachers tend to stray away from rural area schools (The World Bank, 2012) which contain no desks, no chairs, and a poor education curriculum (Mutenga, 2012).

With poor education and poor living standards, the lousy health care system further burdens the lives of many rural Zimbabweans who require quality health care (USAID, 2012). Hospitals, if any, do not contain enough medical equipment or educated physicians to get the job done. In fact many hospitals lack the knowledge of basic doctoral procedures resulting in many deaths of a country with one of the highest HIV/AIDS infection rates (Meldrum, 2008).

Major Barriers Stand in the Way of Improvement

Governmental policies, lack of agricultural resources, and poor funding have obliterated any hope of improvement. The corrupt government implements laws under alleged favoritism towards "pro government" areas (Kuywuya, 2012). Aid has been neglected to Mataberland because it is an anti-government region (International Journal of Socialist Renewal, 2012). Furthermore, because of the 1990s Land Reform Program, most of the land is underutilized (Kuwuya, 2012), damaging the commercial farming system that 400,000 rural citizens were a part of (The International Fund for Agricultural Development, 2013). A previous economic crisis in Zimbabwe, as a result of poor policies, has prevented capital investment. The price of hybrid seeds and fertilizer have sky rocketed and poverty-stricken farmers are unable to cope with the changes. As a farmer, it is impossible to make a living (BBC News, 2012). Even if farmers are able to harvest, the government monopolizes the corn's role in the market through the Grain Marketing Board (Ndela et al, 2007). By the time the corn gets to the bank, inflation has completely diminished the value (Dugger et al, 2012). Because the government had not generated proper mining policies, mining companies polluted the Save river in Zimbabwe during the diamond mining rush. Rivers have become so contaminated that using them poses major health threats (Bank of Africa, 2012).

The lack of proper funding in the Zimbabwe Meteorological Department has played a role in confusing farmers (Kuwuya, 2012). Because of sporadic rainfall and outdated technology, the Zimbabwean Meteorological Department is inconsistent in delivering correct weather reports. Therefore, farmers grow crops during the wrong seasons culminating in a substantial loss in the amount of crops grown (Anthony, 2001).

The Current Water Status

Philip Madzorea, 72 years old, stated, "My son, water is a real problem here. Since 1962 up to this year 2012, this area has not been having any borehole, not even a single one. We drink water which is dirty (Mhofu, 2012)." The government is risking legal action if it does not cope with the water

sanitation problem (AMCOW Country Status Overview, 2012). Abel Chikomo, representing the civic groups, states “Waiting a day longer might mean losing 1,000 lives.” The Zimbabwean Minister of Health, Henry Madzorea, agrees that there is a problem but is difficult to solve, “Water supply remains a serious challenge in our cities and a recurrence of typhoid and other infectious diseases will continue to occur.” In Mudzi, a rural community containing 35,000 citizens, the water source is a muddy dam (Active, 2012). This muddy dam bathes children, cleans laundry, and is shared by livestock and citizens alike (Banda, 2008). Any clear water is only an illusion; it contains bacteria that has caused major cholera epidemics to sweep the country (Active, 2012). The current water shortage has caused serious conflicts among villagers who share Ramakgoebana, a river running in between Botswana and Zimbabwe (Duffield, 2012). Villagers are accusing one another of finishing the water; some villagers have claimed portions of the river as their own (Kinsey, 2010). Because the water source is limited, tensions increase as villagers bring their livestock to drink water, further diminishing and contaminating the water source (Banda, 2008). The lack of water availability has resulted in villagers going up to two days without running water (Ndlovu, 2012).

No significant improvements have been made. The government is doing a poor job; it does not send out water experts, technicians, drilling machines, or purification chemicals to rural areas (World Health Organization, 2012). Previous boreholes that contained water are now dry, and no effort to re-drill or provide a new resource for water has been made (Banda, 2008).

The Effects of Polluted Water and Water Scarcity

The lack of clean water and the decline of rainfall in the past six years have brought famine and negative environmental side effects (Mazimavi, 2012). Water scarcity is contributing to the decrease of food exports, which is damaging the struggling economy even further (Showers, 2002). Product goals have been thrown off; Zimbabwe missed its production goals by 325,000 tons in 2012 (Kuwuya, 2012). The Grain Loan Scheme, a government implemented project, was an attempt to help farmers purchase implements for their crops. The implements proved worthless because water shortages made their use impossible (Fintrac Inc, 2012). Food insecurity is present in rural areas and high dense urban areas where low income and high unemployment levels are present (Kuwuya, 2012). The Red Cross estimates that currently 1.6 million people are in need of food aid.

Food insecurity is not improving. There was an increase by 7% from the 2011/2012 season’s 12% (Johannesburg, 2003). The production of maize, Zimbabwe’s main crop, has declined by 33%. 43% of crops were estimated to be ruined. (International Federation of Red Cross, 2012).

Province	% Food Insecurity 2011/12	% Food Insecurity 2012/13	Food Insecure Population 2012/13
Manicaland	14	15	209,364
Mashonaland Central	10	17	198,065
Mashonaland East	8	10	113,878
Mashonaland West	7	16	159,502
Masvingo	16	28	378,046
Matabeleland North	16	30	155,837
Matabeleland South	16	30	213,338
Midlands	11	17	217,178
National	12	19	1,667,618

Source: International Federation of Red Cross and Red Crescent Societies, 2013

The current water situation has caused a significant domino effect on land degradation the further contributes to food insecurity (Economic Research USDA, 2012). In rural areas, farmers are forced to raise their livestock near rivers which contributes to erosion (Kaseke, 2003). The lack of food and livestock has increased unemployment. In turn, unemployment damages the environment because many resort to cutting down trees and selling them (Kuwuya, 2012). Deforestation is renowned to contribute to

water runoff (Osvald, 2012).

Policy Makers and Future Decades: Factors that must be taken into consideration for viable and sustainable success

In order to achieve food security, the government and policymakers must understand that the growth of the population and natural resource depletion will and have affected the food security in Zimbabwe. The population in Africa is estimated to increase from 1.01 billion to 2 billion by 2050. With the population almost doubling, more food will be demanded (Index Mundi, 2013). Soaring growth rates are expected to occur among the rural populations. If the current conditions remain unchanged, the food insecurity rates will soar and any available water supplies will disappear. Food will be scarcer and therefore even more expensive making it more difficult or near impossible for a rural citizen to purchase food (Welton et al, 2012). Scholars believe that in order for the African people to survive, water supplies will need to be doubled (International Federation of Red cross, 2011).

Policy makers must also understand that natural resources are depleting. 10% of arable land is predicted to be lost due to rising temperature and climate change (Kuwuya, 2012). Inconsistent climate change contributes to both low water supply and high concentration of atmospheric carbon dioxide (Welton et al, 2012). Policymakers must ensure that future farmers have the ability to understand climate change accurately (The Herald, 2011).

Zimbabwe has already committed to the United Nations Millennium Development Goals, which states that by 2015, safe drinking water and sanitation will be provided to over 2/3 of the current population (Banda, 2008). However, significant progress must be made within the next year to achieve this goal. Conventional methods are too expensive and have not worked in the past. The United States' sanitation method should especially be disregarded because on average the U.S. uses twelve times more water than a typical man in a developing country. In the United States, a citizen will use eighty gallons a day on average, whereas, an African citizen will only use fifteen gallons (Parker, 2009). Creative and novel methods must be implemented to improve the situation (Banda, 2008). Specific policies need to target water scarcity and water pollution. Both of these factors contribute to a population's health and food security (Wurzel, 1987).

A current policy change in mining could make a significant difference. Effective mining will reduce water pollution which will scale down outbreaks of disease (Dugger et al, 2012). Because there is limited health care in rural areas, focusing on mining policies will improve the likely hood of sanitation and safety among water (Bank of Africa, 2012).

Investment in New Research Ideas and Technology to Purify Current Supplies of Water

Zimbabwe contains a desert region that contributes to the dryness of the land. Due to the dry land, water is limited. No water means no food. However, even the driest of deserts contain water (Parker, 2009). Zimbabwe has six major river resources that act as the nation's water supply (African Development Bank Group, 2014). Many rural villages in Zimbabwe rely on these contaminated rivers or dams for their water source. An example site is the Zambezi River, which is contaminated with toxic chemicals (Bonzogo, 2008). An effective solution must make use of the present contaminated water; it must make it safe, viable for consumption, and useable. The solution must be cost effective and applicable to Zimbabwe. Researcher Normal Alcantar of the University of Florida, discovered that the *opuntia* (prickly pear cactus) is a cheap way to filter contaminated water containing heavy metals, arsenic, and bacteria (Edwards, 2013).

The prickly pear cactus is also known as Nopal, it is found in semi-tropical areas and continuously grows throughout the whole year (Douglas Laboratories, 2012). The prickly pear cactus' mucilage is produced to

store and protect water levels. Mucilage, a thick mixture of secretory cells, feels gooey (Daniel, 2011) and is made out of carbohydrates (Marshall, 2011).

Expolysaccharide and the remaining carbohydrates can kill bacteria (Peake, 2006) in water (Cunningham, 2011) by surrounding them, starving them, or binding to them. Evidence shows that when the sugars bind to arsenic, the charge on the particles is changed (Sohn, 2005). Exactly how the reaction between arsenic and the particles of the mucilage occurs is not known (Fox, et al 2011). The hydrophilic (Hughes, 2011) part of the carbohydrate polymers, within the mucilage, will chemically interact with arsenic ions (Fox et al, 2011) that contain negatively charged molecules (Jean's Arsenic Site, 2011). Together they become a mucilage-arsenic complex, (Fox, et al 2011) that is hydrophobic. (Biology Online, 2011) Once it is hydrophobic, it moves to the surface where the air hits the water; the water is now clean and contaminants cannot re-dissolve. This allows for easy filtration of the mucilage-arsenic complex (Fox, et al 2011).



Photographs Taken and Compiled by Heya Kaakeh

Zimbabwe has the *Opuntia ficus-indica* (the prickly pear cactus) as well as a vast variety of aloe. My freshman year, I researched the prickly pear cactus and its ability to filter copper sulfate out of water. Working between school and home, I did receive results. However, results were inaccurate due to the lack of advanced equipment. I tried to create an effective precipitate that could filter copper sulfate out of water; I will be continuing my research in the future. I am hoping to produce a multifunctional precipitate filter that is cheap and that can be used in developing countries to create safe drinking water by EPA's standards. In Zimbabwe's case, it would be interesting to study the 30 species of Aloe plants. Because Aloe has very similar characteristics to the prickly pear cactus, it may be another cheap method to filter water. Investing in research on the polysaccharides on both the prickly pear cactus and aloe can create a novel way to filter the water. It would be a great way to help with employment and innovative action in the country playing a role in educational growth. I believe that it is important for Zimbabwe to create a self-dependent system. Aid will not always be there. If we can help them create a country that can produce their own clean water, than we have created a new country.

Sponsors: Organizations that can Eradicate the Problem

The Red Cross is one of many active organizations in Zimbabwe. They can continue to provide emergency food support as the country is working to improve their condition. However, the government should reallocate its money towards helping rural Zimbabwe. The government could supply farmers with seeds that pay back. The prickly pear cactus can be consumed, can be grown in desertous lands, and can be used to filter water. The multifunctional plant is worth the investment. The government should also push for education. For example, the government could invest their money in college research institutions where students can study the synergistic effects of the aloe or prickly pear cactus polymers for filtering water. Students in Zimbabwe must also work towards improving their situation. Academically, at the college level, students should be drawn and focused on fixing their society's problems. The economy is poor, but every dollar they invest will pay back. Zimbabwe will never be able to solve its problem unless the national government starts itself. The goal is for Zimbabwe to be self-dependent, and it cannot do that with continuous support. By involving citizens in research and novel technology, the Zimbabwean population will be inspired to turn around their own situation. By improving water quality and sanitation, Zimbabwe will be ready for its growing population. Rural areas will be able to focus on education, food

insecurity will decrease, the environment will be a better place, water wars will stop, disease will not be as wide spread, and the economy will improve.

Conclusion

As Klaus Topher said, "Access to safe water is a fundamental human need and, therefore, a basic human right. Contaminated water jeopardizes both the physical and social health of all people. It is an affront to human dignity." Improving Zimbabwe's water quality by new and innovative ways will help the country in almost every aspect. Once Zimbabwe will become self-dependent, they will be able to utilize their natural resources and control their lives without support. They must start soon because their population is growing and food insecurity is increasing. These new ways will help Zimbabwe improve its current situation by using what they have.

Literature Cited:

Active, "ACTIVE Ministry - Clean Water For Zimbabwe." ACTIVE Ministry. N.p., n.d. Web. 9 Mar. 2013. <http://activeministry.org/index.php?option=com_content&view=article&id=57&Itemid=57>

African Development Bank Group, 2014, *Water Resource Management, Supply and Sanitation*, www.afdb.org/fileadmin/uploads/afdb/Documents/Generic-Documents/9.%20Zimbabwe%20Report_Chapter%207.pdf

AMCOW Country Status Overview, 2012, *Water Supply and Sanitation in Zimbabwe*, www.wsp.org/sites/wsp.org/files/publications/CSO-Zimbabwe.pdf

Anthony, 2001, *Helping Farmers in Zimbabwe Use Seasonal Climate Forecasts: Six Constraints to Effectiveness*, sedac.ciesin.columbia.edu/openmeeting/downloads/1005784679_presentation_apatt_riopaper1.pdf

Asael, Anthony, and Stéphanie Rabemiafara. *Children of the world: how we live, learn, and play in poems, drawings, and photographs*. New York, NY: Universe, 2011. Print.

Banda, Ignatius. "IPS – POVERTY: Water Wars Hit Rural Zimbabwe | Inter Press Service." Inter Press Service | Journalism and Communication for Global Change. N.p., n.d. Web. 9 Mar. 2013. <<http://www.ipsnews.net/2008/10/poverty-water-wars-hit-rural-zimbabwe/>>.

Bank of Africa, 2012, "The Story of Zimbabwe's Marange Diamonds: Pollution, Politics, Power", <http://www.theafricareport.com/News-Analysis/the-story-of-zimbabwes-marange-diamonds-pollution-politics-power.html>

BBC News, 2012, *In pictures: Rural hardships in Zimbabwe*, news.bbc.co.uk/2/shared/spl/hi/picture_gallery/07/africa_rural_hardship_in_zimbabwe/html/1.stm

Bellamy, Rufus. *Food for all*. North Mankato, Minn.: Smart Apple Media, 2006. Print.

Biology Online, 2011, *Hydrophobic*, <http://www.biology-online.org/dictionary/Hydrophobic>

Bonzogo, Jean Claude J.. "Water Pollution and Sanitation Problems: The African Challenge 2008 Water

- Science Forum . "USGS Science For a Challenging World . N.p., n.d. Web. 13 Mar. 2009.
<water.usgs.gov/nrp/IHP/forum08/11_nsf_foru
- Cunningham A, 2011, *Cactus Goo Purifies Water*, http://www.phschool.com/science/sciencenews/articles/cactus_goo.html
- Daniel, 2011, *Cleaning Water with a Cactus Water Filter*, <http://www.filterfast.com/blog/index.php/tag/cactus-mucilage/>
- Decapua, 2008, *South Africa-Zimbabwe Mediation Unsuccessful says Analyst*,
waronyou.com/forums/index.php?topic=4452.0
- Douglas Laboratories, 2012, *Nopal Cactus Product Data*, www.douglaslabs.com/pdf/pds/98249.pdf
- Duffield, 2012, *Botswana or Zimbabwe? Exploring Africa's Resources Responsibility*,
www.africaportal.org/blogs/community-practice/botswana-or-zimbabwe-exploiting-africa's-resources-responsibly
- Dugger, Celia W. "In Zimbabwe, Survival Lies in Scavenging - NYTimes.com. "The New York Times - Breaking News, World News & Multimedia." N.p., n.d. Web. 9 Mar. 2013.
<<http://www.nytimes.com/2008/12/22/world/africa/22zimbabwe.html?pagewanted=all>>.
- Economic Research Service USDA, "Land Degradation and Food Insecurity." Economic Research Service . Economic Research Service United States Department of Agriculture , n.d. Web. 9 Mar. 2013. <<http://www.ers.usda.gov/media/522091/aer>
- Edwards, Lin . "Common cactus could be used to clean water." *Phys.org - Science News, Technology, Physics, Nanotechnology, Space Science, Earth Science, Medicine*. N.p., n.d. Web. 10 Mar. 2013.
<<http://phys.org/news191826782.html>>.
- Fintrac Inc, 2012, *Zimbabwe USAID-BEST Analysis*, www.usaidbest.org/docs/ZimbabweBellmon2012.pdf
- Fox D, Thomas Pichler, Daniel Yeh, and Norma Alcantar, 2011, *Using Green Processing to Remove Arsenic From Drinking Water*, <http://archivos.labcontrol.cl/wcce8/offline/techs/manuscripts%5Cjnm25.pdf>
- Hughes Tash, 2011, *Hydrophilic Substances*, <http://www.wordconstructions.com/articles/technical/hydrophilic.html>
- James, 2008, *Household Food Security and Regional Geography: Livelihood Prospects in Nembudziya, Northwestern Zimbabwe*, *Geography Compass* 2(5): 1337-1362.
- Johannesburg, 2003, *Zimbabwe: Feature-Food security worsening in the south*,
www.irinnews.org/Report/43026/ZIMBABWE-Feature-Food-security-worsening-in-south
- Kaseke, 2003, *The Use of Deposit Refunds as pollution control policy in urban areas: the case of Zimbabwe (Harare)*, users.ictp.it/eee/workshops/smr1686/Nyasha.doc
- Index Mundi, 2013, *Zimbabwe Economy Profile 2013*,
www.indexmundi.com/zimbabwe/economy_profile.html

- International Federation of Red Cross and Red Crescent Societies, "Emergency appeal Zimbabwe: Food Insecurity." N.p., n.d. Web. 19 Dec. 2012. <www.ifrc.org/docs/Appeals/12/MDRZW006E
- International Journal of Socialist Renewal, 2012, *The Legacy of anti-colonial struggles in South Africa: Liberation movements as governments*, links.org.au/node/1704
- James, Nick. "Household Food Security and Regional Geography: Livelihood Prospects in Nembudziya, Northwestern Zimbabwe." *Geography Compass* 2.5 (2008): 1337-1362. Print.
- Jean's Arsenic Site, 2011, *What is Arsenic?*, [http://www.civil.umaine.edu/macrae/what is arsenic.htm](http://www.civil.umaine.edu/macrae/what%20is%20arsenic.htm)
- Journal of Public Health in Africa, 2012, *Zimbabwe, Chitungwiza: factors leading to poor water sanitation hygiene among primary school going children*, washafrika.wordpress.com/2012/03/26/zimbabwe-chitungwiza-factors-leading-to-poor-water-sanitation-hygiene-among-primary-school-going-children/
- Kinsey Bill, 2010, *Poverty Dynamics in Rural Zimbabwe: The 30 Years (Lost) 'War against Poverty'*, www.chronicpoverty.org/uploads/publication_files/kinsey_poverty_dynamics_zimbabwe.pdf
- Kuwuya , Kumbirai. "Zimbabwe's Food and Water Security Outlook." *Future Directions International* (2012): Print.
- Marshall J, 2011, *Cactus Goo Makes Water Safer*, <http://dsc.discovery.com/news/2008/09/17/cactus-arsenic-water-02.html>
- Mazimavi, 2012, *Is the Rainfall Declining Over Time in Zimbabwe?* <http://168.167.30.140/Kalahari%20Workshop/For%20web/Mazvimavi.pdf>
- Ndela et al, 2007, *Distortions in Agricultural Incentives in Zimbabwe*, siteresources.worldbank.org/INTTRADERESEAR/Resouces/5448241146153362267/Zimbabwe_0708rev.pdf
- Ndlovu, 2012, *Bulawayo's taps tightened as water shortage bites*, mg.co.za/article/2012-10-12-00-bulawayos-taps-tightened-as-water-shortage-bites
- Osvald Thomas Caffrey, 2012, *MDP Zimbabwe Project*, <https://sites.google.com/a/tcd.ie/mdp-zimbabwe-project/home/about-the-wiki>
- Parker, Russ. *Water supplies in crisis*. New York: Rosen Central, 2009. Print.
- Peace and Collaborative Development Network (PCDN), 2008, *Help the people of Zimbabwe*, www.internationalpeaceandconflict.org/forum/topics/780588:Topic:57208?x=1&id=780588%3ATopic%3A57208&page=-7
- Peake Lisa C., 2006, *Cactus Goo: Research that Stuck with a High School Chemistry Teacher*, <http://www.ret.neu.edu/NSTA-Anaheim/Presentations/Peake.pdf>
- Reece et al, 2012, *Diffusion Osmosis PLW- CU Dept. of Biology Instruction*, www.getbookee.org/lab-diffusion-and-osmosis-pearson-answers/

- Showers, 2002, *Water Scarcity and Urban Africa: An Overview of Urban-Rural Water Linkages*,
www.sciencedirect.com/science/article/pii/S0305750X01001322
- Sohn E, 2005, *Cactus Goo for Clean Water*, www.sciencenewsforkids.org/2005/09/cactus-goo-for-clean-water-2/
- The Herald, 2011, *Zimbabwe: Farmers Urged to Appreciate Climate Change*,
allafrica.com/stories/201108120661.html
- The International Fund for Agricultural Development. (IFAD) "Home - Rural Poverty Portal." *Home - Rural Poverty Portal*. N.p., n.d. Web. 9 Mar. 2013. <<http://www.ruralpovertyportal.org/country>>
- The World Bank, 2012, *Zimbabwe Country Economic Memorandum: Achieving Shared Growth*,
web.worldbank.org/WBSITE/EXTERNAL/TOPICS/EXTPOVERTY/EXTPA/0,,contentMDK:20204806~isCURL:Y~menuPK:443279~pagePK:148956~piPK:216618~theSitePK:430367,00.html
- United Nations, 1997, *Zimbabwe*, www.un.org/esa/earthsummit/zimbab-c.htm
- USAID, 2012, *Zimbabwe Food Security Outlook Update*, www.fews.net/docs/Publications/Zimbabwe_FSOU_2012_08_final.pdf
- USAID b, 2007, *Zimbabwe Food Security Emergency*, www.fews.net/docs/Publications/1001381.pdf
- Welton, Jude. *Water supplies*. North Mankato, Minn.: Smart Apple Media, 2006. Print.
 Zuberi Tukufu and Thomas Kevin J.A "Demographic Change, the IMPACT Model, and Food Security in Sub-Saharan Africa." *United National Development Program Regional Bureau for Africa 1* (2012): n. pag. United Nations Development Program. Web. 9 Mar. 2013.
- World Health Organization, 2012, *Intersectoral actions in response to cholera in Zimbabwe: From Emergency response to institution building*,
www.who.int/sdhconference/resources/draft_background_paper23_zimbabwe.pdf
- Wurzel P, 1987, *Hydrology in Zimbabwe- the past and the future*,
iahs.info/redbooks/a164/iahs_164_0265.pdf
- Meldrum, A. (2008) *Zimbabwe's health-care system struggles on*, *The Lancet*: **371(9618)**: 1059-1060.
 doi:10.1016/S0140-6736(08)60468-7
- Mhofu, Sebastian . "Clean Water Project Brings Hope to Zimbabwe Village." VOA - Voice of America English News - VOA News. N.p., 28 June 2012. Web.<http://www.voanews.com/content/project-to-provide-safe-water-in-zimbabwe_tsholotsho/1275555.html>.)
- Mutenga, Tabitha, and 27 April 2012. "allAfrica.com: Zimbabwe: Poverty Decimating Education." *allAfrica.com: Home*. N.p., n.d. Web. 9 Mar. 2013.
 <<http://allafrica.com/stories/201204290264.h>>