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India, Factor 2: Water Scarcity

INCREASING WATER SECURITY
FOR SMALL-HOLDER FARMERS IN RAIN-FED SEMI-ARID TROPIC AREAS OF INDIA

"Access to water is a common goal. It is central in the social, economic and political affairs of the country, African continent and the world. It should be a lead sector of cooperation for world development. No water, no future."
Nelson Mandela 2002 Earth Summit in Johannesburg

WATER INSECURITY WORLDWIDE – "NO WATER. NO FUTURE."

Looking at a picture of the Earth from space is inspiring. The vast dominating areas of blue are beautiful but also misleading. Only about 2.5% of the Earth's water is freshwater. The other 97.5% is ocean saltwater which is not suitable for people as well as the great majority of mammals, plants, insects and other forms of life on Earth. Of the 2.5% of water that is freshwater, about 68.7% is in the form of glaciers, 30.1% groundwater, 0.8% permafrost, and 0.4% is surface and atmosphere water.

This very limited amount of freshwater from rivers, lakes, and groundwater is used for a variety of purposes. Agriculture uses about 68%, domestic use accounts for 19%, energy production utilizes 10% and evaporation from reservoirs consumes 3% (Global Water Security, Intelligence Community Assessment, 2012).

Water is vital to every aspect of our lives. A person could be in the ocean on a luxurious cruise ship with the finest food, entertainment, educational programs and anything else they might want. But without freshwater to drink where and when needed, everyone on the ship will be dead within 7 days. Even if freshwater was in sight on shore.

Water security is defined by the United Nations as "the capacity of a population to safeguard sustainable access to adequate quantities of and acceptable quality water for sustaining livelihoods, human well-being, and socio-economic development, for ensuring protection against water-borne pollution and water-related disasters, and for preserving ecosystems in a climate of peace and political stability." (UN-Water) Without water there is no human wellbeing, socio-economic development or preservation peace. As Nelson Mandela said "No water, no future."

INDIA: WATER INSECURITY AND AGRICULTURE

The nation of India covers 2.4 percent of the world's total area and contains 4% of the world's fresh water. Places in India receive some of the largest amounts of rainfall in the world, up to 40 feet of water falls in some places due to monsoons (FAO, 2002)

Nevertheless, India is currently in a dire state of water insecurity. According to a UNICEF report on Indian water "There will be constant competition over water, between farming families and urban dwellers, environmental conservationists and industrialists, minorities living off natural resources and entrepreneurs seeking to commodify the resources base for commercial gain" (Brooks, 2007).

Due to a lack of infrastructure, many areas have major water challenges. Only a few cities in all of India receive continuous water supply. Most major cities only deliver water for a few hours every other day or so which results in major health care problems.

The quality and quantity of water in an area are linked. Up to 40% of the Indian population does not have access to clean drinking water. Water insecurity and the increase in contaminates impacts populations through the spread of diseases, high rates of infant mortality, and adverse livestock conditions.

Neither rural or urban areas have enough clean drinking water, much less water for effective waste treatment. Rivers in India are filled with high levels of human and livestock waste along with industrial outputs. Rural populations are faced with dry wells in the early summer (Prathapar, 2015) and a drinking water crisis is prevalent in most villages because of the high levels of toxic substances in wells that aren't dry (Prathapar, 2015). Every year 600,000 Indian babies die as a result of diarrhea or pneumonia often caused by bacteria in drinking water (Harris, 2013).

The population of India is expected to increase to over 1.6 billion by 2050 overtaking China as the most populous nation in the world, and the demand for water in India is expected to double (Brooks, 2007). With an ineffective water management system that looses up to 70% of the water generated in water treatment facilities to leaks and theft, India will need to make drastic improvements to both its drinking water generation capabilities (which are already higher than many western nations) and its urban infrastructure to meet the needs of its growing population.

In the semi-arid tropic areas of India, water insecurity is even more of a major challenge. Periodic droughts are typical of the climate in these areas and have affected agriculture in India for centuries (James, 2001). However, in the past several decades, the problem of water insecurity has become more challenging due to climate variation, increased dependence on irrigation, planting of crops requiring more water and a growing population which demands more water.

EFFECT OF WATER INSECURITY ON SMALL HOLDER FARMERS IN THE RAIN-FED SEMI-ARID TROPIC AREAS OF INDIA

"Three-quarters of the world's poorest people get their food and income by farming small plots of land. So if we can make those small-holder farmers more productive and have more profit, we can have a dramatic impact on hunger and nutrition and poverty. Melinda and I believe that helping the poorest small-holder farmers grow more crops and get them to market is the world's single-most powerful lever for reducing hunger and poverty." Bill Gates, Speech at the World Food Prize Symposium 2009.

Water security is vital to all farmers everywhere but especially to small-holder farmers in rain-fed areas because their small size and dependence on rain increase their vulnerability. India's semi-arid tropic areas constitutes about 60% of arable land in India (FAO, 2002).

Water insecurity has a major impact on the productivity, income and education of rural families in the semi-arid regions of India. There are some industries in the semi-arid tropics of India, such as mining and factories, but agriculture is by far the main source of income and employment (James, 2001).

For decades these regions have been characterized by low crop yields and high poverty (Cronin, 2015). According to the government "a substantial amount of time and effort goes into water collection in rural Andhra Pradesh" (James, 2001) as 90% of the families are forced to spend time each day walking to a source where they can find drinking water. Thirty percent of India's population in the degraded semi-arid watersheds are in poverty (Bharucha, 2014). This time and effort could be applied to other pursuits like

vermicomposting, improving the efficiency of irrigation on crop land, or community water collecting projects like dams and rain catchment facilities that would add to the economic output of individuals and villages (Wani, 2002).

Low amounts of water also impact crop production. Besides the obvious impact of drought and the inability to grow crops at their maximum potential in unfavorable climatic conditions, in semi-arid areas there is often not enough water to apply fertilizers and other inputs (Taylor, 2013). This reduces crop potential, especially where there is land degradation, which is common in rain-fed India (Wani, 2002). A government report from Andhra Pradesh cites a lack of surface and ground water as major factors in the continuation of poverty (James, 2001). Farmers who took out loans to build wells often find their wells dry due to the over exploitation of aquifers, leaving them with no water to irrigate their high value crops.

The problem of water insecurity in India is applicable to both water quantity and water quality. There is a lack of water when it is needed. Two-thirds of all of the cropped land in India is reliant upon rainfall as its water source (Wani, 2014). In the semi-arid tropics, this rain comes in torrents dumping a lot of water onto the land in a very short amount of time. Rainfall only exceeds evaporation levels for 5 months out of the year, and these unpredictable storms lead to periods of either too much water sitting in the fields or spells of drought (Wani, 2002). Both adversely impact crop yields.

There is also the problem of water insecurity in relation to clean drinking water in India. Many in India do not have access to drinking water inside their homes. About 90% of rural families in the state of Andhra Pradesh have to walk to get access to drinking water everyday, which requires a substantial amount of time and effort and for up to 40% of the population this water may not even be safe to drink (James, 2001). The major water quality issue for many in semi-arid regions is the rise in levels of fluorides and costal salinity in the underground drinking water which is a correlated to the depletion of aquifers (James, 2001).

TYPICAL SMALL HOLDER FAMILIES

Defining a "typical" family and farm anywhere is challenging but especially rain-fed farmers in India because they are not homogenous. As the report, Empirical Evaluation of Sustainability of Divergent Farms in the Dryland Farming Systems of India, states, "… there are heterogeneous farm systems within the drylands and each farm system is unique in terms of its livelihood assets and agricultural practice and therefore in sustainability."

Typical dryland farmers are difficult to define because:
* Each person and family does things in their own way and they do things in different ways at different times depending on the circumstances.
*One difference in a small-holder farm can make a big overall difference from other small-holder farms. For example, if two small-holder farmers have animals but one has chickens and the other has goats, their operations can be very different. Another example is number of members in the home and gender. If one farmer has two daughters and the neighbor has three sons, the farm operations will be different.
* Information obtained might quickly be out of date or not even correct.

However, generalizations about families in the semi-arid tropics can be made. About 80% of farmers cultivate only 20% of the land, suggesting that a small minority of wealthy land owners control most of the land. Many farmers are poor and have land holdings of less than 1 hectare, which is not sufficient to keep the average family, size of 5 people, above the poverty line (James, 2001). Much of the cultivated land in India relies upon rain to water what is grown, which limits agricultural productivity (Wani, 2014). Many small holder farmers grow a variety of crops including cereals like wheat and rice, but the amount

of acreage planted in other cash crops such as sugar cane has been increasing (FAO, 2002). The livestock of small holder farmers is generally limited with goats being the primary animal in semi-arid areas (James, 2001). Goats are raised for both milk and meat and often serve as an emergency source of income for rural families if needed because they can be easily sold (James, 2001).

The average farm family receives the majority of their calorie intake from cereals which provide 72% of dietary energy, 68% of protein, and 17% of daily fats. Other food common foodstuffs include milk which provides a valued source of protein (FAO, 2002). The calorie intake per day increases with farm size, with the average small holder farmer with sub marginal land holdings consuming only 2,096 kilocalories per day. Malnourishment is common in rural India with over 30 percent of marginal land holders categorized as under nourished (FAO, 2002).

For farmers of the semi-arid tropics, the farming year begins in April with soil preparation. Each field is typically plowed deeply one time then one or two shallow plowings may be carried out to smooth the surface of the soil and control weeds. (IndiaAgroNet, n.d.). Wealthier farmers may use tractors to work their fields while poor farmers use oxen or even pull the plows by hand.

In June, the Southwest monsoon arrives and begins what is called the kharif growing season. There is enough rain from the monsoon that hardy plants such as sorghum, millet, and pulses can be grown. This is often the only chance poor farmers have to grow a crop. (James, 2001)

Once the rains arrive, seeds are sown using a variety of techniques. The traditional method is broadcast seeding where farmers throw seeds across their fields in broad sweeping motions and then till the seeds into the soil. This method is being gradually replaced with sowing seeds in defined rows that make thinning and weed control easier. (Agrifarming, 2015)

From July through September the farmers must weed, fight of pests, and maintain the health of their crops. This can often be a time of starvation as food supplies run out and demanding physical labor is needed to produce the next crop (Thurow, 2012)

In October harvest season begins. The amount of food harvested is often meager and farmers resort to wage labor for the rest of the year to support their families. (James, 2001). A second growing season, rabi, begins in October with the rains from the Northeast monsoon and lasts until March and is used to grow crops such as wheat, oats, chickpea and mustard (James, 2001). Irrigation plays a significant role in the success of rabi crops which is often impossible for poor farmers (Arya, 2015). Therefore, the rabi season is more often utilized by wealthier farmers who employ poorer farmers as wage laborers. (James, 2001)

Three reports by the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) studied the same six communities over several years to better understand conditions that adversely impacted farmers in the semi-arid tropics of India. Of the three reports (Report 65, 66 and 67), the most useful in understanding rain fed farmers was Research Report 67, “Mapping of Household Vulnerabilities and Identification of Adaption Strategies in Dryland Systems of South Asia.”

The following information is from the community of Bijapur in the State of Karnataka. Bijapur is located 241 km or 6 ½ hours drive West of the headquarters campus of ICRISAT which is in Patancheru near the major city of Hyderabad in the State of Telangana.

Bijapur has black clayey vertisol soil and mixed crop-livestock systems predominate. Black soils make up about 35-40% of the cropping belt in South India.

This information is from 250 randomly selected farmers in Bijapur. Of the 250, 9 where landless, 35 were marginal, 70 were small, 69 where medium, 67 were large. The information is about the 2011-2012 production year and the survey was conducted in 2012 and 2013. 62% of the Bijapur families are in poverty or, at best, vulnerable to poverty. The monthly per-capital income for the community is 902 rupees.

The community was surveyed about major challenges they have experienced over the past 10 years. Such challenges can cause famers to fall into poverty especially vulnerable dryland farmers.

Major Challenges	Of the 250 families surveyed	Percentage
Drought	246	98%
Untimely Rain	233	93%
Irregular Weather	171	68%
Hailstorm	44	18%
Flood	11	4%
Temp Fluctuation - High	9	4%
Temp Fluctuation - Low	0	0%

It is also important to note that farmers can experience challenges at the same time or one or more soon after the other which can compound problems. The study calculated that the farmers in Bijapur encountered 72 combinations of shocks.

The study also gathered information about the perceived effects the challenges had on the farmers agriculture, health and income.

Effect of challenge	Number of farmers effected of the 250 surveyed
Crop failure	240
Loss of income	218
Depletion of ground water	179
Pest Damage	169
Change in soil salinity and decrease/increase in soil moisture	72
Loss of assets	60
Food shortage	46
Major changes in crop pattern	45
Decline in health	32
Major changes in farm investment	6
Decline in consumption	6

Actions taken by Farmers after challenges

Farming based adaption	Number of farmers effected of the 250 surveyed
Did nothing	0
Additional skill development activities	204
Change in cropping pattern	141
Change in planting date	107

Followed improved crop production practices	61
Provided supplemental irrigation	46
Sold livestock	34
Maintained poultry or goats	17
Land left to fallow	12
Invested in farm ponds	8
Leased out part of land	5
Sold part of land	4
Other adaption measures	21

Non-farming based adaption	Number of farmers effected of the 250 surveyed
Borrowed money from relatives or others	217
Relying on assistance from government or NGO	189
Out migration to cities	164
Shifted to non-farm employment	93
Reduction in education level of children	118
Less food consumed or changed food habits	6

According to a 2014 report on water scarcity in the semi-arid tropics, "In India, as in the rest of the world, drylands, degradation, poverty, and hunger overlap" (Bharucha, 2014). Acquiring the quantity and quality of water needed in the semi-arid topics of India takes large amounts of time and resources from families that are already below the poverty line, preventing them from educating children, pursuing other options for income, and increasing their quality of life.

DO NO HARM

"It's very easy to do harm in philanthropy, especially when you don't understand the circumstances on the ground, the culture, the unintended consequences—or have a way to deal with them. You have to be careful and remember to go by the old saying, Do no harm." Howard Buffett (Liu, 2015).

The largest mass poisoning in history started as an effort to provide clean drinking water to millions of people in Southeast Asia. In the 1960's, many people in Bangladesh were drinking from sources of surface water contaminated with sewage and falling sick. The United Nations started drilling shallow wells in Bangladesh and neighboring countries to help combat the problem.

The program was successful in its initial goal of reducing infectious disease. This prompted other governments, non-profits and private organizations to install wells with gusto. By the 1990s, over 10 million wells of this type were in use in Bangladesh and more in other countries.

However, the wells created another problem. The soils in Southeast Asia contain a high level of arsenic which seeped into the new wells. Over decades, people were slowly poisoned with contaminated drinking

water and began to develop skin lesions, cancer, cardiovascular disease and other problems. To this day, people are still drinking from contaminated wells and there is no easy solution in sight (Funkhouser, 2015).

Intervention, even with the best of intentions, can cause significant harm to communities. As the example above shows, it is important to consider the broader context of challenges in order to avoid creating even bigger problems.
To do no harm, important questions to ask are:
• What don't I know about the situation?
• What is the real situation on the ground?
• How will the intervention work with or conflict with local culture?
• What are the side effects?
• Are there hidden interactions I am unaware of?
• What is the worst case scenario? Can it be mitigated?

POSSIBLE SOLUTIONS

Howard Buffett has said "As a farmer, I am regularly amazed at how frequently non-farmers are charged with producing analyses and recommending solutions … farmers are best equipped to understand the issues farmers face, and they are best equipped to participate in developing practical solutions that work in the real world, not in hypothetical situations. When hypothetical solutions drive policy, it is a recipe for failure." (Introduction to Africa's Potential for Agriculture, 2015).

No one solution will be the magic bullet. However, through research, thought and a combination of individual, community, and governmental efforts progress towards water security in India can be made.

Integrated Watershed Management

Watershed management began in the 1950's in India but especially after the drought of 1987. The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) has been working to develop the Adarsha Watershed in Kothapally, India for over 15 years. The goal is for the Adarsha Watershed to be an example of effectiveness so that integrated watershed management techniques can be taught and implemented in many other watersheds. These techniques and practices include:

- The creation of watershed associations which are groups of farmers and village members who congregate to discuss problems and solutions in relation to water.
- Women self-help groups that aim to educate and empower women in local communities.
- Building check dams, gully control structures, sunken pits, and gabion structures which increase rainwater storage and give alternatives to wells for irrigation in a cost effective manner.
- Community orchards and plantations.
- Managed Aquifer Recharge to increase water for irrigation.
- Improved farming techniques such as broad-bed furrowing which conserves soil and water, contour planting, and the planting of cover crops.

Increasing rainwater efficiency through rain water catchment facilities and other structures has improved the water security in Kothapally, provided major socio-economic benefits, and has very little adverse effects on populations downstream. The application of education and techniques piloted in Kothapally to other villages in semi-arid India would increase water security, economic out-put, and the quality of life of many rural Indians.

More effective irrigation
The unreliability of rainwater has encouraged the use of other resources like underground aquifers. India is the world's largest user of ground water, with over 20 million wells (Taylor, 2013). Increased access to credit and improved technologies in the early 2000's made it possible for small scale farmers to have their own bore-wells. This allowed more farmers access to water on demand, and for a short period of time held great promise for a "democratization of irrigation." An increase in crop production year round for small holder famers in the semi-arid regions was possible and allowed many farmers to plant water intensive cash crops like rice and implement systems of agriculture which required increased inputs and fertilizers (Taylor, 2013). Increased access to groundwater also put a halt on many projects aimed at cultivating surface and rainwater resources such as canals, dams and other technologies for irrigation.

However, the supply of ground water for many farmers was short lived. By 2008 in the state of Andhra Pradesh an estimated 41% of groundwater blocks were either overexploited, or at semi-critical and critical levels (Taylor, 2013). The large increase in groundwater extraction did not come with an increase of water flowing into the aquifers. Now, many wells run dry in semi-arid zones by March, which is the start of the dry season. More affluent farmers could afford to deepen their wells as aquifer water levels dropped and a "race to the bottom" began (Taylor, 2013). This race for ground water has disenfranchised many small holder farmers in regards to water issues and left them in staggering loads of debt (Taylor, 2013).

Methods of irrigation such as drip irrigation can reduce the quantity of water needed to help plants flourish. Drip irrigation involves supplying a steady drip of low volumes of water continuously through the growing season rather than flooding the soil once then letting it dry out. Work by Daniel Hillel shows that keeping the soil continually moist through drip irrigation can actually increase yields per amount of water used. This allows farmers to be more efficient and better sustain themselves in times of water insecurity (Krajick, 2012). Another solution is as simple as repairing pipes. This could reduce the water needed to irrigate a field as an estimated 50% of water is wasted through pipe leaks in India (Veras, 2016). By reducing the amount of water they need, farmers reduce their vulnerability to water scarcity.

Land conservation
Land conservation practices including cover crops, minimal tilling, crop rotation, contour plowing, terracing, erosion control and other measures are vital because India's intense rainfall results in increase land degradation. According to a 2002 study done by the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) up to 51% of India's geographical area can be defined as degraded. Much of this is due to the inability of many villages and farmers to stop rainwater from flowing off of their land into rivers and streams. According to ICRISAT the efficiency of rainfall use is low, only about 30 to 45% (Wani, 2002).

Diversification of Crops
Many farmers in the semi-arid tropics of India began growing water-intensive cash crops during the increase in availability of ground water, credit, and access to fertilizers. As water levels in aquifers decrease and wells run dry, many of these farmers find themselves unable to grow such water intensive crops like rice, wheat, and cotton. Through a diversification of crops such as the ICRISAT suggested maize and pigeonpea cropping system, a farmer's susceptibility to large scale water problems is decreased and their economic output per year is increased. The green revolution has had and continues to give many benefits to India and has saved over a billion lives worldwide. But the misapplication of certain techniques to areas that are not well suited to mono-cropping agriculture like the semi-arid areas of India has increased many farmers' debt load and produced a system of agriculture that is vulnerable to changes in water availability. Through the diversification of crops, livestock and other economic incomes, farmers in the semi-arid regions of India can decrease their susceptibility to water security issues.

Infrastructure Improvement
Problems with infrastructure have major impacts on water security in the urban cities of India. However, smaller villages in the semi-arid tropics could benefit from investment in infrastructure as well. Through access to markets for a variety of goods, farmers would be less reliant upon water intensive cash crops that are easy to sell and could diversify their farms thereby decreasing their vulnerability to drought and floods.

Improved In-puts
Limited infrastructure impacts access to high-quality seeds, inputs, and markets. Without these many farmers are at a competitive disadvantage with the larger scale affluent farmers who have access to superior technologies. The extension of credit to many small scale farmers in the early 2000's has pushed many farmers into the continuous cycle of debt (Taylor, 2013).

Financing
An intensive study done in the state of Andhra Pradesh about the debt loads of farmers found that an increased access to credit may have helped farmers build up assets like wells and irrigation systems in the short term, but the reduction in water levels and crop production the past decade has led to farmers' inability to pay creditors in the long term which was correlated with the increase in mass farmer suicides.

Social Issues especially gender participation
Improving social issues especially gender participation, would make many subsequent possible solutions more effectively achieved. The continuation of the caste system, cultural customs and gender bias creates barriers to education and governmental benefits for many poor farmers and disenfranchises many women who play an integral part in food production (Cronin, 2015). There have been top-down governmental programs aimed at helping the rural poor such as the Swarnajayanti Gram Swarozgar Yojana Self Employment Program, the wage employment programs such as Rural Manpower Program and the Marginal Farmers and Agricultural Labourers Programme. Some of these programs have been effective however there has not been a major decrease in the poverty experienced by most rural poor (James, 2001). As outlined in "Gender Issues in Water and Sanitation Programmes," progress can be made by focusing on the four E's – empowerment, equality, efficiency, and environment. As well as the four C's: consortium, convergence, cooperation and capacity building. An important goal is income alternatives for females.

Population Control
Water security is dependent upon two major factors, the amount of water available and the demand. One solution is to increase the amount of water available, but the other is the decrease the demand. Norman Borlaug declared in his Nobel Prize acceptance speech that global food security cannot be achieved without population control. The promotion of contraceptives and the education of women and men on the benefits of smaller family size is the most effective way India can pursue water security. By decreasing the rate at which the population increases, India will allow for political, economic, and social development and give itself time to deal with water security issues before they increase to an unmanageable level.

Evaluation, Maintenance and Monitoring
To effectively implement possible solutions, evaluation and monitoring are vital to ensure that goals are being achieved and the right people are being helped. If not, changes need to be made.

IMPLEMENTING SOLTUIONS

Implementing solutions to increase water security is very complicated and will require:

- Recognition of the need.

- Cooperation and coalition building among everyone starting with farmers both female and male.
- Effective laws and regulations at the local, state and federal levels.
- Compromise rather than just competition for limited resources among agriculture, people and businesses.
- Financing from many sources especially within India but also including the World Bank.
- On-going participation of government at all levels, land owners, farmers, private business, and organizations.
- Dealing with unexpected challenges that arise in the process.

CONCLUSION

The outlook for India's future with water security is bleak. With a rapidly increasing population and the demand for water set to double by 2050, the nation of India has many challenges ahead. However, there is hope for the future. Rural villages and small holder farmers in the semi-arid tropics of India can increase their own water security through the diversification of croplands and decreasing their reliance upon ground water by using rainwater efficiency with integrated watershed management techniques.

The issues of water security, hunger, and education are inextricably linked and all three must be dealt with for the long term stability and quality of life of people to increase. Without effectively addressing the issue of water security in rural India, little progress can be made on the production of food and food security, and even less can be made on education. Applying the work of ICRISAT in Kothapally to the issues of water security in the semi-arid tropics of India is key to achieving more sustainable livelihoods for small holder farmers who constitute 78% of the nation's farmers and produce 41% of the nations food-grains (FAO, 2002).

As Norman Borlaug said when he concluded his 1970 Nobel Peace Prize acceptance speech, "by developing and applying the scientific and technological skills of the twentieth century for 'the well-being of mankind throughout the world', he may still see Isaiah's prophesies come true 'And the desert shall rejoice, and blossom as the rose … And the parched ground shall become a pool, and the thirsty land springs of water … And may these words come true!" (Borlaug, 1970).

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