

**Diet Diversification: A Food Based Approach to Control Micronutrient Deficiencies in Morocco's
Tifnoute River Valley
A Proposal for the High Atlas Foundation**

By

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Department of Environmental Science
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April, 2012

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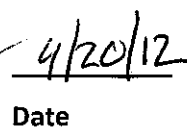
Submitted in fulfillment of the senior thesis requirements of the

Department of Environmental Science at Allegheny College

and approved by the senior thesis committee.



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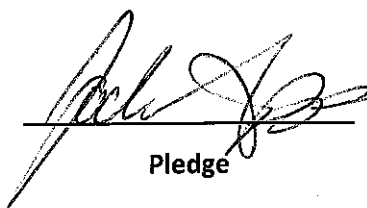

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First, my family. As a parent it is sometimes hard to understand the things a child does, but my parents have always had an ear for my stories, experiences, and even participated in a few debates. When I returned from Morocco they keenly listened to all I had to say and when I started my thesis they were eager from the beginning to see and possibly read the final product. In addition they always asked questions and gave me confidence and a kick in the butt when I needed it. Thank you for all you have done in the past year! Lastly, I would not be who I am today without your encouragement to follow my dreams no matter how far away they may take me. I'll never forget what you have done for me. I love you all. Thank you!

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Title: Diet Diversification: A Food Based Approach to Control Micronutrient Deficiencies in Morocco's Tifnoute River Valley

A Proposal for the High Atlas Foundation

Micronutrient deficiencies affect more than two billion people in the world, primarily in developing countries. As a silent form of hunger, they are unnoticeable to the naked eye, yet cause serious mental and physical damage if left untreated. Resulting from the inadequate intake of necessary nutrients, micronutrient deficiencies disproportionately affect the poor and impoverished. The Tifnoute River Valley in the High Atlas Mountains of Morocco is by no means impoverished, but it is a very isolated and rural ensemble of villages. Harvests last less than half of the year and incomes are small. With the assistance of the High Atlas Foundation, incomes have risen; however, as incomes continue to rise, communities show interest in discontinuing their subsistence agriculture regime in favor of relying on the profits returned from selling fruit from their fruit trees. In addition iodine, iron, and vitamin A deficiencies are already present in the Valley. To ensure these deficiencies aren't exacerbated by market fluctuations, this paper proposes the High Atlas Foundation take a food based approach, including diet diversification, fortification, and education. This combination will provide the Valley with nutrient rich crops to incorporate into their current agriculture system as well as knowledge and skills to sustainably increase their profits through value adding processes and preserve crops, extending availability into seasons of scarcity. This approach will increase community resilience by increasing crop variety, profit potential, and crop availability through preservation.

Key Words: Food Based, Nutrition, Morocco, High Atlas Mountains, Iron, Iodine, Vitamin A, Micronutrient Deficiencies, High Atlas Foundation, Fruit Trees, Diet Diversification

List of Abbreviations

VAD	Vitamin A Deficiency
IDD	Iodine Deficiency Disorder
(w)	Women
(m)	Men
RDA	Recommended Daily Allowance
t/ha	Tons per Hectare
HAF	The High Atlas Foundation
CIA	Central Intelligence Agency
UNICEF	United Nations Children's Fund
WHO	World Health Organization
ICCIDD	International Council for the Control of Iodine Deficiency Disorders
mcg	Micrograms
mg	milligrams
m	meters
NRC	National Research Council
AIWC	All India Women's Conference

1. Introduction

In the summer of 2011, I spent two months in the Tifnoute Valley of the High Atlas Mountains interning for the High Atlas Foundation (HAF), a non-profit organization founded in 2000, by Peace Corps veteran and current foundation president, Yossef Ben-Meir. HAF aims to assist local communities develop and maintain projects they create, allowing local communities to take control of their own development. As an intern, I was responsible for speaking to local communities about the current and proposed projects funded by HAF, especially their One Million Trees project. Launched in 2006, the One Million Trees project is an initiative aimed at reducing erosion and desertification and improving village resilience by increasing income and self-sustainability (HAF, 2011). This project is driven by Moroccan communities where barley and corn are no longer economically viable (HAF, 2011). The first Tifnoute Valley fruit trees were planted in Missouri and Tissalday in 1994 during Ben-Meir's Peace Corps service. Since then, both Missouri and Tissalday have experienced moderate success and most of whom I spoke to throughout the Valley showed great interest in planting their own fruit trees. However these discussions raised three very red flags.

The Tifnoute Valley is a fertile valley nestled within the High Atlas Mountains. Here the majority of villagers practice subsistence farming and animal husbandry. Most households own between 5-15 goats and sheep and one cow, two if they are of a higher socio-economic status. All of the land owners grow barley, which is primarily used to feed their animals during the winter. It is rotated with corn or wheat, and between the three grains, they use the majority of the available arable space. The remaining space is used to grow onions, zucchini, beans, potatoes, carrots, turnips, and tomatoes for domestic consumption. The total harvest is usually enough to sustain a family for a quarter to a third of the year. For the rest of the year, families rely on the market. However, when money is scarce villagers say they are not likely to purchase vegetables, but will instead purchase hospitality items such as tea, coffee, sugar, bread, and oil.

For a Muslim, hospitality is never sacrificed. No matter the time, things going on, or number of people, if someone arrives at their door they invite them in to relax in their guest room and offer bread and Moroccan Toureg tea, prepared with mint and an abundance of sugar. Given this culture, it is understandable that hospitality items would take precedence over other market purchases; however, for a family that has little income and whose harvest lasts them less than half a year, this seemed like a big risk. Red flag number one.

Their participation in HAF's fruit tree project has the potential to raise their income, allowing them to not only purchase hospitality items, but also to supplement their harvest. However, I was dismayed to learn that as their profits increased the less likely they were to continue with animal husbandry and subsistence farming. Their statements during our discussions alluded to their hope that the profit from the fruit trees would not only allow them to buy more food, but buy enough food that they wouldn't have to farm and also have money left to solve their road, erosion, and desertification problems. However, in a region where the roads are often washed out or blocked by snow, this idea seemed to be only half thought out. What would they do if the markets were unreachable for an extended period of time? Furthermore, how will families cope if profits and markets do not provide as expected? If all of the villages start their own fruit tree system, as they professed interest in doing, they are likely to flood the markets with their produce as more and more of the same fruit is offered and the already low prices will plummet. How will they purchase enough food without money to do so and no crops to rely on? Red flag number two.

Lastly, their intention to eliminate portions of their farming system in favor of a potentially high profit fruit tree agriculture system reduces crop diversity, by forcing them to rely on what makes it into their small weekly souks. Decreased crop diversity not only weakens food security, but also limits the variety and number of nutrients one receives. This on top of the current amount of sugar, tea, and bread they eat in comparison to the amount of vegetables they will eat if they no longer grow their own, made me wonder whether a diet focused on hospitality food rich in sugar and little vegetables could sustain one through seasons of scarcity. A little research showed that not only can seasons of scarcity lead to severe malnutrition and even death but Moroccans already suffer from malnutrition, especially in rural regions (UNICEF, 2010). Red flag number three.

Malnutrition is the inadequate intake of essential nutrients. In developing countries, this is often the result of food insecurity and poverty (Csete & Nestle, 2011). Child malnutrition is characterized by low birth weight, wasting, underweight, and/or stunting. In Morocco 15% of children are born with a low birth weight, 10% of infants (under age five) suffer from moderate to severe wasting and underweight, 23% of infants and 20% of children under the age of 15 suffer from moderate to severe stunting (UNICEF, 2010). Malnutrition can also present itself as a specific deficiency. According to Moroccan statistics from the United Nations Children's Fund (UNICEF), low intake of micronutrients has led Morocco to rank 68th for under five mortality with a rate of 33% (UNICEF, 2010). Iodine, iron,

and vitamin A deficiency are all quite high for Morocco's level of development. Iron deficiency affects 45% of children under the age of five while iron deficiency anemia affects one third of women in addition to 31.6% of school children presenting symptoms (Aboussaleh & Ahami, 2009; Belahsen, 2006; Uchendu, 2011). Vitamin A deficiency (VAD) is found in 40.9% of the population and specifically affects 29% of children under the age of five (Aboussaleh & Ahami, 2009; Belahsen, 2006; Nasri, El Bouhali, Aguenau, & Mokhtar, 2004; Uchendu, 2011). Lastly iodized salt, the most successful combatant for iodine deficiency, is consumed in only 21% of Moroccan households (Belahsen, 2006; Nasri, El Bouhali, Aguenau, & Mokhtar, 2004; UNICEF, 2010). Each of these deficiencies affects the population in a negative way, from decreased work capacity to brain damage and even death.

According to Mason, Rivers, & Helwig, (2005) the disease burden in developing countries could be halved by eliminating malnutrition. The main ways nutritional deficiencies are confronted are fortification, supplementation, and dietary diversification because micronutrients (Mason, Rivers, & Helwig,, 2005; Pinstrup-Andersen, 2000). Each technique has proven successful to a degree but each has its challenges as well. Supplementation works the best in urban or easily accessible areas but is less likely to succeed in rural and low-income areas where there is a lack of stable infrastructure, educated personnel, affordable transportation and ultimately the money to pay for the supplements (Haddad, 2000; Smith, 2000; Underwood, 2000). Fortification is a potentially viable and cost-effective solution as long as there is a centralized location to process the food, affordable transportation, income to purchase fortified foods or seed, and the public is both aware of and educated about the need for fortification, without which growing, purchasing, and consuming fortified crops will yield little acceptance (Smith, 2000; Underwood, 2000). Though supplementation and fortification are both plausible solutions, they are unlikely to completely eliminate a deficiency problem, especially when considering the inaccessibility to the rural impoverished (Jackson & Pellett, 2004; Mason, Rivers, & Helwig,, 2005; Underwood, 2000).

It is generally agreed upon by nutritionists that the best approach for reducing micronutrient deficiencies in rural and low-income areas, like the Tifnoute Valley, is to diversify diets through food based approaches, which include nutrition education and, in extreme cases, making use of purchased supplements and fortified foods (Aboussaleh & Ahami, 2009; Martorell, 2002; Mason, Rivers, & Helwig,, 2005; Scrimshaw, 2000; Underwood, 2000). Growing culturally acceptable, micronutrient rich crops are more likely to yield wholesome results rather than expensive, profit focused solutions (Underwood, 2000). By providing communities with knowledge, techniques, and skills to eliminate micronutrient

deficiencies, they become independent from handouts and government provisions, producing empowerment, resilience and self-sufficiency. If the Tifnoute Valley is to increase incomes, resilience, and self-sufficiency from the fruit trees, HAF must be proactive to prevent the elimination of subsistence agriculture and exacerbation of malnutrition and micronutrient deficiencies.

Through a food based approach focused on diet diversification and preservation techniques to increase crop value, HAF can assist communities within the Tifnoute to decrease iodine, iron, and vitamin A deficiencies. The proposed methodology will, in theory, be compatible with the Tifnoute Valley Berber culture, climate, and geography. This paper promotes the prosperity of the people of the Tifnoute Valley and through successful implementation it is hoped that, one day, prosperity will reign.

2. Methods

As an intern with the High Atlas Foundation (HAF) from May 20, 2011 to July 14, 2011, my task was to gauge public opinion about current HAF projects, particularly about the recently planted fruit tree nursery. With the help of my translator and Zahra Baaki, a HAF employee in our village, I arranged multiple sit down discussions in the villages of Aguerzrane, Amsouzerte, Missouri, Takatert, and Tissalday (Figure 6) with groups of men, groups of women, and groups of men and women. Questions for the first round were general, focusing primarily on fruit trees, agriculture, and climate/weather (Appendix A). These discussions were held from 6/5-6/7 in Aguerzrane, Amsouzerte, and Missouri (Appendix B). Questions for the second round were designed to build off the first round of questions. I discovered in the first round that my questions needed specificity; therefore many of the questions in the second round mimic the first round but were designed to yield clearer responses (Appendix C). Discussions were held from 6/21-6/24 in Aguerzrane, Amsouzerte, and Missouri (Appendix D). Results of this round raised a lot of red flags pertaining to their current agricultural regime and how they planned to change it given a more profitable fruit tree agriculture. The final round of discussions took place on 7/7 in the village of Missouri with only men (Appendix E). This round focused particularly on current tree populations planted in 1994, and the profits that have been made from them thus far. In addition to structured discussion, I also held conversations with individuals but these conversations still attempted to have them answer a set of questions (Appendix F).

In order to determine the existence and prevalence of micronutrient deficiencies in Morocco, I completed an extensive review of the existing literature. This literature review made use of databases accessible through Allegheny College's Pelletier Library, Google Scholar, and books from Allegheny College or acquired from another institution through the "EZ Borrow" system. I first looked for literature mentioning transitions in Moroccan agricultural practices from pre-colonization to the present that could have led to any nutritional disorders. Most of the information I found reported that as Morocco became more industrialized as a nation, more people were giving up traditional farm practices and diets in exchange for modernized practices and global commodities introduced during colonization and globalization. The effects of which showed a growing epidemic in chronic diseases and obesity, malnutrition, and micronutrient deficiencies.

Since the Tifnoute River Valley showed little signs of obesity and knowing that food was limited due to limited access to market goods found in most cities, I focused my research on the increasing occurrence of micronutrient deficiencies in Morocco, paying specific attention to the rural, mountainous regions. Studies conducted by Mason, Rivers, & Helwig; Uchendu; and Zimmerman found that iodine deficiencies were very present in both northern and southern rural and mountainous regions throughout Morocco. Vitamin A deficiency was also designated as a problem in Morocco by Mason, Rivers, & Helwig; and Nasri, El Bouhali, Aguenau, & Mokhtar. Aboussaleh & Ahami; Belahsen; Belgnaoui & Belahsen; Mason, Rivers & Helwig; and Zaida, Bureau, Guyot, Sedki, Lekouch, Arhan, et al. each indicated iron deficiency and anemia were present in many rural regions of Morocco. In addition databases belonging to the Central Intelligence Agency, United Nations Children's Fund, and World Health Organization report Morocco as moderately high in child mortality, underweight, stunting, wasting as well as stating nearly 80% of Moroccan households are not receiving iodized salt to supplement their iodine intake. The information presented in these studies led me to focus on three micronutrient deficiencies: iodine, iron, and vitamin A. From there I narrowed in on the causes of these deficiencies, specifically focusing on factors present in the Tifnoute Valley. Seeing a pattern, I proceeded to move forward with my proposed project.

Next, I researched their solutions and expanded on those that had potential to yield successful results in the Tifnoute Valley. The best solutions were diet diversification, fortification, and supplementation. Keeping in mind the characteristics of the Valley, I ruled out fortification and supplementation as the primary solution for iron and vitamin A, and focused instead on diet

diversification. In order to choose crops that would increase micronutrient intake, I researched the micronutrient content of crops native to Africa using the FAOs “Food Composition Table for Use in Africa” (Leung, Busson, Jardin, & NCCDC, 1968) and selected crops that would provide a large percent of the Recommended Daily Allowance (RDA) (NRC, 2001). Preliminary selections included crops possessing an iron content of at least 10mg and a vitamin A/Beta-Carotene equivalent of 500mcg per 100g edible portion. I then created a table (Table 5) that displayed the number of grams one would need to consume of each crop, in various forms, to ingest enough to meet RDA. From there I eliminated any crops that would require an unrealistic number of servings to meet RDA, reducing my list to fifteen crops. Then, using numerous sources I further reduced the list to those best fitting the elevation, rainfall, daylight, and temperature of the Tifnoute Valley’s (these sources are denoted in Tales 6 and 7 by subscripted number corresponding with their location in the list of references). This list was also reduced based on crop potential for: intercropping, pest resistance, high yield, appropriate length of growing cycle, potential for erosion control, long seed life, and similarity to culturally accepted crops. The final list contains ten different crops which are high in iron and/or vitamin A, can be processed into many different forms, and have high acceptance potential.

To determine crop acceptance, I relied primarily on my own personal observations, comparing what I ate in the mountains with the texture, taste, and appearance of the proposed crops. Furthermore, I used Berber and Moroccan cookbooks to verify the existence and use of the proposed crops in their culture. Lastly, I conducted a literature analysis to find reports documenting methods to encourage cultural acceptance and case studies where this was done before.

Dietary diversification approaches are only applicable for iron and vitamin A deficiencies. For iodine, dietary diversification alone will fall short; therefore, I propose alternative approaches to apply in conjunction with dietary diversification, such as, supplementation and fortification. Methodology for sustainable planting and economic specifications are not mentioned as they are beyond the scope of this proposal. Furthermore, this paper does not focus on the full processes by which the Tifnoute Valley can implement the procedures recommended, instead they are recommended as areas for further research.

The final results of this proposal will present a sustainable approach to limit the existence of micronutrient deficiencies which the High Atlas Foundation (HAF) can implement in conjunction with their One Million Trees project. This approach prescribes diet diversification and other food based

approaches as the primary means by which HAF can assist the Tifnoute Valley inhabitants to become healthy and resilient.

3 Background

3.1 Morocco

The Kingdom of Morocco, considered a part of MENA (Middle East and North Africa), is a topographically diverse region located in the North westernmost corner of the African continent (Fig. 1). It is home to three different environmental zones: coastal lowlands, mountain highlands, and eastern deserts (Fig. 2) (CIA, 2011; Nelson, 1985; Swearingen, 1988; US Department of State, 2011). The nation is home to four mountain ranges (Fig. 3): the Rif, the northernmost; Middle Atlas, running across the center of the country separating north from south; High Atlas where most Berbers live; and Anti Atlas, the southernmost (Gary, 1971). Much of these mountains exceed an elevation of 2000 meters and some in the High Atlas exceed 4,000 meters (Swearingen, 1988). The climate is Mediterranean with little seasonal variation on the coasts but extreme fluctuation moving inland (CIA, 2011; Nelson, 1985; US Department of State, 2011). There are two rainy seasons: April to May and October to November (Nelson, 1985). Although the coasts receive the most rain (Fig. 4), the mountains receive the second most amount of rainfall in the country receiving between 600 and 1200mm of rain. However, droughts still occur because rainfall is concentrated during the rainy season and the effects of a changing climate are creating more and more unpredictable precipitation (Appendix B; Hoffman, 2008; Swearingen, 1988). August is the hottest month of the year and January is the coldest; both months receive little precipitation (Nelson, 1985).

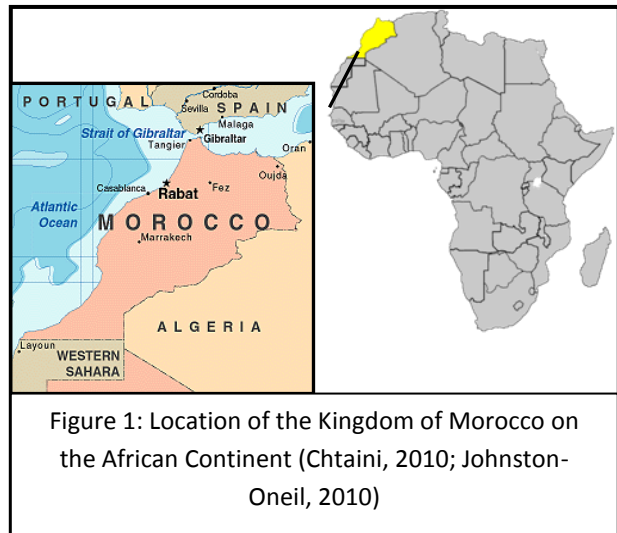


Figure 1: Location of the Kingdom of Morocco on the African Continent (Chtaini, 2010; Johnston- O Neil, 2010)

3.2 Impacts of Colonialism on Agriculture

Like many countries, Morocco had to first endure a period of colonialism before gaining its independence, leaving behind a legacy that to this day influences many operations within the nation. This section will focus on the effects colonialism had on agriculture, food production and consumption.

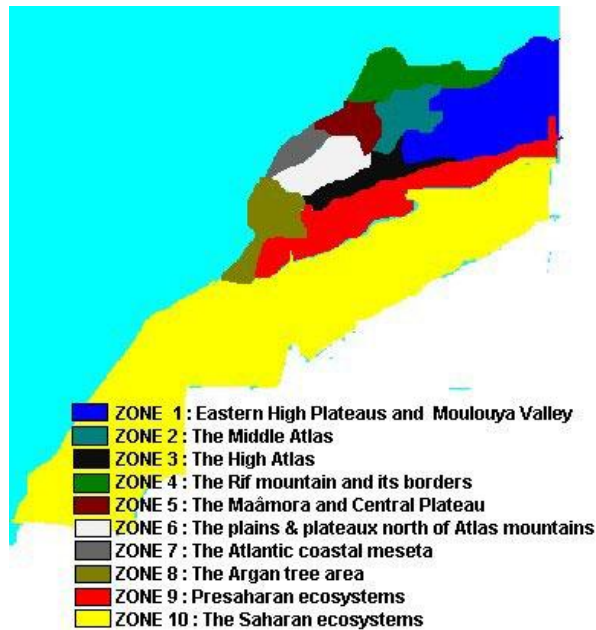


Figure 2: Ecosystems of Morocco (Berkat & Tazi, 2006).

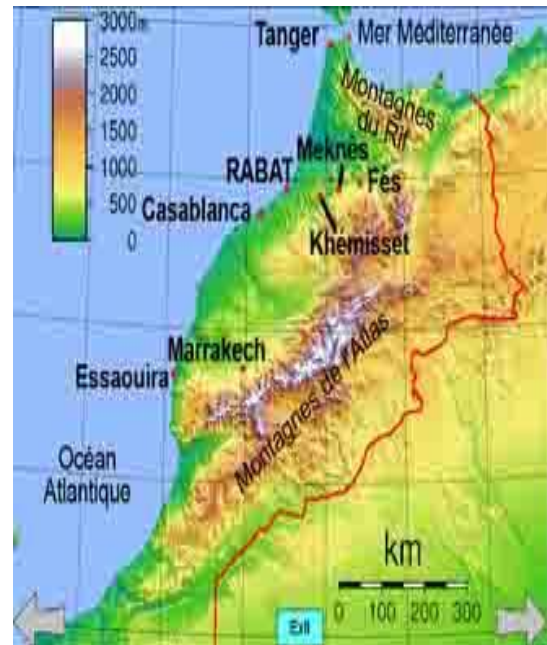


Figure 3: Mountain Ranges of Morocco (Berkat & Tazi, 2006)

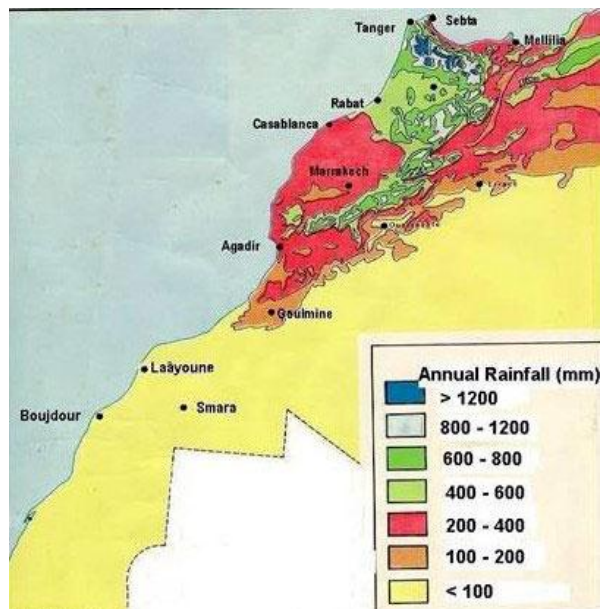


Figure 4: Annual Moroccan Rainfall (Berkat & Tazi, 2006)

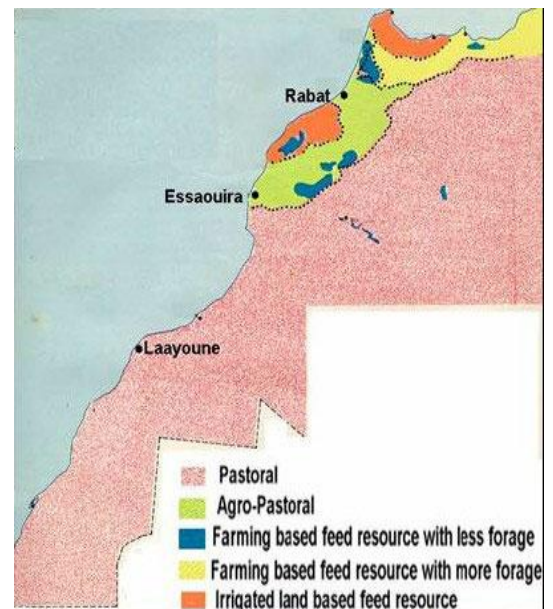


Figure 5: Moroccan Land Use (Berkat & Tazi, 2006)

In 1856, Morocco formed a trade and friendship pact with England, giving England commercial privileges such as free trade, import duties, and unrestricted grain exportation (Laroui, 1977). In 1861, Spain was included in the pact and even though the locals opposed it the pact gave Spaniard settlers the freedom to acquire land along the Moroccan coast (Laroui, 1977). From 1867 to 1912, Morocco experienced multiple droughts, locust plagues, and other climatic disasters, leaving much of the country struggling to survive (Holden, 2011). In order to feed its people, imports and hand outs from other nations were heavily relied upon, especially from 1878 to 1888, a time known as the Great Famine. During this period, Great Britain and France were the primary contributors, sending large quantities of wheat and tea, which the poor drank with small quantities of flour to stave off hunger (Holden, 2011). By the 1900s, Britain and France controlled the majority of Morocco's trade with forty and thirty percent respectively and sought to hold an even larger claim by conquering Morocco (Halstead, 1967). In their eyes Morocco was a fertile land with a varied climate, extensive forests and an abundance of untapped raw resources which they could exploit for their own purposes (Halstead, 1967; Swearingen, 1988). After many agreements between multiple nations, the Treaty of Fez turned Morocco into a French Protectorate on March 30, 1911 and it would remain so until 1956 (Halstead, 1967; Swearingen, 1988).

Throughout Moroccan history, the Berbers have constantly rebelled against all who sought to impose upon them a foreign culture, receiving in return their name which is derived from the word "barbarian" (Tayler 2005). Over time, however, the Berbers were driven from the fertile plains to the deserts and highlands. In the mountains, the Berbers found freedom, uninhabited land to farm, and grasses upon which to feed their livestock (Gary, 1971; Hoffman, 2008; Tayler, 2005). The centuries of unrelenting stubbornness eventually paid off. Though the French largely controlled Morocco, due to the "free and noble spirit" of the Berber people, conquering and converting the native peoples was a much harder task than was originally thought; and therefore, during the French Protectorate, the mountains were given autonomy and designated a "tribal area" (Gary, 1971; Tayler, 2005). In addition, after achieving independence, the new Moroccan government adopted a hands-off policy regarding the mountains, leaving the Berbers to thrive on their own (Tayler, 2005). However, although, they have been reasonably successful at maintaining their culture, they haven't entirely avoided foreign influence. Invasion by the Arabs in the seventh century led to the adoption of an Islamic faith; though Berbers have traditionally made it their own by rewriting many of the stories to fit their own history (Gary, 1971). Furthermore, pacts such as that of 1856 and the Treaty of Fez, allowed participating countries to export their grains and other goods without restrictions. In addition, the increase of foreign presence heavily

affected agricultural practice by introducing modern farming, soft wheat, fruit trees, and other foreign crops.

The most important task of the Protectorate was land reform. To the Europeans, traditional systems of communal lands and indigenous agricultural practices were barbaric, so the natives were forced to modernize and make room for arriving colonists (Halstead, 1967; Laroui, 1977). Under this reform, the protectorate individualized communal lands and allowed perpetual leases of Berber lands to colonists wanting to take advantage of the newly available lands (Halstead, 1967). When incentives didn't lure the natives to comply, those too stubborn to conform were forced off their fertile land, making room for compliant settlers. While large numbers of natives were left without land, French settlers were able to acquire multiple plots (Halstead, 1967). The result of the reform was an increase in the amount of cultivated land, rising from less than 2,000,000 hectares in 1919, to over 4,000,000 in 1938 (Halstead, 1967). Most of the land cultivated by French colonists produced soft wheat, a milling grain previously unknown to Morocco (Halstead, 1967). Exports were without restrictions and in a short time, soft wheat became the number one export increasing from 40 million to over 800 million, severely reducing production of native hard wheat and other traditional crops (Halstead, 1967).

Dependence upon such a small variety of crops left the Moroccan people vulnerable during droughts, locust attacks, and market price fluctuations during times of surplus and scarcity (Swearingen, 1988). In addition, with the increase of imports flowing in from European countries, foreign commodity prices began to fall, while local commodities rose as demands shifted. To compensate Morocco issued taxes, but this only benefitted foreign trade further as foreigners were exempt from such taxes (Laroui, 1977). Since Moroccan exports were also included in the trade agreements, it wasn't long before excessive export grain surpluses began to affect French markets as well. In order to appease farmers in their own country, the French placed bans and restrictions on imports from Morocco that challenged French sales. In order to compensate for the decreased export revenue, Morocco implemented the "California Dream." Both the climate and geography of Morocco are similar to the state of California, so Morocco hoped to access new markets by mimicking California's fruit tree agriculture (Swearingen, 1988). Eighty percent of Morocco's citrus is a California variety and since the program's inception has expanded from oranges to include lemons, tangerines, figs, pears, cherries, apples, pomegranate, apricots, peaches, plums and dates (Nelson, 1985; Swearingen, 1988).

3.3 Present Day Morocco

Today Morocco has a population of 32,309,239 (2012 estimate), with 58.8% (2010) of the total population concentrated in urban areas (CIA, 2012, UNDP, 2011). Though no statistics could be found, many sources present Berbers as making up the majority of the population as either a “true” Berber or of Berber descent (Bahaji, 2011). The lack of an accurate statistic is due in part to the same isolation that once provided them with the means to survive cultural take-over. Today their isolation has become a liability, leaving them vulnerable to poverty and hunger (Tayler 2005). Now, not only are they isolated by their protective mountains, but also by their language. Moroccan Arabic, the official language of Morocco, spoken by 80% of the population, fails to reach many isolated villages. In addition many Berbers do not care to learn a language that is different from that which their ancestors spoke: a dialect of one of three Berber languages: Tashelhit, Tarafit, and Tamazight, and so remain monolingual (Hoffman, 2008).

Though as a country, Morocco is considered an intermediate per capita income nation, most rural regions do not fall under this category (Musaiger, Hassan, & Obeid; UNDP, 2011). Over half of the labor force continues to practice agriculture. However, as the population and erosion have increased, the number of hectares per rural inhabitant has decreased to less than one-half (Swearingen, 1988; UNDP, 2011). The bulk of the farm population throughout the rain-fed regions of the country (Fig. 4) continues to practice traditional subsistence agriculture, using limited high-yield seeds, fertilizers, pesticides, and machinery. Pastoralism is a large component to their agricultural regime, especially in rural regions where it operates as a risk aversion practice (Bencherifa, 1988). Marginal lands serve as pasturelands for livestock and poultry; however, they are subject to cycles of starvation during seasons when fodder food is scarce (Bencherifa, 1988; Nelson, 1985). A farmer may own many goats and sheep but it is uncommon to own more than one or two cows in rural areas. Furthermore, Muslim culture only allows one animal to be killed or “sacrificed” per year, taking place during the Eid al-Adha, a remembrance of Abraham’s willingness to sacrifice his son, Ishmail. Muslims slaughter one cow, goat, sheep, ram, or camel that meets quality standards and is divided into three parts: one-third for the family, one-third for relatives, friends, and neighbors, and the final third to the poor. Modern agriculture is practiced primarily in the irrigated plains where large commercial farms grow beets, sugarcane, fruits, and some vegetables for export (Nelson, 1985). In addition, since implementing the “California Dream,” citrus has become one of the top export items, primarily grown by the wealthy. Due to limited access

and opportunity, purchasing power is low in rural areas, playing negatively on their food intake. In times of scarcity some families even skip meals (Musaiger, Hassan, & Obeid, 2011). However, ventures by organizations such as the High Atlas Foundation have allowed low-income families to profit from the fruit trees as well (HAF, 2011; Swearingen, 1988).

3.4 The Tifnoute Valley

The Tifnoute Valley is located within the Taroudant Province of the High Atlas Mountains at an elevation of approximately 1800m above sea level (Nemeth, 2012). Within the valley there are 28 villages (Fig. 6). The majority of these villages borders the Tifnoute River either on one or both sides and move up the mountainside. Houses typically take the form of a stone structure working up the mountainside with a wood roof. Since it is customary for sons to live with or near their father until his

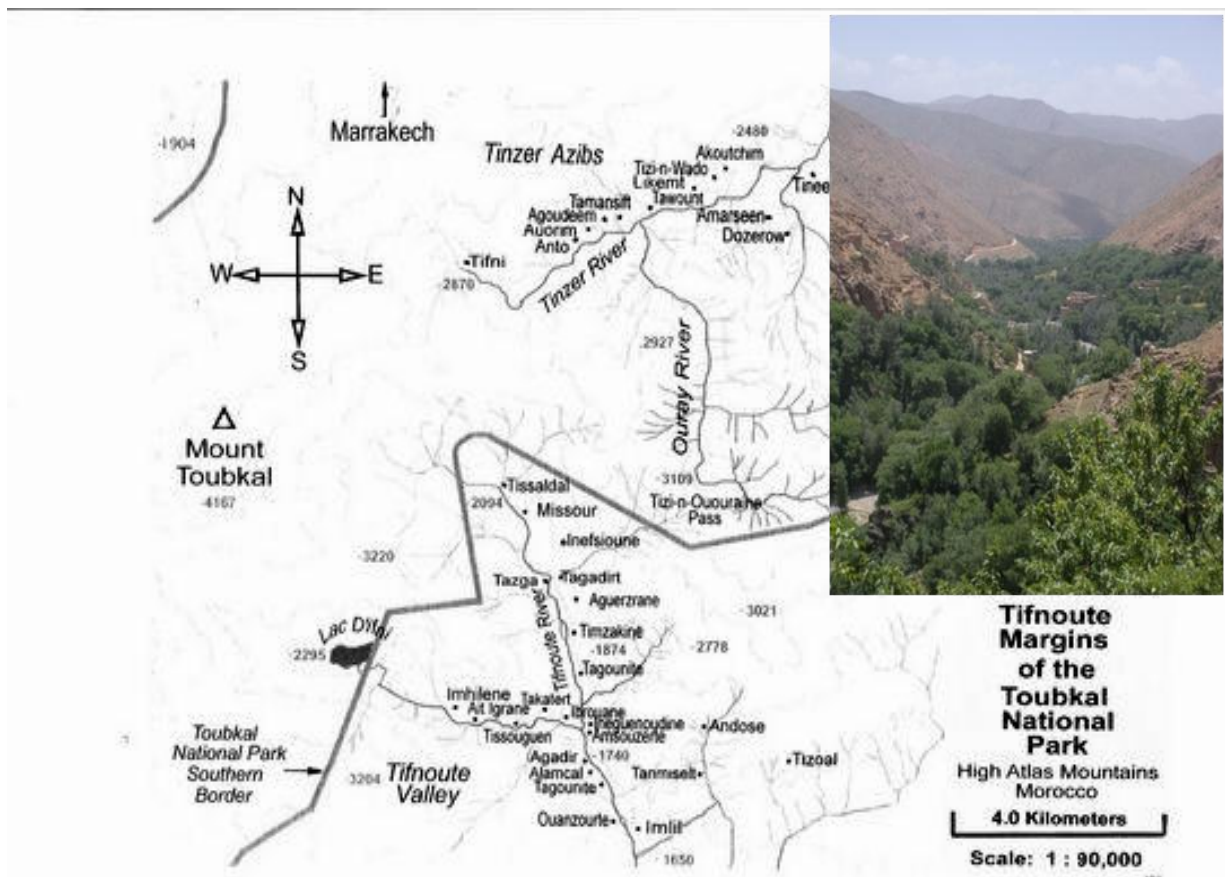


Figure 6: Map of the Tifnoute Valley and surrounding areas (Ben-Meir, 2011). Includes photo from June 2011

passing, a household usually contains multiple generations. Labor is owed to the presiding patriarch until his death and women owe labor to the patriarchal household into which they marry. Once the patriarch of the family dies, the land is divided amongst his sons—and unmarried daughters—and they are free to establish new patriarchal households (Crawford, 2010).

Since land is continuously divided amongst each family's sons, each generation has less land to their name. Each family owns anywhere from 0-15 terraces, with an average of 3 terraces per family. Each year this average shrinks and there is little opportunity to expand their land due to the intense labor requirements for cutting terraces into the mountainside. The fields and terraces in which crops are grown adjoin the village and are divided by raised irrigation canals that traverse the entirety of the village. These canals draw water from the river for lower levels and from manmade reservoirs found at higher elevations. By damming certain places along the canals, communities can direct the water toward different crops (Personal Observation). According to the villagers, space is the most limiting factor when deciding what to grow (Appendix B, D). High energy barley and maize are mostly grown for fodder but also slightly for subsistence and cover the majority of the terrace space. Approximately one-half of a terrace is reserved for vegetables such as onion, zucchini, tomato, potato, carrot, turnip or beans. However, depending on the number of terraces a family has, less space may be dedicated to vegetables. For villages where fruit trees are a part of the agricultural regime, terraces are further divided to include the trees, often reducing the space allotted to both grains and vegetables. Sometimes families have rooftop gardens or small plots next to the house in which vegetables and on occasion, lilies, a very big cash crop, are grown (Personal Observation). In addition, each family also owns between five and fifteen sheep and goats and, if they are lucky, one cow. Most of the barley and maize will be stored to feed the livestock throughout the winter and periods of scarcity.

Caring for the livestock and farming the land is the women's responsibility. Women are the primary caretakers of the family, household, and farm. Duties are split up amongst the different women in the house on a rotating cycle: some to cook, some to work in the field, some to care for the infants. Those going to the fields will tend to the crops, which may involve planting, weeding, harvesting, or adjusting the flow of the water canals. In addition they will gather fodder for their livestock and firewood for their ovens (Hoffman, 2008; Personal observations). They will make multiple trips from the fields to the household or storage building, carrying their load on their back. Duties in the house include: making the four meals, beginning at sunrise and ending near sundown, as well as hand washing

their laundry by the river, milking and washing the cows, and cleaning the house (Crawford, 2010; Hoffman, 2008; Personal Observation). The men typically handle matters pertaining to road care, village business, and attending the market. The market, known as a souk, is held one day a week in a designated location which nearby villages will attend (Mikesell, 1958). Amsouzerte, Tissalday, and Missouri primarily go to the souk on Wednesdays in the Toubkal Commune. Going to the souk is a deeply rooted tradition that not only provides villagers with a location to purchase their weekly provisions and sell their products, but also to have a voice in the center of political decision making (Mikesell, 1958). When one goes to the souk they can settle disputes, take care of any family business, and participate in discussions concerning their commune or village. Women do not take part in the activities of the souk and only attend if they are widowed or single.

4. Nutritional Deficiencies

Though many advances in health and nutrition have been made over the years through programs like the United Nation's Millennium Development Goals and UNICEF's many projects, according to the FAO, in 2009, the number of individuals experiencing "hunger" topped 1 billion for the first time in history (Csete & Nestle, 2011; FAO, 2009). Though a number that has been on the rise for the last few years, this record increase is attributed to decreases in household incomes as a result of the recent global recession (Csete & Nestle, 2011). In addition, the gap between urban and rural populations continues to grow, and access to social services is widely unavailable to the most poverty stricken (Aoyama, 1999; Jackson & Pellett, 2004). The most recent global recession has further decreased household incomes while staple food prices rose to historical highs, leaving the helpless and impoverished on their own. Because they neither have the money to afford help nor do they have consistent access to social services and institutions like hospitals, the impoverished are the most susceptible to nutritional deficiencies like "hunger" and "hidden hunger" (Aoyama, 1999; Csete & Nestle, 2011; Underwood, 2000).

Affecting over two billion people worldwide, micronutrient deficiencies have long been recognized as a public health problem, and are referred to as the "hidden hunger," "silent hunger," or "silent disaster" (Aoyama, 1999; Pinstруп-Andersen, 2000; Welch, 2000). Such names are derived from the often unnoticeable way in which micronutrient deficiencies slowly affect someone even though

he/she may consume an adequate or overabundant amount of protein and fat (Aoyama, 1999). Micronutrients are vitamins and minerals necessary for optimal physiological function, but which the body does not make in adequate quantities without ingesting nutrient rich food sources or supplements (Underwood, 2000). Micronutrient deficiencies are primarily found in infants, children, and women, especially those around child-bearing age (Ensminger, 1994a; Ensminger, 1994b; Nasri, El Bouhali, Aguenau, & Mokhtar, 2004; NRC, 2001; NRC, 1998; Zimmerman, 2006). Women must replace micronutrient stores much faster than men because of losses during their menstrual cycle, pregnancy, and lactation, while children require more because their body is in a state of growth, using micronutrients to build and strengthen tissues and bones (Belgnaoui & Belahsen, 2006). Nutrient deficiencies during pregnancy often result in a deficient infant and a severely deficient mother (Nasri, El Bouhali, Aguenau, & Mokhtar, 2004). The effects of nutrient deficiency in children include low birthweight¹, stunting², wasting³, undernutrition; anemia⁴, severe diarrhea, blindness, and death (Aoyama, 1999; Welch, 2000; WHO, 2008; WHO, 2011).

Agrarian reforms since Morocco's independence in 1956, focused on maximizing production of cereals such as hard wheat, soft wheat, and maize (Aoyama, 1999; Swearingen, 1988). This led to the decreased production of food rich in iron and other micronutrients such as pulses (lentils, chick peas, and broad beans), citrus fruits, and vegetables, as well as, native cereals crops such as millet (Nelson, 1985; Welch, 2000). Furthermore, the typical milling of these cereals and grains removes many micronutrients, making them even less nutritious than they already are (Welch, 2000). According to the United Nations Children's Fund (UNICEF) statistics on Morocco, low intakes of micronutrients have led Morocco to rank 68th for under five mortality with 33% (UNICEF, 2010). Furthermore, 15% of children are born with a low birth weight, 10% of infants (under age five) suffer from moderate to severe wasting and underweight, 23% of infants suffer from moderate to severe stunting with 20% of children under the age of 15 suffering from stunting as well (UNICEF, 2010). Anemia from iron deficiency is also quite high with one third of women and children presenting symptoms for anemia as well as 31.6% of preschool children. Vitamin A deficiency (VAD) is found in 40.9% of the population. Furthermore, Morocco is considered one of the most goiter affected Arab countries with iodized salt only being

¹ This occurs when one is born weighing less than 2,500 grams.

² This occurs when one has a low height for one's age.

³ This occurs when one has a low weight for one's age.

³ This occurs when one has a hemoglobin count below the threshold.

⁴ This occurs when one has a hemoglobin count below the threshold.

Table 1: Iodine, Iron, and Vitamin A Deficiencies

	Iodine	Iron	Vitamin A
Description	• Trace element essential for proper functioning of the thyroid gland and brain health • Stored in the liver, kidneys, muscles, heart and brain	• Found in cells • Carrier of oxygen and necessary for enzyme reactions • Stored in the spleen, liver, and bone marrow	• Fat soluble vitamin essential for vision, cellular reproduction, embryonic development and immune system integrity
Most At Risk	• Children • Pregnant women and infants • Infants born to deficient mothers	• Children • Pregnant women and infants • Menstruating women	• Children • Pregnant women and infants • Lactating women
Tifnoute Valley Susceptibility for Deficiency	• Easily leached mountain and floodplain soil at 2,000m • Far from the sea • Limited accessibility	• Cultural consumption of absorption inhibitors • Poor and rural populations • Low seasonal availability	• Poor and rural • Low seasonal availability
Morocco Statistics:	• Iodized salt only consumed in 21% of Households	• 1/3 of women and children have anemia • 31.6% of school children show signs of anemia	• 40.9% of the population deficient • 29.2% of 0-72 month age range deficient
Found outside the body in	• Soil • Seafood • Leafy greens	• Animal tissues • Non-meat animal products • Vegetables, grains, fruits	• Animal products • Deeply colored fruits and vegetables
Caused by	• Low Iodine content in soils • Overconsumption of goitrogens	• Inadequate consumption of iron rich crops • Overconsumption of inhibitors	• Low intake of animal products • Inability to afford the above
Effects	• Goiter • Impaired mental development • Cretinism • Stunted Growth • Death	• Anemia • Reduced work capacity • Impaired cognitive development • Premature death	• Anemia by impairing Iron metabolism • Impaired immune system • Night blindness and xerophthalmia • Premature death
Solutions	• Iodized Salt consumption • Limit goitrogen consumption • Increase soil iodine retention • Increase leafy green consumption • Decrease milling • Education	• Fortification • Bioengineering • Diversify and balance diets • Increase consumption of ascorbic acid • Decrease consumption of inhibitors • Process food: ferment, sprout, and cook to limit inhibition • Education	• Fortification • Bioengineer crops • Increase bioavailability • Increase consumption of dark green leafy vegetables and animal products • Education

consumed in 21% of households (Belahsen, 2006; NRC, 1998; UNICEF, 2010). These numbers clearly show that micronutrient deficiencies are still a public health problem (Belgnaoui & Belahsen, 2006; Jackson & Pellett, 2004; Underwood, 2000; WHO, 2011). The following sections will look at iodine, iron, and vitamin A deficiency in detail (Table 1).

4.1 Iodine

The micronutrient iodine is an element found only in trace amounts in the human body and is essential for the proper operation of the thyroid. According to the National Research Council (NRC) in their Dietary Reference Intakes report the RDA for iodine (Table 2) increases with age, leveling off around age twelve at 150mcg (micrograms). These amounts increase during times of intense growth such as during pregnancy (200mcg) and infancy (110-130mcg). The required amounts are much larger than those found in the human body and therefore, must be found outside the body for optimal operation of the thyroid.

Dietary iodine is acquired through the substances we eat and drink as inorganic iodate (NRC, 1998). During ingestion iodine is extracted from the ingested compound through a process called de-

Table 2: Recommended Dietary Allowance of Iodine

Age Group	Micrograms/day
0-6 months	*110
7-12 months	*130
1-8 years	90
9-13 years	120
14-70+ years	150
Pregnancy	220
Lactating $\leq$ 18-50 years	290

RDA amounts are based on the Dietary Reference Intakes by the National Research Council (2001)

*Adequate Intakes: recommended intake goals sufficient for infant needs but not an absolute amount

iodination, and absorbed into the blood stream, where it is then carried to the liver, kidneys, muscles, heart and brain. The most common substances with natural iodine stores are soil and seawater (ICCIDD, 2011). Areas near the sea are rarely deficient since seawater is the richest source of iodine; therefore, fish, seaweed, and other seafood are all very high in iodine. In contrast, areas farthest from the sea are at risk for developing iodine deficiency disorders (IDD). Soil often contains adequate amounts of iodine, however, in areas of high runoff, leaching, and erosion, such as those of great flooding and steep inclines, soil iodine content is often quite low (ICCIDD, 2011; Zimmerman, 2009). When soil iodine content is low, the amount of iodine in the food chain is also low (Ensminger, 1994a; ICCIDD, 2011).

Located in the High Atlas Mountains, the Tifnoute Valley is nearly 300km from the nearest sea, the Atlantic Ocean. Distance combined with very limited access to the sea creates an iodine deficiency trap in the valley. Often the only way to acquire seafood is to leave the valley, but opportunity to do so is dependent upon money or family in the city. Furthermore, during the rainy seasons, not only does the river flood, but there is also significant runoff from the mountainsides. As this takes place, the original iodine content is greatly decreased with each season, leaving little iodine to be taken up by plants and subsequently humans. Furthermore, in a study by Musaiger, Hassan, & Obeid (2011), iodine deficiency was found to increase with elevation. The study determined that goiter rates were significantly higher in the upper elevations with 27% to 19% high to low altitudes in Egypt and 31% to 16.8% in Yemen respectfully. The average altitude for the Tifnoute Valley is 1800m, significantly higher than cities and coastal regions (Nemeth, 2012).

Low intakes of iodine decrease the amount of thyroxine and triiodothyronine hormones that are secreted from the thyroid (Aoyama, 1999). These hormones influence chemical reactions to manufacture key proteins and regulate the oxidation rate within cells (Ensminger, 1994b; ICCIDD, 2011). A prolonged lack of iodine often leads to IDD. If at any time one becomes deficient, they are at risk of developing a goiter (Mason, Rivers, & Helwig,, 2005). A goiter is the only physical display of iodine deficiency, appearing as a bulge on the front of the neck from the swelling of the thyroid gland (Aoyama, 1999). Though it mostly affects appearance, a goiter can develop nodules and grow to large enough to press against the other neck organs, leading one to have trouble breathing or choke. Surgical removal is then necessary (Aoyama, 1999; ICCIDD, 2011). Females are the most at risk for developing a goiter since they develop when metabolic rates are low such as puberty and pregnancy (Ensminger, 1994b). However, the most severe impacts of deficiency are hindered cognitive development and mental

retardation in the form of cretinism. IDD is the number one cause of brain damage yet the easiest to prevent (Csete & Nestle, 2011; Jackson & Pellett, 2004; Johnson, Fordyce, & Stewart, 2003; Underwood, 2000; Zimmerman, 2009). Areas with significant iodine deficiency have a 10-15% lower average intellectual capacity and a 13.5 point lower mean IQ, affecting social and economic development (ICCIDD, 2011; UNICEF 2004).

Since more iodine is needed at key stages in life, such as childbirth, pregnancy, and infancy, the effects are most severe in infants and recent mothers. If at any time the mother is deficient during her pregnancy the fetus is affected. Often these affects are irreversible especially after the second trimester (Aoyama, 1999; NRC, 2001; NRC, 1998). It is estimated by Csete & Nestle (2011) that over 38 million babies worldwide are at risk per year and more than 20 million babies each year are born with some mental impairment (Initiative & UNICEF, 2004). During childhood, deficiency can cause stunted growth and motor function problems (Csete & Nestle, 2011; Zimmerman, 2009). Serious deficiency can also result in death of the infant or fetus by still birth or spontaneous abortion (Aoyama, 1999; ICCIDD, 2011; Mason, Rivers, & Helwig,, 2005; NRC, 2001; NRC, 1998; WHO, 2011; Zimmerman, 2009).

In order to combat the effects of IDD and to prevent the further acquisition of IDD, regions such as the Tifnoute Valley must actively add iodine to their diet rather than purely rely on stores in the natural landscape. Iodine is absorbed through ingestion; therefore, the only way to acquire enough iodine is to ingest a sufficient amount. The best and most effective solution at this time is fortification. Fortification enriches a product by adding essential minerals and vitamins, making it more nutritious. Typically fortified foods are those that are widely consumed in most cultures or those that are specific to that region. Some examples of fortified foods include flour, salt, wheat, and rice (Martorell, 2002). Iodized salt is the most successful fortified food to combat IDD's since there is little opposition to exchanging regular salt for iodized salt. Furthermore, since iodized salt costs as little as non-iodized salt, there is little financial obstruction. Despite both of these factors, only 21% of Moroccan households are receiving iodized salt (UNICEF, 2010). The Tifnoute Valley, like many rural mountain regions, has little accessibility; therefore, ensuring iodized salt reaches this area is difficult. However, with assistance from organizations such as HAF, ensuring iodized salt makes its way to the mountain souks is a relatively easy solution to prevent such detrimental effects. When supplying areas that have been significantly deficient for an extended period of time, it is important to carefully monitor the dosage they are receiving, as

they are at extreme risk to develop hyperthyroidism if too much iodine is absorbed too quickly (Ensminger, 1994a).

Although, consuming iodized salt is the most cost effective and efficient solution, there are others that help to create a holistic solution. First, one should limit the amount of goitrogens or absorption inhibitors one includes in their diet. Goitrogens prevent the human body from absorbing bioavailable iodine by binding minerals together (Ensminger, 1994a). They are commonly found in cabbage, turnips, cassava, raw soybeans, and crude fibers (Ensminger, 1994a). To reduce their effects it is best to limit consumption, limit goitrogenous activity through cooking, and accompany goitrogens with iodine absorption catalysts like vitamin C (Ensminger, 1994b). Second, one should increase the variety of iodine rich foods included in one's diet. Certain foods, like seafood and leafy greens, are very high in iodine; however, for areas like the Tifnoute Valley, the availability of fish is nearly impossible (Ensminger, 1994a). Importing fresh fish into the valley is impossible due to the time it takes to get from the coastal cities to the mountains and the lack of resources to transport seafood safely, without spoiling. Therefore, fish consumption is limited to canned or dried varieties. Leafy have an iodine content that increases with the proportion of leaves; however, their iodine content depends on soil iodine content (Johnson, Fordyce, & Stewart, 2003). Over time it is necessary to increase soil iodine content. Regions can increase soil nutrient retention by adding organic matter rich in iodine and changing the soil composition to one with a low pH, abundant pore space, and high microbial and root activity (Johnson, Fordyce, & Stewart, 2003). This process can take decades to establish a system that is not only rich in iodine but also successful at holding soil mineral content; therefore, the most effective first step is to ensure iodized salt is available in every household and action is taken to consume a balanced diet with more leafy greens and less goitrogens.

4.2 Iron

The micronutrient iron makes up .004% of the human body of which 70% is found in hemoglobin and the rest stored in the liver, spleen, and bone marrow (Ensminger, 1994b). Though a small percent of the body, iron is fundamental to life and vital for the following four functions: carrying oxygen to tissues as hemoglobin, oxygen use and storage in the muscles as myoglobin, electron transport as cytochromes, and a necessary part of enzyme reactions (CDC, 1998; Ensminger, 1994b). Since most iron

is found in hemoglobin, women are at the most risk of becoming iron deficient due to their monthly menstrual cycle losses. Iron stores fluctuate very little unless there is a great amount of blood loss or during a period of growth (Ensminger, 1994a; NRC, 2001; NRC, 1998). Infants, children, and pregnant or lactating women, therefore, require larger quantities of iron per day (Hallberg, 1981). The RDA for iron is similar for both males and females until ages 9-13 years (Table 3). After this time females require more iron in order to replenish iron lost during menstruation. However, like iodine, the human body doesn't create iron on its own; dietary iron must be added to the body.

Dietary iron is found in two forms: heme iron and non-heme iron. Heme iron is absorbed directly into the intestine when one consumes food containing hemoglobin such as red meats, poultry, and fish (Ensminger, 1994a; Hallberg, 1981). Non-heme iron, on the other hand, is found in non-animal foods like vegetables, grains, and fruits (Hallberg, 1981). Those richest in non-heme iron are apricots,

Table 3: Recommended Dietary Allowance
of Iron

Age Group	Milligrams/day
0-6 months	*.27
7-12 months	11
1-3 years	7
4-8 years	10
9-13 years	8
Males 14-18 years	11
Males 10-70+ years	8
Females 14-18 years	15
Females 19-50 years	18
Females 50+ years	8
Pregnancy	27
Lactating $\leq$ 18 years	10
Lactating 19+ years	9

RDA amounts are based on the Dietary Reference
Intakes by the National Research Council (NRC, 2001)

*Adequate Intakes: recommended intake goals
sufficient for infant needs but not an absolute amount

peaches, millet, spinach, peas, and beans (Ensminger, 1994a). Though, non-heme iron is the primary source of dietary iron for low income communities, only 10% of the iron present is available to absorb whereas between 15-35% of the available heme iron is absorbable (Ensminger, 1994b). However, heme iron sources are expensive and are consumed sparsely in much of the developing world (Schaetzel & Sankar, 2002).

While working in the Tifnoute Valley, I was fed meat nearly every day, sometimes twice a day. However, conversations revealed that meat was a very small or missing part of one's diet (Appendix B, D). Grains and vegetables comprised most meals, and during periods of scarcity, income is only partially used to purchase vegetables and grains. Rather, income is used to purchase hospitality items such as tea, coffee, bread, oil, and sugar. As a Muslim community, the Berber villagers place a lot of value on hospitality following the Quran principle:

"Whoever removes a worldly grief from a believer, Allah will remove from him one of the griefs on the Day of Judgment. Whosoever alleviates the lot of a needy person, Allah will alleviate his lot in this world and the next. Whosoever shields a Muslim, Allah will shield him in this world and the next. Allah will aid a servant of His so long as the servant aids his brother" (Forty Hadith of an-Nawawi 36).

By offering hospitality even when there is no room, provisions or excess money to do so, Muslims believe they will be rewarded in death. Hospitality typically takes the form of bread with oil and butter and Moroccan mint tea. However, like iodine, there are substances that inhibit iron absorption: tannic acid, found in tea; dietary fibers and phytates, found in unleavened bread; phosvitin, found in egg yolks; and antacids (Aoyama, 1999; Ensminger, 1994a; Ensminger, 1994b). Traditional varieties of bread eaten in the mountains are unleavened and are commonly eaten with tea at each of the four daily meals. Consuming a large amount of inhibitors in addition to low iron intakes from iron rich meat or vegetables produces a dietary imbalance and can lead to iron deficiency.

Iron deficiency is the most common and widespread deficiency, disproportionately affecting the poorest and least educated (Ensminger, 1994a; WHO, 2011). It is a subtle disease often remaining unnoticed until nearly too late. If left unchecked for too long, iron deficiency usually becomes iron deficiency anemia, a condition resulting from inadequate iron levels to initiate red blood cell production. When the size or number of red blood cells is inadequate, less oxygen reaches the tissues of the body causing shortness of breath, loss of appetite, rapid heartbeat, sores and cracks by the mouth, paleness, weakness, tiredness, dizziness, loss of energy, increased infection, and reduced intellectual performance

and work capacity (Aoyama, 1999; Ensminger, 1994a; WHO, 2011). It is estimated by Csete & Nestle (2011) that more than 1.62 billion people worldwide currently suffer from iron deficiency anemia (NCBI, 2011). In Morocco one-third of all women suffer from anemia, with 45% of children under the age of five and 31.6% of school children presenting symptoms (Aboussaleh & Ahami, 2009; Uchendu, 2011). Iron deficient and/or anemic mothers often give birth to deficient infants who are at risk for low birth weight, cognitive impairment, and even death (Csete & Nestle, 2011; Ensminger, 1994b; Musaiger, Hassan, & Obeid, 2011; Schaetzel & Sankar, 2002).

To combat iron deficiency it is best to increase one's meat and fruit intake. The most applicable approach is a food based approach including fortification, supplementation, and diet diversification. While fortification is usually successful, urban locations where access, supply, cost, and production are affordable are the most successful (Aoyama, 1999). Rural, isolated regions do not have the medical and transportation institutions to ensure fortified foods make it there, nor, do they have officials necessary to regulate the quality and distribution (Aoyama, 1999). On the other hand, fortification is much cheaper than supplementation, typically a pill or injection of vitamins or minerals to supplement the current deficient supply of a specific population (Aoyama, 1999). Supplements can effectively prevent and limit deficiency through applications during and after pregnancy, if she is not already deficient (NRC, 1998). Unlike fortification, supplements are preventative, not curative and are a short term solution in times of crisis (Thompson, 2007). Furthermore, supplements, though often integrated with other health policies, are more expensive than fortification. However, both of these options require monetary inputs and educated individuals to oversee distribution, which is often absent from rural, impoverished communities.

Both, supplementation and fortification might pose a problem for the Tifnoute Valley due to its isolation, lack of easy access in and out, and missing educated health facilities and officials that could administer and manage distribution. Diet diversification is the simplest and most effective solution for a developing country with few financial resources because it is not a lifestyle change, but a continuation of the practices in which most developing countries already partake. Furthermore, it is considered by many, especially recently, to be the safest and most sustainable solution. Deficient locations should not only diversify their diets but also limit the amount of iron absorption inhibitors are included in their diet on a daily basis. The diets of most poor communities rely heavily on grains that are often high in phytates and dietary fibers which limit absorption; therefore, limiting inhibitor consumption may pose a

problem (Schaetzel & Sankar, 2002). In addition, for Muslim communities like the Tifnoute valley, tea is not something that can be sacrificed; therefore, the other option is to increase growth and intake of iron rich crops. Though, non-heme iron has a much smaller absorption rate, the amount of absorbed non-heme increases fourfold when it is ingested with foods rich in ascorbic acid or Vitamin C (Csete & Nestle, 2011; Ensminger, 1994b; Hallberg, 1981; Schaetzel & Sankar, 2002). This can also be difficult for many low income communities as fruit is expensive in regions that do not have their own fruit production and fruit is not available year round in most climates (Schaetzel & Sankar, 2002). Fortunately the Tifnoute Valley has a significant amount of fruit trees; however, there is still the problem of year round fruit availability.

4.3 Vitamin A

Vitamin A is essential to the proper function of the human immune system as well as one's vision. Once in the body, vitamin A is converted into one of three forms: retinol, retinoic acid, or retinoids (Aoyama, 1999; NRC, 2001; NRC, 1998). Retinol converts light into signals, giving humans their vision. Serving the most purposes, retinoic acid is essential for regulating gene expression for various proteins and enzymes and is necessary for developing limbs, heart, eyes, and ears within the embryo during gestation (NRC, 2001; NRC, 1998). Retinoids maintain proper immune system function through cellular differentiation and proliferation (Aoyama, 1999; NRC, 2001; NRC, 1998).

Dietary vitamin A is absorbed by the body, typically through the intestine, as either preformed vitamin A or as a carotenoid such as β -Carotene (beta-carotene). While the human body can absorb 70-90 percent of preformed vitamin A, it is found solely in animal products (NRC, 2001; NRC, 1998). β -Carotene on the other hand, is found in most fruits and vegetables, but it has a lower absorption rate since it must first be converted to Vitamin A (NRC, 2001; NRC, 1998). For areas where animal products are rare, β -Carotene rich products such as spinach, peppers, and carrots, are essential for acquiring vitamin A.

The average RDA for vitamin A is smaller than that of iodine and iron and is measured in micrograms (1000 micrograms = 1 milligram). Furthermore, though intake similarly increases with age, males on average require more vitamin A than females in the 14-70+ years age group, only surpassed by females during lactation (Table 4). While breastfeeding, females require nearly twice the average

Table 4: Recommended Dietary Allowance
of Vitamin A

Age Group	Micrograms/day
0-6 months	*400
7-12 months	*500
1-3 years	300
4-8 years	400
9-13 years	600
Males 14-70+ years	900
Females 14-70+ years	700
Pregnancy ≤ 18 years	750
Pregnancy 19-50 years	770
Lactating ≤ 18 years	1,200
Lactating 19+ years	1,300

RDA amounts are based on the Dietary Reference
Intakes by the National Research Council (NRC, 2001)

*Adequate Intakes: recommended intake goals
sufficient for infant needs but not an absolute amount

amount of vitamin A with 1,200 and 1,300mcg per day for ≤ 18 and 19-50 year olds respectively (NRC, 2001). At this time, most of the mother's vitamin A is given to the infant through the breast milk; therefore, both infant and mother are at high risk of becoming vitamin A deficient if the mother has insufficient stores of vitamin A during pregnancy (Martorell, 2002; Nasri, El Bouhali, Aguenauou, & Mokhtar, 2004; Welch, 2000). Furthermore, severe deficiency in the mother can cause total blindness in the fetus (Ensminger, 1994a).

When someone becomes vitamin A deficient the retinoids, retinol, and retinoic acid slow down. Vitamin A deficiency (VAD) leaves one vulnerable to vision impairments, immune system failure, and impaired development. Vision impairments are the most recognizable symptoms of VAD. Xerophthalmia, the inability for the eye to maintain a coat of tears becoming dry and wrinkled, is the most severe ocular effect of VAD and often leads to blindness if untreated (Aoyama, 1999; Csete & Nestle, 2011; Ensminger, 1994a; NRC, 2001; NRC, 1998). Before xerophthalmia sets in, one first experiences night blindness (NRC, 2001; NRC, 1998). Night blindness is the inability for the rod cells in the eye to respond to changes in light, often leaving the subject unable to see in low light (Aoyama, 1999; Csete & Nestle, 2011). According to Csete & Nestle (2011), night blindness affects over 6 million

people, leaving half a million of them permanently blind once reaching the xerophthalmia stage. If night blindness is treated before xerophthalmia sets in, impairments improve rapidly (NRC, 2001). Night blindness is the stage at which VAD should be halted. If left untreated, half of those who go blind from xerophthalmia will likely die within twelve months of losing their sight (Csete & Nestle, 2011; Jackson & Pellett, 2004; Underwood, 2000).

In addition, VAD affects the immune system, and many resulting deaths are not solely from vision impairments but from the dual effects of vitamin A deficiency. When the retinoids do not work at an optimal level, the immune system does not function appropriately. Therefore, as many people suffer from the immediate vision effects of VAD their bodies are also struggling to fend off disease or illness even while their immune system is failing. Many VAD subjects often acquire infectious diseases such as measles or—most often— diarrhea. Diarrhea further inhibits the absorption of vitamin A and if severe enough can cause death from dehydration (NRC, 2001). Furthermore, vitamin A deficiency overlaps with iron deficiency; one typically leads to the other. VAD is known to cause anemia by impairing iron metabolism, while iron deficiency inhibits vitamin A absorption (UNICEF, 2004; Zimmerman, 2006).

The three main ways to combat VAD are fortification, supplementation, and dietary diversification. Professionals recommend administering a supplement to infants and children who are at high risk of developing VAD or providing a fortified crop variety. However, as mentioned above in section 4.1, supplementation and fortification are less viable in isolated areas with minimal access, health officials, and income. Sources with the highest vitamin A content are products with preformed vitamin A such as liver, fish, butter, whole milk, and egg yolks. In regions like the Tifnoute Valley, however, it is unlikely that villagers will be able to afford these products. It then becomes especially important for deficient regions to consume more β -Carotene rich products, such as carrots, sweet potatoes, and leafy greens denoted by their deep yellow, orange, red, and green color (Ensminger, 1994a). If regions can consciously increase their β -Carotene consumption during times of immense growth and pregnancy, they can ward off VAD.

5. Solutions for Implementation in the Tifnoute Valley

Micronutrient deficiencies, like most health problems, are solvable with a pill or another technological fix, but the most effective solution is derived from the root of the problem. Micronutrient

deficiencies result when the body hasn't consumed and absorbed a sufficient amount of micronutrients either in quantity or quality of nutrient rich food. Deficiency is therefore, the result of a poor diet (Thompson, 2007). In addition, one's nutritional status is often an indicator of one's financial status (Aoyama, 1999). The healthier one is the more likely that person is able to both eat the appropriate foods and see a doctor to correct any bodily problems. Poverty is, therefore, a common indicator of poor nutritional status. According to Csete & Nestle (2011), poor diet and nutrition are the leading cause for undernutrition and childhood morbidity and mortality, which affect more rural, low income people than urban upper class groups. A food based approach consisting of diet diversification, processing, and fortification in extreme cases, treats deficiency at its roots. Crop and dietary diversification can not only supply the body with multiple nutrients, but it can also, space out the growing season and increase food security through preservation (Ruel & Levin, 2000).

Fortification and in severe cases, supplementation are complementary to diet diversification. Diet diversification alone is an apt solution when there is enough time to both implement and experience the resulting benefits, however, in the interlude, fortified foods and, if necessary, supplements are viable solutions with the right assistance. For iodine deficiency, which is often the result of depleted soil iodine content, though efforts should be made to increase retention and soil iodine content, the time in which it would take to reach an adequate level to supply the population with iodine is longer than a single person's lifetime. Fortification, in this case, is the primary means of solving and preventing deficiency disorders such as cretinism and cognitive disorders. The following two sections: *Diet Diversification* and *Market Solutions* outline the benefits of application and the methods in which both can be implemented in the Tifnoute Valley to prevent and reduce iron, vitamin A, and iodine deficiencies.

5.1 Diet Diversification

Until recently, governments, health officials, and donors supported fortification and supplementation programs that were quick, easy, and yielded easy to measure results, however, the number of people suffering from hunger and food related deficiencies continued to rise (Thompson & Amoroso, 2010). It is now believed that neither fortification nor supplementation is effective on their own. Today, food based approaches, are considered viable and cost-effective sustainable solutions to

prevent and control the effects of micronutrient deficiencies (Thompson & Amoroso, 2010). By improving the intake of bioavailable nutrients through fruits, vegetables, and animal products, one can maintain a healthy lifestyle, even in areas of low access or little income (Thompson, 2007; Thompson & Amoroso, 2010).

The Tifnoute Valley, though not the most impoverished place in the High Atlas Mountains, is home to over 2,800 people who consistently live on the margin. A rare occurrence for many families in Aguerzrane, Amsouzerte, Missouri, and Tissalday, meat is not a viable option for most; therefore, this proposal places little emphasis on increasing consumption of animal products (Appendix B, D). Instead, it focuses on traditional fruits, grains, and vegetables. Traditional and native crops were chosen for four reasons. First, native crops are compatible with the climate without needing any genetic modification, therefore, crops native to Africa are typically adapted to drought and waterlogging. Furthermore, they often have root systems that can extend deep into the soil, extracting as much water as necessary and assisting to preventing soil erosion. Second, they require little fertilizer or pesticides with some even reducing pest and disease buildup (FAO, 1997). In addition, since they require few inputs and are native to the area, their cost is relatively low and available to all income types. Third, traditional plants are compatible with the palate and taste preferences of most native people. Traditional plants add taste and flavor to diets that are preoccupied with foreign imports and global staples (FAO, 1997). Furthermore, in many rural locations, traditional foods are grown in addition to global staple crops as a way to see them through seasons of scarcity, succeeding where non-native varieties fail. Lastly, traditional crops are naturally rich in minerals and vitamins, such as, vitamin A, iron, and calcium (FAO, 1997).

5.1.1 Recommended Crops

The following ten crops were chosen for their iron or vitamin A content and are compatible with the majority of the valley's culture and limiting climate factors: plant hardiness zones 9-11, 750mm of rainfall or less, average temperatures of 31 degrees North latitude, and an elevation of 1800-2000m (Table 5, 6). In addition each crop has the potential to serve doubly as animal fodder, erosion control or has seeds that can be saved for future plantings (Table 7). None of these crops are recommended as a

means to reduce IDD since iodine is not readily available through food sources where the soil is low in iodine content. Instead solutions for iodine are prescribed in section 5.2 *Market Solutions*.

Amaranth (*Amaranthus caudatus*)

Amaranth is an annual herb with red or green leaves and trailing tassels bearing very small seeds in a variety of colors (Infonet). Its iron content is five times more than that of wheat and is found all over the world. If eaten as a whole grain it takes fewer than 300g for males (m) and a little more than 400g for women (w) to meet the recommended daily allowance (RDA) for iron (Table 5). Amaranth leaves are high both in iron and vitamin A needing 172.69g for (m) and 248.91g (w) for iron RDA and only 57g (m) and 44g (w) for vitamin A RDA. Amaranth is also a valuable source of protein, lysine, methionine, fiber, and calcium. In addition, amaranth can also serve as a palatable and nutritious fodder crop for livestock. It is a rapid growth plant, sometimes ripening within a few weeks of planting (NRCS, 2006). In a good season, amaranth can have multiple harvests, lasting for more than ten weeks and seeds can be saved for three years. Furthermore, it can be intercropped with young fruit trees or utilized as a cover crop to prevent erosion (Agong, 2006; NRCS, 2006). It is recommended that amaranth be planted in place of barley or maize to increase iron intake as well as to prevent erosion.

Beans (*Phaseolus vulgaris*)

A warm season annual, beans are grown worldwide as a protein staple. Rich in protein, folate, riboflavin, copper, starch, and fiber, beans are an excellent source of iron and vitamin A (Table 5). The broad bean (*Vicia faba*) is already grown in the valley, but it is consumed sparsely. As a raw, podded seed men and women need only 273g and 212g to meet the RDA for vitamin A. As flour one needs only 153g and 220g to meet their RDA of iron. Though high in iron, broad beans are also high in tannins, absorption inhibitors, and therefore, should be processed to reduce their effects (see 5.1.2.2 *Processing*). The seeds, pods, and leaves are all edible and easily digested portions of bean plants and can be dried or cooked fresh. If dried, seeds can be saved for up to 7 years in the right conditions. The growing cycle is relatively short, lasting between three and five months depending on the species. It is a good nitrogen fixing cover crop and is a complimentary intercrop for cereals, deterring most pests. It is recommended that communities increase their bean intake, consuming more broad beans and growing more varieties. It should be noted however, that overconsuming broad beans can trigger genetic favism, an enzyme deficiency that can lead to anemia.

Table 5: Nutrition: Iron, Vitamin A, Vitamin C										
Crop	Processed Form	Intake required to consume 100% Recommended Dietary Allowance (grams)						Additional Nutrients		
		Iron ¹		Vitamin A ²		Vitamin C ³				
		Men	Women ⁴	Men	Women ⁴	Men	Women ⁴			
Amaranth (<i>Amaranthus caudatus</i>)	Grain, whole	283.50	408.80	-	-	NI	NI	Protein, Lysine, Methionine, Calcium, Fiber		
	Grain, toasted	595.34	907.18	-	-	-	-			
	Leaves	172.69	248.91	56.98	44.23	128.42	109.15			
Bean (<i>Phaseolus vulgaris</i>)										
Broad (<i>Vicia faba</i>)	Seeds, in pods, raw	618.87	874.02	273.29	212.62	NI	NI	Protein, Folate, Riboflavin, Copper, Starch, Fiber		
	Seeds, whole, dried	228.21	329.14	420.42	326.87	-	-			
	Flour	153.09	220.56	NI	NI	-	-			
Buckthorn (<i>Rhamnus prinoides</i>)	Leaves, dried	38.00	54.80	13.04	10.14	-	-			
	Seed, dried, pounded	8.06	11.62	7.63	5.93	-	-			
Millet										
African Finger Millet (<i>Eleusine coruana</i>)	Whole Grain	55.56	80.12	-	-	-	-	Energy ⁵ , Calcium, Potassium, Methionine, Protein, Oils, Carbohydrates, Amino Acids		
	Meal	17.43	25.14	-	-	-	-			
Pearl Millet (<i>Pennisetum glaucum</i>)	Whole grain	224.00	322.00	-	-	-	-			
	Meal	96.11	138.63	-	-	-	-			
	Bran	25.53	33.74	-	-	-	-			
	Seeds, whole, dried	53.07	76.54	NI	NI	-	-			
Peas (<i>Pisum sativum</i> and <i>P. arvense</i>)	Flour	84.07	121.24	189.47	147.37	-	-	Energy, Protein, Carbohydrates, Fiber, Calcium, Magnesium, Lysine, Methionine		
	Seeds, immature, raw	500.00	721.05	272.73	212.12	343.75	291.67			
	Seeds, mature, dry, whole, boiled	227.20	326.40	428.80	332.80	-	-			
	Seeds, mature, dry, split, w/out seed coat, cooked	556.84	789.88	NI	NI	-	-			
	Podded, raw	643.86	927.99	63.00	48.51	185.85	158.13			
	Podded, boiled, drained	NI	NI	156.80	123.20	628.80	532.8			
	Immature, green, raw	543.75	785.90	153.70	118.90	333.50	282.75			
	Immature, green, sweet, boiled	563.20	811.20	NI	NI	440.00	372.8			

Table 5: Nutrition: Iron, Vitamin A, Vitamin C

Table 5: Nutrition: Iron, Vitamin A, Vitamin C										
Crop	Processed Form	Intake required to consume 100% Recommended Dietary Allowance (grams)						Additional Nutrients		
		Iron ¹		Vitamin A ²		Vitamin C ³				
		Men	Women ⁴	Men	Women ⁴	Men	Women ⁴			
Peppers (<i>Capsicum</i>)										
	Bell (<i>Capsicum annuum</i> /c. <i>abyssinicum</i>)	Immature, green, raw	NI	NI	637.84	496.23	191.59	163.03		
		immature, green, boiled	NI	NI	216.87	168.68	87.03	73.71		
		Red, mature, raw	NI	NI	26.18	20.23	53.55	45.22		
	Chili (<i>Capsicum frutescens</i>)	Immature, green pods, no seeds, raw	NI	NI	71.10	55.35	21.15	18		
Red, mature, raw pods w/seed		NI	NI	1.80	1.35	9.90	0.86			
Red, mature, dried pods		123.60	178.04	1.13	0.85	NI	NI			
Pumpkin (<i>Cucurbita Pepo</i>)	Raw, diced	744.72	1074.16	34.8	27.84	574.2	487.2			
	Seed kernels, roasted	138.47	197.49	NI	NI	-	-			
	Flowers, raw	63.34	91.34	30	23	30.56	25.92			
	Deep yellow, raw	678.57	978.57	25.25	19.64	-	-			
	Leaves, raw	NI	NI	25.00	19.44	103.13	87.5			
	Leaves, dried	46.34	66.83	-	-	-	-			
	All varieties, raw	NI	NI	13.00	10.40	510.90	432.9			
Sweet Potato (<i>Ipomoea batatas</i>)	All varieites, baked in skin	NI	NI	6.60	5.40	225.00	190.8			
	All varieties, boiled in skin	NI	NI	14.30	11.70	630.50	535.6			
	Yellow, raw	-	-	71.71	55.78	-	-			
	Deep yellow, raw	-	-	37.50	29.17	242.65	189.19			
	Leaves, raw	-	-	15.33	11.83	NI	NI			
Teff (<i>Eragrostis tef</i>)	White, whole grain	45.96	66.34	-	-	-	-			
	White meal	44.51	64.07	-	-	-	-			
	Red, Whole grain	12.76	18.43	NI	NI	-	-			
	Red, Meal	19.85	28.44	-	-	-	-			

Table 5: Nutrition: Iron, Vitamin A, Vitamin C									
Crop	Processed Form	Intake required to consume 100% Recommended Dietary Allowance (grams)							
		Iron ¹		Vitamin A ²		Vitamin C ³		Additional Nutrients	
		Men	Women [*]	Men	Women [*]	Men	Women ⁴		
Winter Squash (<i>Cucurbita maxima</i>)	Leaves, raw	NI	NI	25	19	103.13	87.5	Magnesium, Folate, Calcium, Potassium, Vitamin E	
	All varieties, raw	918.72	NI	13.92	10.44	367.72	312.04		
	All varieties, baked	1186.95	NI	21.94	17.02	635.50	539.15		
	All varieties, boiled, mashed	NI	NI	31.85	24.50	1232.35	1046.15		
Acorn (<i>Cucurbita pepo</i>)	Raw	739.20	1065.40	53.20	40.60	413.00	350		
	Baked	861.00	1240.25	63.55	49.20	635.50	539.15		
Hubbard (<i>Cucurbita maxima</i>)	Raw	918.72	NI	12.18	9.40	435.00	368.88		
	Baked	1186.95	NI	18.66	14.56	824.10	699.05		

NI designates values that are not of significant enough quantity for an adequate intake of that nutrient

¹ Values were converted using the number of mg specified in Table 1

² Values were converted using the number of mcg specified in Table 2

³ Values were converted using the number of mg specified in by the National Research Council's Dietary Reference Intakes (55)

⁴ Is an average for ages 14-70+ and does not factor in times of greater need such as during menstruation, pregnancy, or lactation.

⁵ Food Energy Content: all components that provide energy after consumption

References: 28, 29, 37, 50

Table 6: Growing Conditions								
	Temps (°C)	Minimum Rainfall/water	Sunlight	Ideal Soil	Growing Cycle/time	Yield (tons/hectare)	Intercrop with...	Pest/Disease Resistance
Amaranth (<i>Amaranthus caudatus</i>) 1, 28, 29, 37, 61	•Tropical or Temperate •16-40 •Cold Sensitive	•300-550mm •Drought intolerant	•Some shade	•Light, sandy, fertile loam •Water retaining	•90-120 day cycle •Rapid growth •Multiple harvests	•4-14 t/ha	•Fruit trees •Maize	•Susceptible to foliar insects
Beans (<i>Phaseolus vulgaris</i>) 2, 28, 29, 37, 46, 84	•17.5-27 •Frost intolerant	•300-400mm •Waterlogging and Drought intolerant	•Full Sun	•Well Drained •Medium Texture	•60-90 day cycle	•1.3 t/ha	•Maize, cereals •Not with legumes	•Little Resistance
Broad Beans (<i>Vicia faba</i>)	•Mean: 13 •Temperate and subtropical	•700-1000 •Waterlogging and Drought intolerant	•Sunny	•Rich, well drained	•90-200 days	•8-9 t/ha	•Cereals •Creates shade	•Little resistance to fungal or rust disease
Buckthorn (<i>Rhamnus prinoides</i>) 27, 28, 29, 37, 66	•Avg: 10-15 •Cold and frost tolerant	•400mm	•Well lit or shaded	•Deep, well drained sandy loam	•4-5 years after planting	•10 t/ha •30 year productivity	•Until too shaded	•-
Millet 3, 26, 28, 29, 37, 60	•Semi-arid	•Some drought tolerance		•All except coarse sand	•60-120 day cycle	•2-3 t/ha	•With Legumes	•Very Resistant
African Finger Millet (<i>Eleusine corucana</i>)	•Temperate and subtropical •18-35	•500-1200mm •Waterlogging Intolerant	•12 hours	•Well drained, sandy-sandy loam •Water retaining	•50-120 day cycle •Potentially 2 crops per season	•Seed: .25-1.5 t/ha •1-2.5 t/ha	•Legumes, Pulses, Cereals, Vegetables, Maize	•Very Resistant
Pearl Millet (<i>Pennisetum glaucum/Pennisetum spicatum</i>)	•Arid •Tolerant to extremes •21-35	•250-750mm •Waterlogging and Drought intolerant	•Long days	•Light, well drained loams	•75-180 day cycle	•670-790 kg/ha	•One or several crops	•Mostly Resistant-- more than maize

Table 6: Growing Conditions								
	Temps (°C)	Minimum Rainfall/water	Sunlight	Ideal Soil	Growing Cycle/time	Yield (tons/hectare)	Intercrop with...	Pest/Disease Resistance
Peas (<i>Pisum sativum</i> / <i>P. sativum</i> var <i>arvense</i>) 4, 28, 29, 37, 53	• Temperate • 13-30 • Cool season crop	• 400-1000mm • Waterlogging intolerant	• Short days	• Well drained, fertile	• 60-90 day cycle	• 1-4 t/ha	• Esp broad beans	• Little resistance
Peppers (<i>Capsicum frutescens</i> and <i>C. annuum</i> / <i>C. abyssinicum</i>) 5, 28, 29, 34, 37	• Warm, mild • 18-24 • Intolerant to high temps	• 600-1250mm • Severe drought and flooding intolerant	• ≤ 45% shade	• Well drained, loamy	• 90-150 day cycle	• Hot: 1.5-18 t/ha • Sweet: up to 30 t/ha	• Tomatoes, Onions, and Pulses • Not with sweet potato or Jute	• Little resistance • Increased if intercropped
Pumpkin (<i>Cucurbita pepo</i>) 6, 28, 29, 37	• Temperate • 18-29 • Slight cold tolerance • Frost intolerant	• 250-500mm • Waterlogging and Drought intolerant	• Day neutral	• Well drained, fertile • Sandy, alluvial, or rocky	• 90-120 day cycle	• 5-8 fruits/plant • Seed: 400-500 kg/ha	• Maize, flower gardens	• Mostly resistant • Weak in humidity
Sweet Potato (<i>Ipomoea batatas</i>) 7, 28, 29, 37	• Warm, temperate • 12-35 • Frost intolerant	• 600-1600mm • Waterlogging intolerant	• ≥ 11 hours • 30-50% shade	• Well drained, sandy loam	• 120 day cycle • Variations with each cultivar	• 10 tubers/plant	• Very common • Rotate often	• Somewhat resistant • Cultivar dependent
Teff (<i>Eragrostis tef</i>) 8, 28, 29, 37, 60	• 15-35 • Frost tolerant • Humidity intolerant	• 300-1000mm • Adapted to Drought and Waterlogging	• 11-13 hours	• Any	• 45-160 day cycle • Red: short cycle • White: long cycle	• Straw: 3 t/ha • Grain: 1.7-2.5 t/ha • Stable yields	• Rotation plant: after pulses and legumes	• Highly resistant
Winter Squash (<i>Cucurbita maxima</i>) 6, 22, 28, 29, 37	• Tropical or temperate • 18-27 • Low temp tolerant	• Very little • Drought Tolerant • Waterlogging intolerant	• Semi shade or full sun • Long days	• Well drained, organic matter rich	• 90-120 day cycle	• 1-2 fruits per stem • Fruit: 5-15 t/ha • Seed: 3-500 kg/ha	• Cereals and field crops: maize	• Mostly resistant • Weak in humid tropics

Table 7: Benefits and Uses							
Crop	Main Areas of Cultivation	Labor	Palatability	Forms of consumption	Animal fodder?	Erosion control	Seed Life
Amaranth (<i>Amaranthus caudatus</i>) 1, 28, 29, 37, 61	•All Over, considered a weed in Europe •Carribean and humid lowlands of Africa and Asia	•Light: land prep, pruning, weeding and harvest (10 weeks)	•Leaves like spinach and artichoke •Mild, sweet, nutty •Soft texture	•Leaves, stems, seeds •Flour, porridge, salad, popped seeds	•Yes: seeds, straw, leaves •Palatable and nutritious	•Quick fix crop	•3 years
Beans (<i>Phaseolus vulgaris</i>) 2, 26, 29, 37, 46, 84	•Protein staple all over	•Weeding, staking, harvest (2-3 day intervals)	•Early harvest: bitter •When ripe: sweet	•Dry seed, pod, leaves •Dried, raw, soup, beverage	•Seeds, stems, leaves	•Cover Crop	•2-7 Years
Buckthorn (<i>Rhamnus prinoides</i>) 27, 28, 29, 37, 66	•Ethiopia to S. Africa	•Pruning, harvest (hand pick)	•Bitter like hops	•Seed, fruit, leaves - Tea, berries	-	•Ideal for land reclamation and nitrogen fixing	-
Millet 3, 26, 28, 29, 37, 60		•Land prep, weeding (2-3 weeks)	•Nutty flavor	•Cereal, roasted, boiled, flour	•Grains, greens, straw		•Up to 5 years
African Finger Millet (<i>Eleusine corucana</i>)	•East and South Africa •Very common in Uganda	•Intensive: weeding, harvest, milling (tiny seed)	•Pleasant, better than other grains	•Grain •Flour, bread, porridge, malted, popped	•Straw, stalks, hay •61% digestible nutrients	•Excellent •Strong roots •Better than Legumes	•10+ years
Pearl Millet (<i>Pennisetum glaucum/Pennisetum spicatum</i>)	•Semi-arid tropics of Africa and Asia •North Africa	•Land Prep, weeding (2-3/week), harvest	•Wheat and rice like •Made into couscous	•Grain •Roasted, flour, porridge, gruel, bread	•Straw, stalks	•Extensive and dense, deep root extension	•Preferred: hybrids affect productivity

Table 7: Benefits and Uses							
Crop	Main Areas of Cultivation	Labor	Palatability	Forms of consumption	Animal fodder?	Erosion control	Seed Life
Peas (<i>Pisum sativum</i> / <i>P. sativum</i> var <i>arvense</i>) 4, 28, 29, 37, 53	•Subtropics and high altitudes	•Land prep, weeding, harvest	•Already eaten	•Seeds, pods, foliage, vegetable •Raw, cooked, dried	•Seeds, straw, forage hay	•No	•1-3 weeks
Peppers (<i>Capsicum frutescens</i> and <i>C. annuum</i> / <i>C. abyssinicum</i>) 5, 28, 29, 34, 37	•Widely throughout Africa	•Weeding, staking, harvest	•Eaten in Berber cuisine	•Fruit •Sauce, spices, pickled, dried, processed	•Forage hay and seeds	-	•2-3 years
Pumpkin (<i>Cucurbita pepo</i>) 6, 28, 29, 37	•Tropic lowlands •All but Antarctica •Largely in Kenya and S. Africa	•Harvest (30-40 days)	•Slightly sweet flavor, similar to zucchini •Used in coucous and soups	•Shell, fruit, seeds, leaves, flowers •Boiled, raw, fried	•Vines and leaves	-	•Fruit: 5-6 weeks
Sweet Potato (<i>Ipomoea batatas</i>) 7, 28, 29, 37	•Tropics •East Africa	•Land prep, intense weeding, harvest	•Similar to squash, sweeter than regular potato, yam-like	•Roots, leaves •roasted, boiled, dehydrated (flour)	•Vines and other parts	•Ground Cover	•Replanted 2-3 days after harvest
Teff (<i>Eragrostis tef</i>) 8, 28, 29, 37, 60	•East African highlands: almost solely in Ethiopia	•Plant and leave; Intensive: harvest and milling (tiny seed)	•Mild and nutty; molasses like sweetness •Similar to millet and quinoa	•Grain •Flour, bread (Injera), beverages	•Forage hay, seed, or stalk •Nutritious and palatable	•Quick fix crop	•Multiple year storage
Winter Squash (<i>Cucurbita maxima</i>) 6, 22, 28, 29, 37	•South Africa and Sahel •Some varieties all over	•Harvest (2-6 months)	•Like sweet potato •Already eat squash varieties	•Fruit, leaves, seed, flowers •Bread, dried, raw, cooked	•Livestock feed	•Extensive root system	•Up to 9 months

Buckthorn (*Rhamnus prinoides*)

Buckthorn is a small shrub-like, berry producing tree, standing 2-4m tall. As a winter crop, it is adapted to withstand cold temperatures and even frost, flowering between October and December and bearing fruit between January and March (*Rhamnus prinoides*, n.d.). It is commonly found in both medium and high altitudes often along rivers, forest margins, and among rocks (*Rhamnus prinoides*, n.d.). It is ideal for land reclamation and for fixing nitrogen. In addition buckthorn is extremely high in both iron and vitamin A, requiring less than 60g of leaves and seed to meet RDA for both males and females (Table 5). As a dried seed, less than 10g meets RDA for both iron and vitamin A for both genders. In addition, this tree also has medicinal qualities and is used in many African nations as a purgative or a treatment for diarrhea, stomach ache, and respiratory infections (Dlamini & Turner, 2002). Furthermore, though it takes 4-5 years for this tree to reach fruit bearing age, once it begins to bear fruit it will do so for nearly 30 years, dropping up to 10 t/ha (tons per hectare). It is recommended that HAF incorporate this tree into their One Million Trees project in the valley as a winter crop to increase vitamin A and iron intake.

Millet

Millet is a cultivated grass with small edible seeds. It is adapted to semi-arid regions and is drought tolerant and disease resistant. There are two species of millet that are recommended for the Tifnoute Valley: African Finger Millet and Pearl Millet. Both are high in energy, calcium, potassium, methionine, protein, oils, carbohydrates, and amino acids, as well, as iron (Table 5). African finger millet (*Eleusine coruana*) in only 55.56g (m) and 80.12g (w) as a whole grain or 17.43g (m) and 25.14g (w) of meal supplies enough iron to meet RDA. In addition over 61% of the nutrients in millet stalks are digestible for animals, making it an excellent fodder supplement. Furthermore, finger millet is a quick growing grain with two potential harvests per season and possible seed storage ten or more years. Though not as rich in iron as finger millet, Pearl millet (*Pennisetum glaucum/Pennisetum spicatum*), when consumed as a bran, one needs only 25.53g (m) and 33.74g (w) to meet their RDA. In addition pearl millet is well adapted to temperature extremes, however, if seeds are not saved, they tend to become hybrids with decreased productivity. Both pearl and finger millets have extensive, dense, and deep rooting systems that not only extract nutrients and water from deep under the soil but are also excellent agents for erosion control (de Wet, 2006). Furthermore, both are easily intercropped with any

type and number of other crops. It is recommended that over time barley production decrease in exchange for one of the above millet varieties.

Peas (*Pisum sativum*/*P. sativum* var *arvense*)

Peas are a temperate, cool season crop rich in energy, protein, carbohydrates, fiber, calcium, magnesium, lysine, and methionine (Table 5). Dried seeds and pea flour have the best iron content, with 53.07g (m) and 76.54g (w) of dried seeds and 84.07g (ma) and 121.24g (w) of flour meeting RDA. Pea flour is also rich in vitamin A with less than 200g meeting RDA for both men and women. When peas are raw and podded men need only 63g and women only 48.51g to meet RDA and is also a significant source of vitamin C. Podded and boiled, as well as immature and raw, are also significant sources of both vitamin A and vitamin C. Peas are also a relatively low labor crop with a 60-90 day growing cycle. In addition, crop residues can be used as animal fodder. Peas are already eaten in the valley, however, they were a very rare presence in tagines; therefore, it is recommended that pea consumption be increased.

Peppers (*Capsicum*)

Peppers are widely cultivated throughout Africa, and though they are not native to the continent, chili peppers (*Capsicum frutescens*) are considered a traditional vegetable and spice. The chili pepper is a fast growing herb, typically with a red color and a very hot taste. It is high in both vitamin A and vitamin C with mature pods meeting vitamin A RDA for men and women with just 2 g (Table 5). The sweet bell pepper (*Capsicum annum*), though considered an exotic European vegetable, is becoming increasingly important as a summer vegetable. It too is high in vitamin A and vitamin C, though not as much as the chili pepper. When raw and mature only 26.18g (m) and 20.23g (w) of raw and 52.55g (m) and 45.22g (w) of mature peppers are needed to meet RDA for vitamin A and vitamin C respectively. Both chili and bell varieties are excellent for drying, allowing them to be eaten throughout the year. Furthermore, they are an excellent intercrop, handling up to 45% shade and compatible with tomatoes, onions, and pulses. It is recommended that peppers be intercropped with fruit trees and dried and sold in the souks as a spice.

Pumpkin (*Cucurbita pepo*)

Pumpkin is a trailing or climbing herb with large leaves, flowers, and a large berry. The shell, fruit, seeds, leaves, and flowers are all edible and are high in calcium, magnesium, and potassium as well as vitamin A, vitamin C and iron (Table 5). The flowers, leaves, and seeds are the highest in iron with only 46.34g (m) and 66.83g (w) of dried leaves needed to meet RDA. Leaves, flowers, and fruit are also high in vitamin A and raw flowers have a very high content of vitamin C, aiding in iron absorption. *Cucurbita pepo* varieties are drought and cold tolerant with a moderate growing cycle between 90 and 120 days. It is recommended that pumpkin production be initiated to promote food security and micronutrient intake.

Sweet Potato (*Ipomoea batatas*)

A vine-like perennial, sweet potato has more beta-carotene than any other member of the carotene family. Raw or cooked, vitamin A RDA is achieved with less than 15g (Table 5). The leaves are also a source of vitamin A, meeting RDA with only 15.33g (m) and 11.83g (w). Sweet potatoes are such a great source of vitamin A that many nutritionists have started to promote sweet potatoes as an agent to combat vitamin A deficiency around the world. However, sweet potatoes are also a rich source of vitamin C, protein, thiamin, riboflavin, folic acid, and potassium, making them an even more nutritious option for diet diversification. Slightly drought tolerant, sweet potato can also act as ground cover and tolerates up to 50% shade. It is recommended that villagers rotate sweet potatoes with current varieties to prevent the accumulation of diseases from recurrent plantings.

Teff (*Eragrostis tef*)

Teff is an annual grass, native to Northern Ethiopia. There the highest yields were gathered between elevations of 1800-2000m with 750-850mm of rainfall and an average daily temperature between 15-27 degrees Celsius. Each of these limitations is a direct match with the Tifnoute Valley; however, teff production has yet to spread much farther than Ethiopia. Teff is an unmatched source of iron with one needing no more than 30g from red teff and 70g from white teff to meet RDA. However, when eaten before processing, most of the iron content is bound by phytic acid. Therefore, teff must first go through fermentation or malting in addition to being consumed with absorption enhancing vitamin C to increase the amount of bioavailable iron. Though teff is a little more laborious post-harvest, the time from sowing to harvest is “hands off.” Teff seeds are so tiny, one handful is sufficient to cover

nearly a whole terrace. On average, one single teff plant yields over 10,000 seeds. Furthermore, teff's resilience and soil flexibility are worth the extra labor needed for harvest and processing. In addition to being drought, waterlogging, and frost tolerant, it can grow in any soil type, be used as a quick, nutritious and palatable fodder crop, or as a cover crop to prevent soil erosion. It is recommended that teff be planted on both lands that are currently saved for barley, wheat or maize and marginal lands to be used as a nutritious erosion control and fodder suppliant.

Winter Squash (*Cucurbita maxima*)

Unlike its cousin *Cucurbita pepo*, Winter squash (*Cucurbita maxima*) is a winter fruit with less water and more fiber, sugar, and protein. It is a significant source of vitamin A, with nearly all varieties meeting RDAs with less than 50g (Table 5). Nutrient content is greatest when consumed raw, but when baked, values decrease only slightly. Winter squash requires very little water and is drought tolerant. In addition it has an extensive root system for controlling erosion. Its growing cycle lasts between 90-120 days, occurring during the cooler months with a 2-6 month harvest. Similar to pumpkin, squash can be stored for many months, increasing food security during seasons of scarcity. It is recommended that squash be used both as a means to control soil erosion as well as to increase food security and control of micronutrient deficiencies.

5.1.2 Preparation, Processing, and Preservation

The aforementioned crops are all high in either iron or vitamin A; however, overcooking and consuming too many absorption inhibitors can significantly limit the amount that is absorbed. The following sections: preparation, processing, and preservation prescribe actions that will increase nutrient bioavailability as well as food security and profits.

5.1.2.1 Preparation

Nutrients are absorbed through the stomach tissue; therefore, our meal combinations directly affect bioavailability. The best way to increase nutrient bioavailability is to improve food preparation and consumption practices. First, when cooking, it is important not to overcook, especially leafy greens,

since longer cooking times yield fewer nutrients (Ensminger, 1994a). However, it is essential to cook goitrogens, since cooking prevents the absorption inhibiting process from occurring. It is important then, to know which cook times are best applied to different crops. The second method is food to food fortification, a dietary modification technique that consists of consuming foods that act as absorption catalysts or increase the micronutrient bioavailability of other foods (Ruel & Levin, 2000; Thompson, 2007). Food to food fortification can take the appearance of limiting absorption inhibitors while increasing absorption enhancers. Absorption inhibitors include phytic acid, tannins, dietary fibers, and goitrogens. Iron absorption inhibitors are a very common appearance in Tifnoute Valley diets. High in phytic acid and dietary fibers, tea and coffee, as well as unleavened bread, are regular meal accompaniments. Eliminating tea consumption in infants until at least the age of five and reducing the amount of tea, coffee, and unleavened bread that is consumed during meals can significantly increase the amount of bioavailable iron (Schaetzel & Sankar, 2002). In addition by simply waiting 1-2 hours between the meal and drinking tea or coffee can significantly decrease inhibitory affects (Ruel & Levin, 2000).

The other side of food to food fortification is to consume more absorption enhancers (Thompson, 2007). Absorption enhancers are nutrients that assist the absorption of other nutrients such as vitamin C or ascorbic acid. According to Thompson (2007), the amount of bio-available iron can increase to a level similar to meat products if at least 25mg of vitamin C is consumed with each meal. Of the ten recommended crops, peppers (chili and bell), pumpkin flowers and leaves, and winter squash have the most vitamin C (Table 5). In addition most citrus fruits, including many of those grown throughout the valley, are also high in vitamin C. By eating fruit and other crops rich in vitamin C and ascorbic acid with every meal, families can increase nutrient iron and vitamin A availability. In Nigeria, by incorporating a baobab fruit pulp drink into the diets of 6-8 year old for three months, hemoglobin counts rose from 10.85g/dL to 12.92g/dL. The study conducted by Nnam (2004), concluded that consuming a high vitamin C diet such as one with baobab fruit (60mg), increases iron absorption to a degree that reduced deficiency (Nnam, 2004). Food to food fortification is, however, a tricky process and the addition of even the slightest amount of certain spices (e.g., oregano) or a cup of tea can limit absorption (Thompson, 2007).

5.1.2.2 Processing

In addition to food to food fortification, there are a number of processing techniques that can also increase bioavailability, such as fermentation, malting, and soaking (Ruel & Levin, 2000). These processes decrease inhibitory action. Fermentation and malting involve enzymatic hydrolysis of phytic acid. Using naturally present microorganisms, fermentation increases other nutrients such as riboflavin. This is an ideal process for cereals, legumes, and vegetables. The process of malting increases phytase activity, releasing phytic acid. It also increases the vitamin C and riboflavin content in addition to iron (Ruel & Levin, 2000). This process induces germination by placing grains in water until they sprout after which they are dried. Malted grains are commonly used for porridge and are a popular food for babies and the elderly (Ruel & Levin, 2000). Lastly, soaking consists of soaking crops in water for a period of time whereby the phytic acid hydrolyzes (Ruel & Levin, 2000). Each of these processes has the potential to significantly reduce if not eliminate the action of phytic acid and other absorption inhibitors.

5.1.2.3 Preservation and Storage

Once harvested most crops are typically eaten right away, stored for a few days until they can be eaten, or sold in the market. Large harvests, those too large for one family to consume before spoiling, often go wasted if they cannot be sold in the market (Ruel & Levin, 2000). However, markets can only absorb so much of one type of crop before demand decreases and prices plummet. Any harvested food left unconsumed translates to both a loss in profit as well as a loss in vital nutrients that could have otherwise helped to improve health. For population groups entirely dependent upon their crops for feed and profit, wasted crops are a significant loss. Therefore, preservation and storage are crucial technical skills to include in any food based approach. Preservation techniques include drying, jarring, and adding value. Not only does preservation have the potential to increase household income by adding value to a product, but more importantly, it can increase food security by limiting post harvest losses and increasing food and nutrient availability during periods of scarcity (Ruel & Levin, 2000).

The most applicable preservation methods for the Tifnoute Valley are sun drying and value adding. Sun drying is the process of drying fruits or vegetables by leaving it out in the sun to dry for an extended period of time. This process eliminates moisture from the crop, extending its post harvest life. If stored properly, dried crops can last for months. In addition, drying can preserve more of the

micronutrient content that is traditionally lost when cooking (Ensminger, 1994a). However, sun exposure can significantly decrease β -carotene content, therefore, when affordable many regions have switched to solar drying (Ensminger, 1994a; Ruel & Levin, 2000). Solar drying is a mechanical process that dries crops in the shade while using higher air temperatures and lower humidity to increase the rate of drying and moisture content removed (Ruel & Levin, 2000). Though this method is proven to work more efficiently and to preserve more micronutrient content, the cabinet-like product requires monetary investment.

During a pilot project in India, the All India Women's Conference (AIWC) demonstrated the commercial viability of solar drying by placing four 50 kg dryers in four different communities (Balakrishnan & Banerje, 2006). Each dryer cost 1700 USD; therefore, though solar dryer costs are not unaffordable, this method may not be economically feasible at startup. The AIWC, however, experienced much success and demonstrated it to be an "ideal source of income generation for poor women;" therefore, solar dryers should be implemented in the near future. Preservation techniques can also add value to a crop and increase profits (Balakrishnan & Banerje, 2006). Value adding is the process of making it more attractive or readily usable for a buyer. Examples of products that can add value include jam, juice, spices, and bread. This concept will be explored further in the next section.

Once a crop has been preserved, it must be stored appropriately to maximize the length of time it will remain edible and nutritious. Appropriately storing preserved crops can ensure the availability of that product at opportune times, such as when market prices are high or food is scarce. In addition, one can also store seeds which can then be used for future plantings, eliminating much of the necessity to purchase new seeds each season. Of the nine recommended crops, most can handle seed storage for months if not multiple years (Table 7). The valley already has storage facilities in most of the villages, in which they typically store their grains, with adequate spacing and effective management, they can use this space to also store their seeds and preserved crops.

5.2 Market Solutions

Increased profits allow communities to supplement their harvests with additional items such as meat, fruit, and even fortified foods. Increasing consumption of meat, animal products, and fish, can significantly raise absorption rates for both vitamin A and iron. In addition it will allow communities to

purchase emergency supplements and fortified foods like iodized salt. Profits can be increased in a number of ways. First, crop diversification allows farmers to present a more diverse array of produce at the marketplace, creating competition amongst his neighbors. Second, products that have been modified to add value by making them more attractive or convenient can be sold for a higher price and will have less competition since less are likely to sell the same product. Value added products, such as dried fruit, leaves, and seeds, as well as jams, juices, and spices can all create new market demands. Cherries and apples are the most abundant fruit visiting the Tifnoute Valley souks at this time and have great potential for drying. In addition, by introducing new crops and preserving both new and current crops, villagers can create resiliency against market fluctuations, harvest extremes, and nutritional deficiencies. It is recognized that most of the preparation, processing, and preservation tasks are completed by women. Some of the aforementioned crops are labor intensive and have in other cultures been avoided in favor of less laborious crops, however, as I will describe later (Section 5.4), men should be encouraged to partake in these activities by assisting or managing the processing and sale of their crops, thereby removing some of the burdens of labor from women.

Additionally, increased profits can provide opportunities for communities to collaborate with government or non-governmental entities to ensure fortified foods, such as salt, flour, and sugar reach them. Fortification is an excellent approach to preventing or relieving micronutrient deficiency when implemented in conjunction with food based approaches. This is especially helpful when food supplies or market access is limited and cannot supply an adequate amount of nutrients to the population. However, it can also serve as the primary means to prevent and eliminate deficiency if other options would take too long to implement. Diet diversification cannot prevent IDD. The most effective way to reduce and prevent the occurrence of IDD is to add iodized salt to one's diet. Not only is iodized salt widely accepted throughout cultures, it is also similar in price to unfortified salt (Thompson, 2007). Fortification can, therefore, be a very viable solution if implemented appropriately and as a part of a food based approach (FAO, 1997; Thompson, 2007).

For regions or individuals that are severely deficient or vulnerable to deficiency such as menstruating and pregnant women, supplementation is an approach that can quickly increase one's nutritional intake (Schaetzel & Sankar, 2002). However, too many supplements can have adverse affects on the human body and therefore, should be restricted to use with only those who are vulnerable to deficiency such as childbearing women, infants, young children and the elderly (Thompson, 2007). For

example, iron supplements are often provided to pregnant women to prevent iron deficiency anemia in the mother and iron deficiency in the newborn (Thompson, 2007).

4.3 Cultural Acceptance

When introducing anything of a foreign nature, the biggest barrier is cultural acceptance. According to Rozin (1996), "In most if not all cultures, food is laden with meaning, and constitutes a major form of social exchange" (pg 83). Everything from what one eats to when, how, and whom with has significance. The decisions one makes are based on cultural norms, religious beliefs, knowledge, and attitude as well as availability, palatability, and mimicry (Rozin, 1996). Each of the aforementioned are either supported by the prevailing culture, or by personal understanding and self-discovery.

Factors supported by the prevailing culture, such as norms, religious beliefs, and to an extent, knowledge are in a constant state of flux as the culture changes with the passing of time. Choices made based on a cultural factor are instilled in a person through laws, media, religious services, and schooling. Therefore, because these choices are propagated by factors within a culture in which most people trust and follow fervently, their decisions can be without reason or freedom, or based on incomplete or manipulated information. Such norms in the United States include shaking hands and using a fork or knife to eat. In the Tifnoute Valley, these norms include men and women eating in different rooms or using bread as a utensil. Seemingly harmless, each of these are propagated by the prevailing culture and followed without personal investigation and choice. Religious beliefs operate in the same way. For Muslims the eating of swine, smoking, and drinking alcohol are strictly forbidden, and hospitality is a top priority. One's religious beliefs are based on religious scripture and mandates by religious officials but are often believed without having completed any personal investigation. In addition, to disobey a culturally enforced idea, especially religious ideas, risks punishment and possible exile. Therefore, one's preferences will coincide with the norms of the dominant culture so as to avoid becoming an outcast or delinquent.

Factors such as availability, palatability, and mimicry are examples of non-culture based and personal ideas. These factors are not guided by the prevailing culture but are instead determined through personal understanding and processes beyond individual control such as the market. Market factors such as availability, affordability, and quality play a large role in how one chooses what to buy

(Rozin, 1996). The rural souks in the Tifnoute Valley were much smaller and with significantly less variety of products than souks I visited in Marrakech and Tahanout. In addition, one's financial status determines what is affordable, limiting both choice and opportunities to try new things. Not only are the souks small with little variety, but the majority of inhabitants are of a low socio-economic status which prevents them from buying food items such as fruit and meat.

Choices are also determined by personal understanding of what one likes, dislikes, and the development one's own beliefs through self-discovery and personal investigation. As children, humans acquire preferences by mimicking those of their parents. As they grow, their choices are often in response to a role model, television personality, or those they envy, in addition to their parents and other family members (Rozin, 1996). One's choices are also largely determined by an attraction inspired by one of the five senses: taste, touch, sight, smell, sound. Products that are attractive for one of those reasons are more readily accepted by a person. Therefore, foods that are palatable are easily accepted over those that are unpleasant. Lastly, as one becomes an adult, choices are also determined in accordance with one's personal beliefs, which have been discovered through education, research, and, experience. These choices are separate from mainstream ideas such as religion and culture.

The aforementioned factors can often act as a constraint, that which prevents one from making a choice free of cultural and impersonal interference. Choices made under the direction of cultural, religious, or market constraints are often followed only so long as the constraint exists. An action or choice may have multiple constraints, therefore, even though one constraint is lifted others still cause one to select or avoid certain foods and actions. For example, if a parent prohibits their children from drinking coffee while they are not of age, once they become of age, there is no longer any prohibition. However, it may yet be out of reach because it is unaffordable or unavailable for purchase. Once all constraints are removed, one is free to choose as they will. For example, once a parent allows coffee drinking and coffee is both affordable and available, the child may choose to drink coffee.

A choice will become a preference and internalized when that choice matches both the personal beliefs and predilections. Internalized preferences are not issued determined by cultural constraints but are discovered through personal beliefs and choices. Choices guided by cultural constraints can become internalized therefore, even though what once was taboo, though now free of the label taboo, may remain an individual taboo based on one's experience, beliefs, and knowledge about it. Once

internalized it often takes great personal effort or a moment of dissonance for that preference to be forgotten or exchanged (Rozin, 1996).

The ten recommended crops, though most are foreign to the valley, were chosen in part for their compatibility with acceptance influencing factors in the Tifnoute Valley. The first factor is taste. Each of the crops is either similar to another crop currently grown in the valley or is similar to one utilized in Berber and Moroccan cuisine (Table 7).⁵ For instance millet is very similar to wheat and barley, and it has a history of growth in Morocco. Sweet potatoes are very similar to squash and pumpkin, which were a regular appearance in couscous dishes served to me during my stay there. Peppers are also used widely in Moroccan dishes as a spice or vegetable, though its presence in the valley is absent or limited. In addition, they were chosen for their compatibility with current dishes. Millet, amaranth, and teff are all wheat like and can be made into bread or even couscous. Beans, peas, squash, pumpkin, and sweet potato can all be used in tagines and couscous.

The main constraints for their acceptance in the Tifnoute Valley are availability, the cultural norm placing most of the labor burdens on women, and mimicry. First, with the assistance of HAF, which I will discuss further in section 5. *Discussion*, these crops will be readily available for planting, iodized salt will be consistently available in the market, and any materials needed for adding value will be available for use. Second, the current norm places women in position where the daily labor burdens are their responsibility. If processes like value adding, drying, and storage are going to work to their fullest potential, men will have to shoulder some of that burden, which is already starting to become the mindset of many men and women (Appendix B, D). Not only do men want to have control over the fruit trees, but they also wish to see women have more time to work and converse with others in the newly developed women's cooperatives. The biggest constraint, however, is mimicry. During conversations with many villagers, when asked if their current crop production was different from that of the past, they responded with, "we grow what our ancestors grew" (Appendix A, B). When they elaborated, however, their statements contradicted their initial response. Some responded that they once grew sorghum but stopped due to spatial constraints. Others responded that their ancestors didn't grow vegetables, just barley, corn, and walnuts or that only turnips and barley were grown, which is a clear contradiction with what they currently grow: barely, maize, turnips, carrots, potatoes, etc (Appendix B,

⁵ Due to conflicts with having direct contact with any Berbers while conducting this portion of my research, most of my sources are cookbooks and my own personal observations.

D). Though their responses indicate that many changes to their agricultural regime have occurred, they still consider their actions in line with their ancestors. It is likely that there will be some resistance to the recommended crops for this reason; however, the fruit trees introduced by HAF are not of ancestral origin. Acceptance and popularity of these trees, however, was not just a result of pleasant taste or even dish compatibility but one based on education and trust in HAF. For any of the recommended actions to become acceptable within the Valley, men and women alike will have to undergo an educational process.

5.4 Education: The Community Based Approach

Diet diversification is only as successful as the amount of knowledge possessed by all involved. If farmers do not understand how or why they are growing certain crops, especially those recommended by outsiders, the chances of that farmer continuing to grow those crops without constant pressure or incentives for them to do so is based on experience and an open mind. Similarly, a mother will not feed their family something they do not believe is good for them or worth their time to cook. Patterns of negative food related habits, like eating less leafy greens in exchange for fats or foregoing breastfeeding, are often based on blindly obeyed traditions, taboos, or poor understanding of the relationships between food, body, and health (FAO, 1997). Therefore, one of the principal aims of diet diversification must include an educational component, creating a bond of trust in order to provide communities with information, skills, and motivation to take a prominent role in managing their family's health (FAO, 1997; Ruel & Levin, 2000). It is important, however, to educate in a way that increases participation as well as understanding. Too often organizations employ methods that neglect the community's opinions and focus on implementing their own ideas (NRC, 1998). Organizations that are willing to take the time to work with the community and collect their input are more likely to positively impact the community (NRC, 1998). When the time is taken to build a relationship, establish trust, provide both knowledge and understanding, and empower them, communities can make their own responsible choices about what food to produce, eat, and purchase. Education cannot be limited to only one group; all those involved in food growth, preparation, and consumption should have some knowledge about what is eaten and why.

The most sustainable method for educating and motivating in such a manner is through a community based approach. Community based approaches not only impart knowledge, but work to

develop trust between the instructor and the instructed (FAO, 1997). In addition, they involve community members throughout the entire process, from determining what needs to be done through completion. In doing so, this approach listens to indigenous knowledge and ensures that those most affected have a say in what occurs on their land, in their household, or around their children (FAO, 1997). HAF already uses the participatory method, which is a community based approach. Through this method, HAF has been able to develop project goals and to implement the projects in coordination with the desires of the communities they are working with (HAF, 2011). Their success is largely a result of the respect and appreciation they show for the communities by working with them in such a capacity.

Hagenimana, Oyunga, Low, Njoroge, Gichuki, & Kibira (1999) conducted a study in Kenya on acceptance of beta-carotene rich sweet potatoes based on education. The sweet potatoes were introduced to two women's groups: the control, receiving minimal amounts of support; and the other which received not only nutrition education but lessons on food processing and technical assistance. The educated group was found to have a "statistically significant" increase in consumption, while consumption in the control group decreased overall. Furthermore, a trial completed in Malawi by Gibson, Yeudall, Drost, Mtitimuni & Cullinan (1998) used the above strategies to combat iron, zinc, and vitamin A deficiency. By using the participatory approach, community members were able to voice and select specific features to focus on. Based on social, cultural, economic and environmental conditions of the area, the following interventions were determined acceptable and feasible: 1) activities promoting sunflower seed, groundnut, soybean, and leafy vegetable production; 2) food preservation and processing methods to increase bioavailability; and 3) fermentation to increase bioavailability. In order to achieve sustained behavioral change, the community in collaboration with Gibson promoted changes in knowledge, attitudes and practices via a social market and communication campaign.

5 Discussion

According to Thompson (2007) as incomes begin to increase, traditional practices like eating leafy greens, gathering wild foods, and breast feeding decrease. The people of the Tifnoute Valley are beginning to experience this. During conversations with many of them, once they start to earn a steady profit from the fruit trees they plan to stop growing barley, maize, and possibly even vegetables in addition to eliminating animal husbandry (Appendix B, D). For the women who work tirelessly in the

fields, an increased income lessens the work load as more dependence can be placed on going to the market than in the field; however, it is likely that most of these women have not considered the risks associated with eliminating their direct control over their food production and consumption and increasing their reliance on the market. Without education, they cannot know how important micronutrients are for growth and development, as well as, the direct connection between food and micronutrients. Furthermore, they won't know the empowerment that typically results from the control one has over their own life, which in this case can take the form of ensuring their family's health, financial stability, and food security.

Though the Tifnoute Valley is an isolated, rural community in the High Atlas Mountains, they have the potential to control micronutrient deficiency and increase food security. A food based approach that includes diet diversification as well as preservation and fortification, can be easily implemented with assistance from organizations like the High Atlas Foundation (HAF). By using the participatory method, HAF developed a relationship with the Valley and have been able to introduce their One Million Trees project as well as a women's cooperative, a relatively radical project for such a rural area. The trust the Valley has with HAF, will allow them to share ideas and work with HAF to implement them if they so choose. If HAF were to choose to encourage the following diet diversification plan, it is likely the Valley would take interest and work to incorporate it into their lifestyle.

Iron, vitamin A, and iodine deficiencies, though unknown at this time, are likely present in the Tifnoute Valley. This is due to the limited diversity of crops that are grown as well as the limited array of products found in the souks. Currently the majority of the Valley grows barley, wheat, maize, tomatoes, potatoes, beans, peas, turnips, onions, zucchini, and carrots. In addition they also have almonds and walnuts that grow wild, and apple, cherry, quince, pear, pomegranate, and peach trees that were introduced by the Peace Corps in 1994 and again recently by HAF. Vegetables are grown sparsely with the majority of the terraces dedicated to barley, wheat, and maize which are used primarily as a fodder crop, but also as a grain. Many of these crops are low in nutrient content, excepting carrots, beans, peas, tomatoes, and fruit. In addition each villager works with an average of 3 terraces and a household garden for their entire harvest, which limits yield potential.

The ten crops recommended earlier in this paper each have the potential to increase iron or vitamin A intake and with increased incomes from both the sale of the fruit as well as value added products, they can purchase iodized salt as the primary means to ward off iodine deficiency. First, it is

recommended that the Valley slowly move away from their current grains, exchanging them for grains rich in iron as well as calories such as teff, millet, or amaranth. Teff is a tiny seed that can grow in nearly any soil, therefore marginal lands that otherwise could not grow barley or maize, can be used to grow teff. In addition the proposed grains are all cover crops and nutritious fodder food. In complement to onions, carrots, beans, peas, potatoes, and zucchini, it is recommended that they add squash or pumpkin, peppers, and sweet potato. Each provides a significant amount of vitamin A, and some also provide iron or vitamin C. Lastly, buckthorn, which is a berry yielding tree, is not only extremely high in iron, but it is also used for medicinal purposes throughout Africa. It is recommended that this tree be incorporated into the One Million Trees project as a winter crop. It is essential that if these crops are to have the desired impact on communities, they must be treated as any other crop, even if culturally that crop is only grown and eaten in times of scarcity.

By using the participatory method, or another community based approach, HAF can not only educate the Valley on the benefits of exchanging some of their current crops for the above nutrient rich crops, but they can also provide technical skills for increasing nutrient bioavailability, limiting nutrient absorption inhibitors, and increasing food security and profits. Women are responsible for the majority of a families food related tasks, planting, tending, harvesting, preparing, and cooking. However, education should not be limited exclusively to women. Each area of education should correspond to the group whose job it is to oversee the execution of that task. Since, women are responsible for both farming as well as meal preparation it is best to focus their education on the best farm practices, processing, cooking methods, and food to food fortification. For teff, millet, and many others, processing the grain or vegetable eliminates the presence of phytic acid and tannins, which are absorption inhibitors. By doing so, the abundance of nutrients become available for the human body to consume. Such processes may be more laborious for teff and millet since their grains are so small, however, with HAF assistance and investment it is possible to supply the Valley with materials that will aid in the efficiency of such a process.

There are four meals in an average Moroccan day: breakfast, lunch, late afternoon snack, and dinner; therefore, there are four opportunities to either increase or decrease nutrient intake. Since cooking can significantly reduce the amount of nutrients that are available in leafy greens, when they are used as a part of a dish, such as a tagine which cooks for a long time, they should be added towards the end. In addition, it is particularly important that with the increase in fruit around the Valley,

households begin to work toward consuming vitamin C rich fruit with the majority of their meals, if not all of them. This also includes vitamin C rich vegetables such as leafy greens, peppers, and pumpkin. Lastly, though this will take the longest to implement, it is crucial that the appearance of tea, coffee, and unleavened bread be limited at meal times. Knowing, that tea, especially, can hardly be eliminated entirely from the Moroccan diet; it is recommended that one drinks tea and coffee at least 1-2 hours after a meal. Furthermore, it is highly recommended that infants, and children under the age of 6, as well as pregnant women, refrain from drinking tea and coffee, so as to maximize nutrient absorption.

As for men, since they are responsible for the proceedings in the souks and the fruit trees, their education should particularly focus on the possible value adding and preservation processes, in addition to market responsibility. The Valley's fruit trees are not only good sources of vitamin C, but they also have the potential to increase incomes and food security. Currently, the majority of the trees' fruit is sold in the souks. During conversations with a number of men in Missour and Tissalday, I discovered that the average kilo of cherries sells for approximately 7-10 Moroccan Dirhams (dh); however, most of the villagers sell their cherries and apples by the tree which can range from 30dh to over 100dh per tree (Appendix E). This is a significant increase to their income, which previously depended on sales of surplus crops and the annual livestock sale. However, if the entire valley begins to grow fruit trees, profits per tree will decrease as the market becomes flooded and demand goes down. In order to maintain or even increase fruit profit, men can add value to their fruits and even their vegetables and grains. A process that both adds value and increases food security is preservation. Drying crops via sun or solar drying methods will preserve the nutrient content as well as extend crop availability through seasons of scarcity. Cherries that have not undergone some sort of preservation only last a few days before rotting. If they are preserved they can be eaten and sold throughout much of the year. Portions of the crops that should be preserved via drying are fruit, leaves, and seeds. Preserved products should then be stored in appropriate storage facilities. Most villages throughout the Valley have community or individual storage facilities. It is recommended that these spaces be used for not only storing grains until they can be processed, but also for seed saving and storing preserves.

Men must also be educated on proper market responsibility. This includes providing them with reasons to purchase healthy and nutrient rich food, iodized salt or supplements when they are needed, and to give them the skills to sell their products such as bartering, price awareness, and language skills (Appendix E). It is common for increased incomes to translate to an increase in consumption of fats and

sugars; however, with proper education, men can ensure that their family's needs are met before purchasing such luxury items. As previously mentioned, iodized salt is necessary for preventing iodine deficiency. It is unknown at this time whether iodized salt is available in the Valley, however it can be assumed that most of the villagers are not receiving it due to their isolated location. It is in the valleys best interest to have a dependable amount of iodized salt available on a regular basis. Therefore, it is recommended that HAF do their best to ensure that iodized salt is always available in the Valley. Options for doing so include working with government entities or hiring someone to transport iodized salt into the valley.

This combination of methods within a food based approach represents a long-term goal toward which society has always approached: "provision of assurance of access to a nutritionally adequate diet achieved through diversity of food availability, wise consumer selection, proper preparation, and adequate feeding" (Howson, Kennedy, & Horwitz, 1998). There are many organizations that are now interested in implementing food based approaches. It is recommended that in considering this approach, HAF seek assistance and funding from organizations like the Food and Agriculture Organization, which advocates for diet diversification as the means to not only improve diets but to improve health and generate income in poor populations (Thompson, 2007). If HAF can acquire funding and work with the villages to understand and implement this recommended food based approach, it is believed that this approach can control the occurrence of micronutrient deficiencies in the Tifnoute Valley and possibly other regions of the High Atlas Mountains.

6. Conclusion

Despite being a very isolated, rural region, the Tifnoute Valley has the potential to not only control micronutrient deficiencies through diet diversification but also to increase food security and financial stability. Though diet diversification alone cannot fully control iron, vitamin A, and iodine deficiency, by implementing a whole food based approach that incorporates food to food fortification, market solutions, and inclusive education, along with diet diversification strategies, they can not only control micronutrient deficiencies but also increase food security and income. By adding the ten recommended crops to their diet, in addition to improved cooking, processing and preservation methods, villagers can increase bioavailability and minimize the chances of becoming micronutrient

deficient while also increasing income. With the assistance of HAF, iodized salt and supplements can be made available in the souks on a regular basis. Incomes can then be used to purchase these products to control iodine deficiency or treat severe cases of iron and vitamin A deficiency. Lastly, if HAF teams up with another organization in support of food based approaches to micronutrient deficiencies, they can increase their available funds which can be invested in solar drying, processing, and jarring techniques.

7. Recommendations for Further Research

Due to the time frame in which I had to complete my research, comments on the economic paybacks as well as the proper farming methods were beyond the scope of this proposal and should be looked into before implementing the above recommendations. Specific farming methods to pay attention to are: mixed farming, intercropping, cover-cropping, and composting. In addition, time limited my ability to provide full and accurate processes to preserve and add value to fruits and vegetables. To increase profits in the valley and reduce market flooding, this should be looked into.

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Appendix

Appendix A: Meetings Round 1 Questions: Aguerzrane, Amsouzerte, and Missour

1. What have been the impacts of the HAF projects in your village?
(Income, health, opportunities, nutrition...)
2. What kinds of trees do you currently have?
3. What do you expect to have result from the continued growth and sale of these fruit trees?
4. What do you wish to use additional income on?
5. Who is responsible for the trees after distribution?
6. How have you been using the fruit trees?
(Sale, consumption...)
7. How much of your harvest do you approximately keep for your family to eat?
8. What other types of crops do you cultivate?
9. What is done with those crops? (market, consumption...)
10. What do you buy at the market?
11. Is there a season or a specific time of the year when food is scarce? What do you do/eat?
12. Is the present agriculture/crop production any different than they were in the past?

Appendix B: Round 1 Meeting Responses

Aguerzrane: 1 Female, 1 Male (6/5)

❖ **Impact of Trees & Impressions:**

- Preferred Cherry, Apple, Walnut, & Almond
- Access to resource otherwise too expensive to buy
- Low maintenance-can cultivate without sacrificing other crops
- Increase incomes slightly
 - Income only spent on food
- Some believe trees take up precious land that could be dedicated to other crops

❖ **Expectations from Trees:**

- Further increase income so they can buy more than just food such as clothes and books

❖ **Current Agriculture Growth:**

- Potato
- Onion
- Zucchini
- Beans
- Barley
- All of this only covers approximately 15% of their food needs

❖ **Agriculture Distribution (Consumption vs Market):**

- Fruit and nuts are taken to the market but most other crops are kept to eat
- Purchase: tea, bread supplies, sugar, oil, coffee
 - Do not usually buy vegetables or fruit in the market
 - Some can only buy meat once a year

❖ **Hardest Time of the Year:**

- Rainy season causes the roads to close so it is impossible to get to the market
- At this time forced to rely on what has been stored, tea, sugar, bread, or sell their animals in exchange for other food

❖ **Past Vs Present:**

- Used to grow sorghum but now there is too little space to do so
- Climate has changed over the years
 - Rains have increased and are unpredictable

❖ **Other:**

- Would like more water channels for irrigation of land and trees
- Need more land to farm farther up the mountain
- Would like to plant argan and olive trees
- Would like the wash room that is currently being built to open soon
- Would like a women's cooperative
- Would like a communal bathroom

Amsouzerte: 5 mid to young Women (6/5)

❖ **Impact of Trees & Impressions:**

- Appreciate the project
- There are no fruit bearing trees in Amsouzerte at this time
- Prefer Cherry, apricot, apple, and nuts
- Feel it is better to work with trees than in the fields because it can yield a “legitimate” income unlike working with the animals

❖ **Expectations from Trees:**

- Increase Income
 - Currently incomes are only used for food (mostly sugar and tea) and no money is spent on themselves
- Women hope to have their own income as a result from the trees being under their control
 - Men are currently responsible for the trees and receive most of the profits

❖ **Current Agriculture Growth:**

- Carrots
- Tomato
- Potato
- Onion
- Barley

❖ **Agriculture Distribution (Consumption vs Market):**

- There are no market sales to be spoken of
- Families consume everything that is grown
- Purchase: tea, sugar, coffee, oil
 - Vegetables are purchased on occasion
 - Meat is purchased twice a week

❖ **Hardest Time of the Year:**

- Rainy season causes the roads to close so it is impossible to get to the market

❖ **Past Vs Present:**

- It is believed that they do exactly the same thing as their ancestors before them

❖ **Other:**

- Would like more water channels for irrigation of land and trees
- Would like trees to build bridges and prevent flooding rather than fruit trees
- Would like the wash room fixed and operational (Requires sunlight and reliable water supply)
- Would like a women’s cooperative so they can make carpets, jewelry, and clothing

Amsouzerte: 28 Men, mixed (6/6)

❖ **Impact of Trees & Impressions:**

- Trees are not yet at fruit bearing stage
- Currently have walnut, almond, apple, apricot, and plum
- Not everyone in Amsouzerte has trees at this point

❖ **Expectations from Trees:**

- Expect cherries to have a good result since they are not susceptible to many pests and diseases like others
- Expect trees to assist with erosion prevention

❖ **Current Agriculture Growth:**

- Potato
- Onion
- Zucchini
- Tomato
- Barley
- Carrot
- Some beans
- This does not reach subsistence levels, they must still go to the market
- There is too little land
- Would prefer to grow susan/lilies/irises instead of barley

❖ **Agriculture Distribution (Consumption vs Market):**

- There is currently no market to sell the fruit once it is ready
 - People come buy the fruit from the tree for a low price instead
 - Believe at this time that they have too little fruit to justify selling it in the markets
 - Cost of transportation to do so is high and they have to also pay those who help with the harvest
 - Once there is a market, they do not plan to keep any fruit back for themselves but will sell it all
- Purchase: more of everything they grow, sugar, coffee, tea, oil, and sometimes lemon and rice
 - Tea, sugar, coffee, bread, salt and oil are the most important market items
 - Meat is bought once a week

❖ **Hardest Time of the Year:**

- Stores are depleted by March
- At this time of the year there is little chance of getting to the market as well since the roads are wiped out
 - Rely on tea, sugar, and bread

❖ **Past Vs Present:**

- Believe they are growing what their ancestors grew: Barley, walnuts, and corn...but no Vegetables

❖ **Other:**

- Create forests to stop erosion of the mountainsides and protect roads from destruction
- Would like to cultivate date trees
- Would like agricultural guidance concerning the maintenance of the fruit trees
- Would like a women's cooperative so women can also make a profit
 - Not all agree with this idea
- Would like bridges for the roads and across the river to allow travel during rainy seasons

Missour: 3 Males (talked the whole time) and 4 women (barely spoke) (6/7)

❖ **Impact of Trees & Impressions:**

- Cherries have been successful but apples do not bear fruit consistently due to pest
 - Believe apples will prosper if they are cared for properly
- Also have almond, walnut, quince, and plum trees
- Prefer Cherry trees because they can buy the tree for a small price and sell the fruit for significantly more
- Increase incomes since planting in the '90s

❖ **Expectations from Trees:**

- Expect incomes to further increase
- Plan to use increased incomes to build shops, bathroom, wash room, etc... to increase the livability of the village
- Would like to have more trees: believe they have room for 200,000 more

❖ **Current Agriculture Growth:**

- Potato
- Onion
- Zucchini
- Tomato
- Barley
- Turnips
- Carrot
- Maize
- Can only cultivate where there are terraces and where there is access to water channels
- These crops do not meet subsistence levels
 - Believe there is a lack of nutrition due to this

❖ **Agriculture Distribution (Consumption vs Market):**

- Currently sell fruit by the tree or terrace for approximately 3.5dh/kilo but it is sold in the market for 35 dh/kilo (cherry) and walnuts are bought for 10dh and sold in the market for 150dh
 - Do not believe they have the means to sell in the market themselves
- Purchase: tea, bread supplies, sugar, oil, coffee, barley for animals, food
 - It is necessary to go to the market to supplement their harvest but there is very little money to do so
 - Those without money are loaned food
- ❖ **Hardest Time of the Year:**
 - It is necessary to go to the market between June and September since there are no more stores and crops are not yet harvestable
- ❖ **Past Vs Present:**
 - Used to grow barley and turnip
 - Believe no other vegetables were grown
- ❖ **Other:**
 - Expect apple trees, cactus, and eucalyptus to prevent erosion
 - Huge illiteracy problem, with women having the worst problem, would like this fixed
 - Would like bridges over water channels, ravines, and river
 - Would like a wash room
 - Would like a women's cooperative
 - Would like a Hamam and hospital

Appendix C: Meeting Round 2 Questions: Missouri, Amsouzerte, Agrzan (Solo and Groups)

1. What do you plant on your land?
2. What grows wild on your land that you consume, sell, feed your animals?
3. Is there anything you do not grow that you wish you did? Why? and Why is it not grown?
4. Do you have spatial concerns?
5. Do you have health concerns?
6. How many fruit trees do you currently own?
7. How many of those are HAF trees?
8. How old are the trees/Do they bear fruit?
9. How many trees do you plan to buy when HAF distributes the nurseries in Amsouzerte?
10. Who is or will be the primary caretaker of the trees? Profiteer?
11. If you were given many more fruit trees and there was a profitable market to sell them in, what changes, if any, would you make to your land?
 - Is there anything you would stop growing?
 - Is there anything you would stop doing?
12. If yes, what if the market is inaccessible or the price falls or you have a bad crop, how do you plan to feed your family?
13. What are your top priorities?
 - Nutrition, Children's Schooling, Road Repairs, Erosion Control, Terrace Expansion, Health, other

Appendix D: Round 2 Meeting Responses

Missour: 5 Women of mixed age (all spoke) 6/21

Different designated by letter A-E, C&E are mother and daughter

❖ **Planted on land:**

- Cherry
- Plum
 - Hard to take to market, rots easily in sun
- Apple
 - Produce little income due to disease, pests
- Barley & corn
 - Can cultivate under fruit trees for first 4 years but then they cast too big a shadow
- Tomato, Potato, onion, beans, turnip

❖ **Wild:**

❖ **Wish to grow:**

❖ **Spacing:**

- Number 1 limiting factor for agriculture expansion
- Trees take up fallow land
- Terraces:
 - Ranges from 0-10
 - This interview
 - A: 2, B: 3, CE: 4, D: 3,
 - Those without trees evenly mix barely, corn, and vegetables (1/3 land each)
 - Those with trees often grow mostly barley but no corn and rarely vegetables (ED grew veggies)

❖ **Health:**

- Feel undernourished; not getting enough of what they need

❖ **# fruit trees:**

- Have improved income
 - Income has only increased security to continue purchasing what they normally do, cannot afford new things
- Most people own trees
 - Land is limiting factor

❖ **Purchase:**

- Buy meat once a week
- Always have to buy additional fruits and vegetables

❖ **Sale:**

- Souk (market) is very far
 - Must pay to have goods taken to market for sale
- Wait for buyers to come to them
- If crop is big will keep some, if small will sell all
- Animals mostly to sell, but some for milk and butter
 - 1 cow/year
 - 2 sheep/year

- Slaughter one/year
- ❖ **Caretaker/profiteer:**
 - MEN
- ❖ **Trade-offs:**
 - Some have decreased growing barley (B,C,E) and rely more on the market
 - Families stock up on necessities during available months and when they have the money to do so
 - Storage facilities in each house
 - Would stop growing barley and corn if trees provide enough income without
 - Would stop caring for animals if trees provided another form of income

Aguerzrane (6 Women, 1 Man)

Women stop studying to collect barley and such

Against selling fruit as a village, need income now

- ❖ Planted
 - Apple
 - Nut
 - Plum
 - Pear
 - Almond
 - Cherry
 - Lily
 - Barely
 - Corn
 - Potato
 - Tomato
 - Onion
 - Beans
 - Zucchini
 - Turnip
 - Carrot
- ❖ Wild
- ❖ To Grow
- ❖ Spacing:
 - Little land
 - 10-30 small terraces (no exact measurement for size)
 - If given 10 terraces what grows where:
 - 1 for vegetables, 2-3 for barley, 2-3 corn, rest for trees
 - 23 Families
 - Average of 20-30 trees per family
 - Oldest fruit trees are 5 years

- 4 families without land=no trees
 - Work land of others
- Only women work the land, men go to the city or rely on Allah
- Have land for more trees but no channels to water them
- Can only grow vegetable with trees for 5 year before overshadowed
- ❖ Health
- ❖ # Trees:
 - Apple and Cherry most successful
 - Sell and consume fruits
 - Produce 3-6 kilos/tree
- ❖ Purchase:
 - Must go to the market
- ❖ Sale:
 - Some take fruit to market and others wait
 - 4 families take to market
 - Must pay to take stuff to market
 - Price is low if many fruit, high if little
 - .5dh-300dh !!
 - Sell by land
 - 250-300dh for land
 - Cherry: 7-10dh
 - Apple: 7-10dh
 - Nut: 10-15dh
 - Almond: 35 dh
- ❖ Caretaker/Profiteer
- ❖ Tradeoffs
 - Will replace land for barley ad corn to grow trees
 - Will consider sacrificing vegetables

Amsouzerte: 21 Women (mid-old) 6/22

- ❖ **Planted:**
 - Corn
 - Planted in June
 - Harvested in October
 - Barley
 - Planted in October
 - Harvested in June
 - Given to animals or eaten
 - Walnut & Almond
 - Fruit only if not too cold
 - Onion
 - Turnips: Winter
 - Potatoes

- Summer: tomatoes, carrots, zucchini, beans
 - Only 3 months long
- Snow: November-May
- ❖ **Wild:** Walnut trees (few own)
- ❖ **Wish to grow:**
- ❖ **Spacing:**
 - Terraces:
 - 4,3,0,6,7,4,3,3,1,6,0,2,4,2,3,1,5,0
 - Average: 3 terraces
 - Divisions are dependent on amount of land
 - Crop rotations most often
 - Plant barley & corn on land for vegetables after they are harvested
 - Some leave vegetable plots open after harvest
 - Most land designated for barely & corn
- ❖ **Health:**
 - Disease: eyes and stomach
- ❖ **# Fruit Trees:**
 - Cherry, Apple, Plum, Pear
- ❖ **Purchase:**
 - Must go to market throughout the winter
 - Harvest lasts 2-3 months
 - Tea, sugar, flour, oil, rice, corn, barley, coffee, animal food, more of what they grow
- ❖ **Sale:**
 - Those with many nuts sell some and keep rest
 - Share harvest with those that do not have nut trees
- ❖ **Caretaker/Profiteer: MEN**
 - Women do not know how
 - “Women can just grow flowers”
 - Only men harvest
 - Women do not want this role
- ❖ **Tradeoffs:**
 - If given a club or opportunity to make own profit:
 - No cows, rely on market
 - Use profits to buy sufficient sustenance
 - share with man
 - Will work in shifts
 - Will NOT stop farming or animals
- ❖ **Other:**
 - “No work, nothing to do”

Amsouzerte: 12 Men (mixed, mostly old answering) 6/23

❖ **Planted:**

- Cultivate vegetables March-June, after harvest plant corn, then barley
 - Dependent on number of vegetables
- Corn
 - 2 Types
 - Planted March
 - Planted June
 - Harvest September
- Barely
 - Planted October
- Potato
- Tomato
- Zucchini
- Beans (few)
- Turnips
- Carrots (summer)

❖ **Wild:**

- Walnut trees
 - Some are hundreds of years old
- Almond trees

❖ **Wish to grow:**

❖ **Spacing:**

- Average between 2-5, high 20
 - Would not give individual number
- Feel there is little land (limiting factor)
- 48 families in Amsouzerte
 - 50% have land
 - Those without land work on others' land and are given some of the harvest (tenant system)
 - "People help each other"

❖ **Health:**

❖ **# Fruit Trees:**

- Apple, plum, cherry, pear
 - Planted 2002-2005
- Those with land have 20-30 trees/family
 - Some have much more (60+)
- Those without land have no trees
- Would like to purchase 40,000-50,000 trees

❖ **Purchase:**

- No market for 4 months
- Market: Aug-Oct
 - Some must go each month

❖ **Sale:**

- Use profit to buy more food/increase nutrition
- Additional profit put towards children's schooling
- ❖ **Caretaker/Profiteer:**
 - Men and Widows
- ❖ **Tradeoffs:**
 - Would plant all trees
 - Believe weather is bad for vegetables and barley
 - Prepared to sacrifice barley growth
 - Have to buy barley anyway (buy all of it now)
 - Trees bring a larger profit
 - Women can work in the women's association
 - additional profit to provide for children..but the woman's to spend
 - Will continue to plant vegetables and intercrop if possible
 - Believe trees are the only real successful thing for agriculture...need little sun

Appendix E: Round 3

Missour Men A-J

A=Guide

20-30 families in Missour, few have zero trees (due to no land); some people own land but do not live there so sublet the land to others

1. 3 men (A-C)

- Cherry, Apple, walnut, and almond successful
 - Planted plum as well but has not born fruit
 - Peach doesn't do well either
 - Goes bad before fruit is bought off the tree
 - Some people have trees, most without land do not
 - # of Trees
 - A: 140 Apple & 120 Cherry
 - B: 100 Apple & Cherry
 - C: 120-130 Apple & Cherry
 - All have some walnut, very old trees
 - Fruit is not harvested, walnuts are
 - Sell fruit by the tree
 - Cherry: 10 trees=500-1000dh=max of 100dh/tree
 - Apple: Same, but sold in boxes
 - ◆ Each box: 15-20 Kilos
 - Would sell as a village if opportunity and arrangement made
 - Potential problems: None
-

2. 2 Men (middle/young) (D,E)

- Cherry, Apple, Nut trees
- # of trees
 - D: 100 Apple, 70 Cherry, 10-15 Walnut
 - E: 50 nut, 70 Cherry, 200 Apple
- E Buys fruit from other villages and sells in the market
 - Casa Prices
 - Cherry: 15dh/kilo
 - Apple: 20dh/kilo
 - Closer Markets:
 - Cherry: 7-10dh/kilo
 - Apple: 3-4dh/kilo
- Sell fruit in trees because they have few trees bearing sometimes only 20 kilos so the cost to transport isn't worth it
- Would sell as a village in the market if transport costs wer shared
 - D: must be confidence and trust between people

- A: Some families have 500-600 kilos, other have 20; must have someone from village and good at selling stuff; someone with knowledge of markets
 - Want to sell in both far and close markets
-

3. 1 Man (F)

- # of trees
 - 60 Cherry, 40 Apple, 20 nut shared with others
 - Sells by tree
 - 10-100dh/tree
 - Kilos/tree
 - Cherry: 10-15 kilos/tree (old trees 35-40kilos/tree)
 - Walnut: 40-50 kilos/tree
 - ◆ Can be harvest in September and stored til February when price is high
 - Fruit sells for high price in market but it costs a lot to get there
 - Low: 1dh/kilo (Agadir & Marrakech)
 - High: 2dh/kilo (Casablanca)
 - Problems selling as a village:
 - Some prefer to sell the tree before the harvest so as to make a profit no matter the success or failure of the tree
 - Some people do not know how to harvest trees, damage them sometimes
 - Fruit does not last long in the sun once picked...cherries only 24 hours??... Apples 2-3 months???
-

4. 1 Man (G)

- # of trees
 - 15 Cherry, 40 Apple, 80 Nut between 4 ppl (20 each)
 - Sell Cherry and Apple in tree, store nut til February
 - Apple: 1400dh for 40 tree=37.5dh/tree
 - Cherry 600 dh for 15 trees=40dh/tree
 - No one to take stuff to market and long winter with bad roads
 - Do not want to sell their stuff all at the same time
-

5. 1 Man (H)

- # of Tree:
 - 1000 Apple, 40 Cherry, 400 Walnut
- Sells by the tree
 - Cherry: 1500-2000dh
 - Apple: 5000dh=5dh/tree
 - Sold by the box=60dh/box with avg of 3-4 boxes/tree=180-240dh/tree
 - Feels there is no transportation
 - Sometimes sells before tree has flowered to ensure a profit
 - Poor people with little income, rely on fruit
- would sell with the village
- Income: 1000-1500 dh/month for subsistence
 - Cow: 3500dh

- If short on money:
 - Give up luxury fruits and nuts
 - Absolutely buy: sugar, oil, coffee, tea, flour
 - Store food and borrow from others if necessary

A: People do not want to change, do not know what is good for the village, people do not want to go to school, language is a huge barrier, need someone with market knowledge and language experience

6. 2 Men (I,J)

- I: 500 Apple, 60 Cherry, 30 Pear (poor fruit)
 - Shares fruit with G
 - J: if there is a place to store the fruit (refrigerator) people would be more inclined to sell in the market
 - Long term solution: preserves, juice, drying
 - Transport costs based per kilo,
-

Tisselday: 30 families, those with few lands rent from outside the village; disease problems

1. 2 men (K,L,M)

- K: 25 Cherry, 25 Apple, 20 Walnut
- L: 300 Apple, 75 Cherry, 80 Walnut (only him)
- M: 150 Apples & Cherry
- ❖ Sell by the tree
 - 10 trees = 400-600dh
 - I: Apples depend on quantity
 - 600-700dh/10 trees
 - Sold in September (Walnut too)
 - Cherry 700-900dh
 - M: 4000-5000dh for all trees
 - Buyers are responsible for harvesting the fruit they buy
- ❖ Transportation costs are high
 - Would be good if there was one person specifically responsible for transportation

Appendix F: Solo Meeting Questions

1. What types of crops do you cultivate?
2. What grows wild on your land that you either sell or consume?
3. Is there anything that you currently do not cultivate that you wish you did? Why?
4. How many fruit trees do you approximately have on your land? (HAF and non-HAF)
5. How many trees do you plan to buy when HAF distributes the trees in the nurseries?
6. If you were able to buy many and there was a market to sell the fruit for a nice income, is there anything you currently grow or spend time doing that you would stop or limit doing?
7. If yes, what will you do if the market price falls or the crop is bad, limiting your income that year? How will you feed your family?
8. Do you have spatial concerns?
9. Do you have any nutritional concerns?
10. What do you think are the top priorities for the village?

Nutrition, children's schooling, village resilience, erosion control, road repairs, terrace expansion, health