From a PhD Dissertation entitled: The Behavioral Ecology and Economics of Variation, Risk, and Diversification among Mikea Forager-Farmers of Madagascar, By Bram T. Tucker. Submitted to the Faculty of the Department of Anthropology, University of North Carolina at Chapel Hill. Copyright (c) 2001, Bram Tange Tucker. All Rights Reserved.

# Chapter 7
# Variation in Market Participation and the Commercialization of Foraged Goods

## A. Introduction

The previous chapter dealt with intragroup food transfers, a type of non-market exchange. While sharing appears to be a form of exchange that Mikea households rarely practice, all Mikea households participate in market exchange to some degree. In non-market exchange behaviors, the exchange value is often implicit and not discussed, reciprocity may occur with some delay (Sahlins 1972; Pryor 1977:31-33), or may not occur at all (Kaplan, Hill, and Hurtado 1990:127-128), and the exchange is usually made between parties who have strong social or kin ties with one another. In market exchange, on the other hand, goods are exchanged at an explicit rate—the sales price—which is shaped by market forces of supply and demand and which is negotiated between buyer and seller. Reciprocal exchange, usually for cash, occurs immediately (Pryor 1977:31-33). The buyer and seller may have a long-standing social and economic interpersonal relationship, or they may be complete strangers (Granovetter 1985). Market exchanges are conducted in numerous venues. A marketplace is a centralized venue, often chartered by a local government, where large numbers of buyers and sellers meet at a regularly scheduled time to conduct economic, as well as social, transactions. Other market venues occur informally wherever individuals with demand and cash meet those with supply (Plattner 1989:171).

Among Mikea households there is considerable diversity in market behavior. The market plays a central role in the economy of some households, who sell the majority of what they produce and then use their cash earnings to purchase the food and nonfood products that they will consume. The market plays only a peripheral role for others, who consume the food they have produced themselves and only occasionally use the market to transform surplus production into nonfood items such as tobacco, clothing, coffee, and soap.

By selling a good in the market, the decision-maker has the opportunity to transform the value of the good into another currency. Food producers, especially farmers, often generate a large surplus of relatively few goods, which they may not value very highly because of diminishing marginal utility. The market provides food producers with a system for increasing the diversity of the goods they consume, and thus increasing utility and household welfare in general (Barnum and Squire 1979). However, there are costs to transacting a commercial exchange, including the time and energy required to process the good to commercial standards, and to transport goods to or from the market venue (deJanvry, Fafchamps, and Sadoulet 1991; Sadoulet and deJanvry 1995:149-150). There are also important social costs and benefits to market participation. The ratio of costs to benefits in a commercial decision may vary in time, for market prices vary between seasons and years (see Chapter 4).

Frequently, Mikea households choose not to sell the food they have produced, but rather, to consume it at home. Agricultural economists deJanvry, Fafchamps, and Sadoulet (1991) have studied the phenomena of market non-participation, which they refer to as "missing markets" or "market failure."[1] They argue that peasant farmers chose not to participate in a market when the transaction costs are prohibitively large. The transaction costs effectively reduce the price at which a peasant can sell a good, while increasing price at

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[1] These terms carry several unfortunate connotations. "Missing markets" does not mean that the markets themselves have been misplaced, and "market failure" does not mean that a market has ceased to function correctly. Both terms refer to the decision not to participate in a market, a decision that is household-specific and product-specific. I avoid these misleading terms, using "market non-participation" instead.

which the good can be purchased. When the gulf between the effective selling price (the market price minus transaction costs) and the effective buying price (the market price plus transaction costs) is sizable, it is possible that the household will find itself in a position where it gains no net utility by either buying or selling, because these utility gains are offset by the costs of achieving them.

This chapter examines the decision made by Mikea households as to whether or not to sell a good in a given market. Using the model by deJanvry, Fafchamps, and Sadoulet (1991) as a conceptual starting point, I created a mathematical model that calculates the costs and benefits of participation and non-participation in different market venues, for different products. I have chosen to apply this model specifically to foraged goods, because temporal-discounting aspects of value calculation are less of an issue for activities that offer immediate rewards (as explained in Chapter 8). The model produces three solutions—one that maximizes net energy gain per hour, a second that maximizes protein gain per hour, and a third that maximizes cash gain per hour.

Next, I compare the model's predictions with the observed behavior of 15 Mikea households during three time periods. Mikea households, in their attempt to optimize acquisition of multiple currencies subject to time and resource constraints, may at different times emphasize acquisition of energy, protein, or cash, depending on how they subjectively value these currencies. By comparing the observed behavior of these households to the model's predictions I discovered that households who were threatened by food shortage tended to emphasize acquisition of food value (energy and protein), while households that were not in immediate threat of shortage often emphasized acquisition of cash. This finding supports the theory that the general shape of utility functions is sigmoidal (Friedman and Savage 1948; Winterhalder, Lu, and Tucker 2000). The model demonstrates that under conditions of risk, affected households may either increase *or* decrease market participation, depending on which strategy yields the most food value.

## B. The market economy of the northern half of the Mikea Forest

### 1. Regional market exchange and the place of foraged goods

In chapter 4 I demonstrated that there is low spatial covariation between carbohydrates and protein, and that this inequity of macronutrient distribution on the landscape has resulted in a vigorous trans-forest trade in which carbohydrates flow westward and protein flows eastward. Farmers in the savanna to the east cultivate maize, manioc, rice, and sweet potatoes but do not produce much protein; supply of carbohydrates is high and demand is low, while supply of protein is low and demand is high. The contrary conditions exist on the coast to the west, where fishers have easy access to protein but only a limited supply of carbohydrates; supply of protein is high and demand is low, while supply of carbohydrates is low and demand is high. Therefore, agricultural staples have a low price on the savanna and a high price on the coast. Marine foods have a low price on the coast and a high price in the savanna. Potential for commercial profit awaits anyone with the patience and the means to travel from one environment to the next, on a journey that passes through the Mikea Forest.

The outlets for much of this trans-forest commerce are the villages of Vorehe and Ankindranoke. These two villages lie on opposite ends of a long, dusty road that bisects the forest. The 36 km-long road from Ankindranoke to Vorehe represents the shortest possible distance from a coastal village to a savanna village that is not obstructed by tall coastal dunes, in the northern part of the forest (see Figure 1.1). Most of the traffic on this road is by foot. Some retailers travel by oxcart, but this can actually be slower and more troublesome than foot travel because oxen tire easily on the sandy road and there is almost no water or forage available for them.

Forest dwellers occupy a unique niche in this commercial setting. They are not strictly dependent on the market to achieve their subsistence needs, for they produce both carbohydrates in the form of maize and wild tubers, and protein in the form of birds and small mammals. In the forest there is high demand for what the forest cannot provide—

nonfood items such as tobacco, clothing, soap, batteries, pots, plates, buckets, jerry cans, kerosene, tools, alcohol, coffee, sugar, and medicine. Depending on where they are in the forest, foragers can potentially access market venues on both the coast and the savanna. They sell wild tubers most profitably on the coast, and tenrecs most profitably in the savanna.

There is an important difference between the marketing of foraged goods versus agricultural goods. Agricultural staples such as maize, manioc, rice, and beans are sold in bulk to households who store them for consumption during the subsequent days or weeks. Foraged goods on the other hand are sold in small quantities, usually in ready-to-eat fashion. At the Vorehe market, wild tubers sold for a higher price per calorie than maize or manioc, and tenrecs sold for a higher price per gram of protein than beans (see Table 7.1). Agricultural foods provided more food value per franc than foraged goods. Market-goers purchased foraged goods as flavorful snacks.

## 2. The Vorehe market

The largest market venue in terms of numbers of buyers and sellers in the north-central part of the Mikea Forest region is the weekly market in the village of Vorehe. Throughout Madagascar some rural villages have government-chartered marketplaces that sponsor weekly markets; Vorehe's market occurs each Wednesday. Vorehe is one of the smaller villages to sponsor a weekly market. The market was chartered in 1991 thanks to the combined efforts of the village council (*fokotany*) and Vorehe's Lutheran mission. Because of Vorehe's favorable access to the savanna, forest, and coast, it was a center of trade for years before the marketplace was chartered.

Compared to other weekly markets in rural Madagascar, Vorehe's is a small one—the average number of vending posts in 1998-1999 was 211, and the largest market I witnessed during this period had only 322 vendors. In contrast, the next two closest village markets at Antanimieva and Soahazo hosted twice to three times as many vendors. Vendors at Vorehe sold a variety of products (Figure 7.1). On average, I observed that 14 percent of the vendors

Table 7.1: Relationship between price and food values for foraged and agricultural products at Vorehe.

7.1a: Agricultural products

| | kcal gained per franc spent | grams protein gained per franc spent |
|---|---|---|
| **High-carbohydrate** | | |
| maize | 7.1 | 0.02 |
| dried manioc | 2.9 | 0.02 |
| rice | 2.4 | 0.04 |
| **High-protein** | | |
| vohem beans | 3.0 | 0.20 |
| lima beans | 3.0 | 0.20 |

7.1b. Foraged products

| | kcal gained per franc spent | grams protein gained per franc spent |
|---|---|---|
| **High-carbohydrate** | | |
| wild tubers *ovy* and *balo* | 1.2 | 0.01 |
| honey | 1.3 | 0.00 |
| **High-protein** | | |
| *tambotrike* | 1.4 | 0.05 |
| *tandrake* | 0.4 to 0.5 | 0.20 to 0.30 |
| fish | 0.7 | 0.12 |
| crabs | 0.4 | 0.04 |

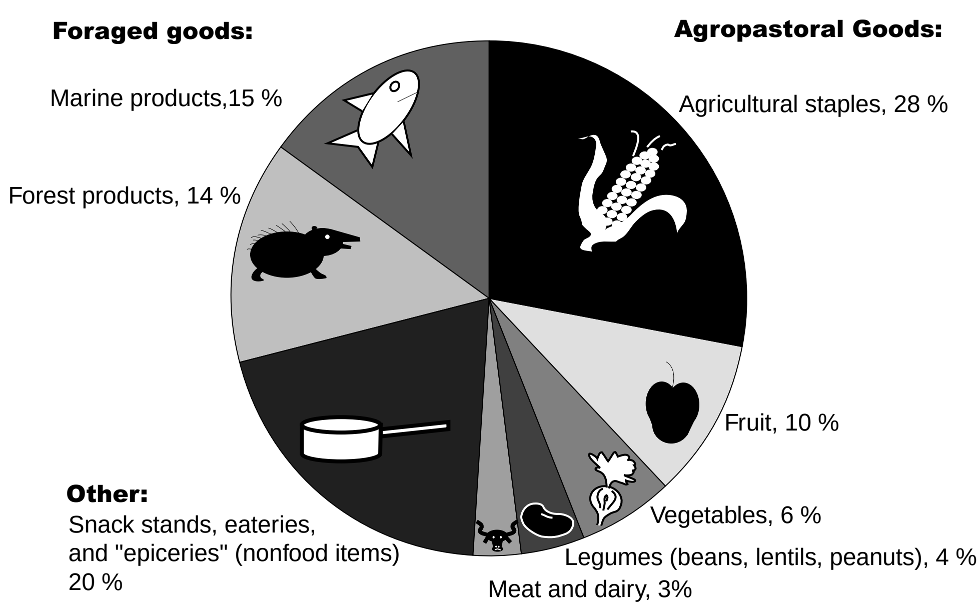


Figure 7.1: Vendors selling different types of goods at the Vorehe market, by percent. These figures are averages based on 32 weekly markets visited in 1997, 1998, and 1999. Considerably more of these observations were made during the season of *asotre* (May-July) which may bias these results. Most vendors sold only one product. In collecting these data, we counted vendors selling two products twice, once for each product.

were selling foraged products such as wild tubers, tenrecs, and honey, and 15 percent of the vendors sold marine products such as fish, crabs, and octopus. Twenty-eight percent sold carbohydrate-rich agricultural staples such rice, maize, manioc, or sweet potatoes, and four percent sold beans. Twenty percent of vendors managed snack stands/eateries and "epiceries." The epicerie vendors sold industrially-produced foreign imports such as clothing, shoes, hardware items, plastic buckets, metal pots and pans, pillows, Coca Cola, candy, etc., as well as domestically-produced chewing tobacco, cigarettes, rum, and soap. The epicerie vendors were mostly ambulatory, making a regularly scheduled circuit of weekly markets in the region.

Vendors attempted to liquidate their entire supply before the end of the market day, while buyers sought the best quality and price. There was little haggling in terms of price, but buyers would often ask vendors to supplement the purchased quantities with a *kado,*[2] or gift, such as an extra orange or onion. Near the end of the market day, normally about noon, vendors dropped their prices in an attempt to sell out, and patient buyers could get good deals. Mobile retailers offered vendors a lump sum for unsold products. They resold the products at a markup either at Vorehe during the rest of the week, or at other market venues.

Despite its relatively small size, the atmosphere at the Vorehe market was vibrant. It was a place for social as well as financial transactions. For young people who spent the majority of their time in small rural villages or camps surrounded by their kin, the market was one of the few opportunities to flirt with members of the opposite sex and arrange romantic trysts. The market was also a chance for old friends and family members to reunite. While women were conducting the market transactions (most vendors and buyers alike were female),[3] men often sat in shady spots and chatted with one another, or demonstrated their friendship for one another by buying their fellows rounds of coffee, rum, or wine. By the end

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[2] Pronounced "ka-DOO," a Malagasy interpretation of the French word "cadeau," meaning "gift."

[3] Because females are more likely to conduct the market transactions of the household than are males, I use the feminine form of singular pronouns throughout this chapter when referring to the actions or decisions of individuals.

of most market days, many of the men and some of the women who remained in the marketplace were intoxicated. Fights were not uncommon. By about 5:00 pm each Wednesday, the marketplace was empty. Villagers would release their pigs to clean up the market's residue.

### 3. Market venues on the coast

On the other side of the forest, Ankindranoke was far too small to support a marketplace. However, money played a central role in the local economy and market exchange opportunities were common.

First, exchange opportunities were provided by mobile retailers, known locally as *mpanao kinanga* or *mpanao kasave*. Mobile retailers purchased goods in one place and then sold them at another at a higher price (see Plattner 1975, 1980). Some people were full-time mobile retailers, and most Ankindranoke households practiced mobile retailing occasionally. As a result, just about any household may have been buying fish, crab, or octopus or selling maize, manioc, or *ovy* at any given time.

Mobile retailers often made regular circuits. For example, many would buy fresh fish in Ankindranoke in bulk, then smoke them for preservation, transport them to Vorehe, sell them, purchase maize, and then transport maize back to Ankindranoke to sell at a markup. Other mobile retailers transported marine goods to *hatsake* farmers in the forest.[4] Some mobile retailers specialized in a specific product. In 1998 there were several buyers of sea cucumbers. While most Malagasy do not eat sea cucumbers, sea cucumbers have a high commercial value in Asian markets. The sea cucumber retailers would buy the animals from Ankindranoke foragers, process them, and then transport them to the city of Morombe by oxcart or canoe, where they were resold to exporters. Full-time mobile retailers sometimes had a fixed clientele and offered credit to their suppliers.

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[4] In the forest south of Vorehe there are communities composed primarily of Tandroy or Mahafaly immigrants who practice *hatsake*. They constitute a market of buyers for marine products.

A second market venue in Ankindranoke were the shopkeepers, called *doka* or *dokany*. In 1998 there was only one shop in Ankindranoke, and by 1999 there were two of them. These shops sold foodstuffs like maize, dried manioc, rice, and beans, as well as nonfood items such as tobacco, kerosene, fishing wire, fish hooks, soap, beauty aids, coffee beans, sugar, cooking oil, batteries, and rum.

The larger and older of the two shops was run by a merchant of mixed Vezo and Pakistani descent. This merchant was an agent of a wealthy Pakistani entrepreneur who lived in the village of Antanimieva, on the other side of the forest, east of Vorehe (see Figure 1.1). The entrepreneur purchased dried manioc in bulk from the neighboring savanna farmers, and then resold the manioc both to international exporters in the port city of Toliara, and in isolated communities such as Ankindranoke through the storefronts of his agents. The entrepreneur transported large quantities of dried manioc by tractor across the forest to Ankindranoke, where it was resold by his agent at a 40 to 50 percent markup. At times when mobile retail trading was light, this merchant had a monopoly on carbohydrate sales for the entire bay. The shopkeeper also ran his own side business (to the displeasure of his boss), in which he bought fresh fish from locals, salted them,[5] and then shipped them by canoe to the port city of Morombe where they were resold to exporters.

The village of Andavadoake, located about 16 km north of Ankindranoke, is the largest coastal village in the northern half of the Mikea Forest region. Apart from the resident population of Vezo fishermen, Andavadoake was also home to a Catholic mission and convent managed by a Spanish priest, and tourist hotel run by a Pakistani family. Due to its size and diversity, this village of about 1000 people offered many commercial opportunities. Although it lacked a formal weekly market like that found in Vorehe, it did support a daily bazaar. On any given day, the main street of this seaside village contained

[5] In this region, fish are processed in three different ways. First, they may be sun-dried (*fia vendra*). This will preserve the fish for only a few days, and so *fia vendra* are not considered sellable. Second, they may be smoked (*fia sale*), which preserves them for up to two weeks. The majority of fish sold locally in the forest or in Vorehe are processed in this manner. Finally, they may be salted (*fiantsira*), which preserves them for a month or more. *Fiantsira* are sold exclusively to exporters.

five to thirty vendors selling agricultural or foraged goods. There were also numerous shops in Andavadoake, some of them quite large. Small shops sold tobacco, coffee, soap, sugar, and batteries. Larger shops sold clothing, cloth by the meter, hardware items, canned foods, packaged cookies, imported packaged crackers and cheese, Coca Cola, bicycle parts, etc.

## 4. Market strategies by Mikea households

Below, I apply a mathematical simulation to evaluate the market strategies of 15 households living in four different communities. The first of these communities is Ankindranoke. People in Ankindranoke foraged for fish with a line or a net, and they gathered crabs in the shallow bay. Occasionally, during times of food stress, they excavated wild *balo* tubers in the forest. *Balo* is rare in the forest surrounding Ankindranoke. Foragers traveled 8 to 12 kilometers to reach areas such as Famata and Ampasipoine where *balo* was plentiful. Once they have harvested fish, crabs, and *balo*, Ankindranoke foragers had three market strategies available to them.

(a) Eat the products. This strategy has no transaction costs.

(b) Sell the products in the Vorehe market. This strategy requires that the products be processed and transported 36 km away. The forager can sell her marine goods at high prices, and use her earnings to purchase agricultural goods at low prices.

(c) Sell the products to a mobile retailer in Ankindranoke itself. This strategy requires negligible transaction costs. However, the forager can only sell at a low price, and can buy agricultural staples only at a high price.

The remainder of the households profiled in this chapter divided their time between three forest communities, where they gathered honey, excavated the wild tuber *ovy*, and collected two species of tenrecs, *tambotrike* and *tandrake.*

Behisatse and Amondralambo were semi-permanent forest camps in the mixed deciduous-euphorb “Midforest” (see Chapters 1 and 3). These camps differed from one another in their distance to the Vorehe market—Behisatse was 15 km from Vorehe, and Amondralambo was located 6 km from Vorehe. The coastal markets were too far distant to compete with Vorehe. These households had two market strategies available to them.

(a) Eat the products.

(b) Sell the products in Vorehe.

When they were not at Behisatse and Amondralambo, these households were most often found in their home villages of Ankilimiavotse and Andolonaombe in the Namonte Basin, a region of seasonal lakes. Tenrecs and honey are more plentiful in this region than they are the Midforest, and so may be harvested as a higher rate. Wild *ovy* tubers, on the other hand, are nearly absent within the Namonte Basin itself but may be foraged at the margin between the Basin and the Midforest, two to six kilometers away. This additional travel time reduces the production rate for wild tubers.

Namonte is located 30 km from Vorehe to the east and 23 km from Andavadoake to the west. The route to Andavadoake is perhaps more difficult, however, because it crosses tall coastal sand dunes. Namonte households had three market strategies available to them:

(a) Eat the products.

(b) Sell the products at Vorehe.

(c) Sell the products at Andavadoake.

The model presented below evaluates these strategies. In the remainder of this chapter I compare model predictions with the observed market behavior of the 15 focal households.

## C. The model

### 1. Currencies and acquisition rates

The model presented here evaluates market strategies by tallying all the costs and benefits of each strategy. I calculate costs and benefits in three different currencies: energy, measured in kilocalories; protein, measured in grams; and cash, quantified as Malagasy francs. The first two currencies are ways to measure food value. The rationale for using energy as a food value measure has been argued elsewhere (Winterhalder 1981: 20-22). People must obtain energy from the food they eat on a consistent daily basis to avoid starvation. I have chosen to use protein as a measure of food value as well. Protein is limited in the Mikea diet, which is dominated by carbohydrate-rich wild tubers and agricultural staples. The third currency, cash, is a proxy measure for the value of various nonfood goods, including tobacco, clothing, soap, alcohol, coffee, pots, plates, batteries, kerosene, etc.

Following the tradition in behavioral ecology and optimal foraging theory, the model calculates the rewards of different strategies as rates per unit time: net calories per hour, grams of protein per hour, and cash per hour (MacArthur and Pianka 1966; Schoener 1974; Stephens and Krebs 1986; Winterhalder 1981; Kaplan and Hill 1992; Hill 1988; Smith 1991). The advantage of this method is methodological convenience—payoffs from strategies with different time and amount components are reduced to comparable values. This method of evaluating payoffs is different from that used by economists.[6]

[6] Calculating rewards as average rates per unit time is a foreign concept to economists (see, for example, Barnum and Squire 1979; Ellis 1993; Sadoulet and deJanvry 1995). Economists view time as another currency, like food or cash, that must be optimized given competing goals and constraints. In the same way that people gain utility by consuming food, they also gain utility by consuming time, through indulging in leisure activities. The utility of time, like that of food, may diminish with increasing quantity. The problem with calculating rewards as rates, as ecologists have done, is that time is assumed to have a constant value for all decisions and all decision-makers. For example: it is possible that two competing strategies, one with a large payoff after a long period of time and another with a small payoff after a short period of time, will yield the same quantity per unit time. However, these strategies are not equivalent for busy people versus bored people. Busy people value time more than bored people do, so busy people may prefer the strategy that requires the least expenditure of time. Ecologists are aware of this problem (Bateson and Kacelnik 1995) but have not yet arrived at a concensus on how to deal with it. In future, I plan to include an interest rate function into the acquisition rates calculated here (Green and Myerson 1996; Rogers 1994). I discuss time more thoroughly in the next chapter.

## 2. Input

The input variable in this calculation is the quantity ($Q$) of the product. The same quantity can be expressed in the three different currencies.

$Q_{wt}$ = quantity by weight (grams)
$Q_{kcal}$ = energy quantity (kcal)
$Q_{pro}$ = protein quantity (grams of protein)

For example, if the product is *ovy* and the input variable $Q$ is equal to one kilogram, then $Q_{wt}$ = 1000 grams, $Q_{kcal}$ = 1190 kcal, and $Q_{pro}$ = 20 grams of protein. The conversions from weight to energy content and protein content for *ovy* come from a chemical analysis reported by Kelly (1997). Table 7.2 lists all the food values used in this study, and the published sources for these data.

## 3. Production costs

The input variable $Q$ is combined with two production parameters to calculate the production costs. The first production parameter is foraging acquisition rate ($f$), expressed in the average weight of the product that can be procured during one hour's foraging time (grams/hr). I measured this parameter empirically for each product with methods discussed in chapter 4; Table 7.3 summarizes the $f$ values used in this chapter and how I measured them. The second production parameter is caloric expenditure rate ($e$), which is the average number of calories spent per minute foraging (based on Durnin and Passmore 1967).

The production cost variables represent the time and energy spent acquiring the quantity $Q$. Production costs ($c$) include the time ($c_t$) and energy ($c_{kcal}$) spent foraging. They are calculated as follows:

$$c_t = (Q_{wt} \cdot 60) / f \qquad \text{(eq 7.1)}$$

$$c_{kcal} = c_t e \qquad \text{(eq 7.2)}$$

Table 7.2: Food values used in market model.

| Product | kcal/kg | grams protein/kg | weight of sellable unit (g) | source |
|---|---|---|---|---|
| fish | 1158 | 190 | 250 / pile | mean values from 40 ocean fish (A: 128-138) |
| crabs | 905 | 78 | 300 / each | crab, queen, raw (A: 130) |
| wild tubers | 1190 | 20 | 1350 raw tuber, 420 piece of cooked tuber | Kelly 1997 |
| honey | 3040 | 3 | 600 / *kapoake*[a] | honey, strained or extracted (B: item 1134) |
| small tenrec *tambotrike* | 2812 | 100 | 250 / each | vienna sausage, beef & pork (A: 221) |
| large tenrec *tandrake* | 4200 | 218 | 938 / each | pork, retail cuts, picnic, fat class, total edible, cooked (69 % lean, 39% fat) (B: item 1745) |
| maize | 3640 | 67 | 261 / *kapoake* | maize, whole kernal, dried, yellow (C: item 44) |
| manioc | 3570 | 13 | 1000 / kg | cassava, sweet, roots, dried (C: item 224) |
| rice | 3630 | 10 | 350 / *kapoake* | rice, white (fully milled or polished), unenriched, common commercial varieties, raw (B: item 1877) |
| vohem beans | 3400 | 225 | 350 / *kapoake* | beans, raw, red or white (B: items 154, 159) |
| lima beans | 3450 | 204 | 324 / *kapoake* | lima beans, mature seeds, raw (B: item 176) |

**Sources:**
A: Pennington (1998)
B: Watt and Merrill (1975)
C: Wu Leung (1968)

**Notes:**
a. A *kapoake* is a standard unit of measure in markets throughout Madagascar; it measured with a 354 mL Nestle condensed milk can, piled heaping full.

Table 7.3: Foraging return rates (*f*) (grams per hour) for foraged products per season, and sources of data.

### 7.3a: Ankindranoke

| Product | Wet season, 1997-1998 | Dry season, 1998 | Dry season, 1999 |
|---|---|---|---|
| fish caught with a line[a] | 182 | 140 | 140 |
| fish caught with a net[b] | 1300 | 1000 | 1000 |
| crabs[c] | 1280 | 1280 | 1280 |
| wild tubers (*balo*)[d] | not in season | 815 | 815 |

a. 13 focal follow observations during the dry seasons of 1998 and 1999 averaged 140 g/hr. The folk model discussed in chapter three suggests that fish are more plentiful during rainy times. I assumed the wet season would be 30 percent more profitable.
b. 4 focal follow observations during the dry seasons of 1998 and 1999 averaged 925 g/hr, but in all cases foragers insisted that I was witnessing a bad foraging day (my presence was also a hinderace). 1000 g/hr gives them the benefit of the doubt. I assume net fishing to be 30 percent more profitable during the wet season.
c. Average of two focal follows. The folk model suggests that return rates for crabs remains constant over seasons and years.
d. I assume that once in the region of Famata, return rates for tubers are equivalent to those measured at Behisatse. This figure includes the average return rate at Behisatse weighted by the travel time and costs of walking 16 km through sand.

### 7.3b. Forest camps

| Product | Wet season, 1997-1998 | Dry season, 1998 | Dry season, 1999 |
|---|---|---|---|
| wild tubers (*ovy*)[e] | not in season | 1290 | 1290 |
| large tenrec *tandrake*[f] | 352 | 167 | 167 |
| small tenrec *tambotrike*[g] | not in season | 166 | 166 |
| honey, wild[h] | 694 | not in season | not in season |
| honey, from hive[h] | 2341 | not in season | not in season |

e. Average of 102 observations at Behisatse during dry season 1998 and 1999, using foraging log method (see Chapter 2)
f. Average of 8 observations at Behisatse during the wet season of 1998 using foraging log method was 352. Tandrake are extremely difficult to find during the dry season; foragers averaged one per 6 hour day. At 1000 grams per animal, the return rate is 167 g/hr.
g. Average of 6 observations at Behisatse during the dry season of 1998 using foraging log method.
h. Nine observations of honey foraging using the foraging log method and one focal follow demonstrated a bimodal distribution in returns. Those foragers who were simply checking known hives averaged 2341 g/hr. Those foragers who sought honey at hitherto unknown locations in the forest averaged 694 g/hr.

### 7.3c. Namonte

| Product | Wet season, 1997-1998 | Dry season, 1998 | Dry season, 1999 |
|---|---|---|---|
| wild tubers (*ovy* and *balo*)[i] | not in season | 1032 | 1032 |
| large tenrec *tandrake*[j] | 458 | 217 | 217 |
| small tenrec *tambotrike*[k] | not in season | 216 | 216 |
| honey, wild[l] | 902 | not in season | not in season |
| honey, from hive[m] | 2341 | not in season | not in season |

i. Tuber foraging is less productive at Namonte than it is at Behisatse—I assumed that it was 20% less productive
j. Assumed 30% more productive than at Behisatse
k. Assumed 30% more productive than at Behisatse
l. Assumed 30% more productive than at Behisatse
m. Same as at Behisatse

The production cost variables represent a deficit of time and energy which the forager must offset with the benefits of her market strategy.

### 4. General form of the output variable, *A*

The remainder of this simulation calculates the costs and benefits of different marketing strategies and compares them. The cost/benefit ratio for each strategy is calculated as a gain per hour rate, called acquisition rate (*A*). Like the input variable, the output variable is calculated for multiple currencies:

$A_{kcal}$ = net calories gained per hour;
also called NAR, net acquisition rate
$A_{pro}$ = grams of protein gained per hour
$A_{cash}$ = malagasy francs gained per hour

The first output variable, $A_{kcal}$ is a net variable—it is the only variable for which the model takes into account expenditure of the currency in question. I call this NAR in other contexts in this dissertation. This is not to say that protein and cash are not spent in performing foraging or marketing tasks. Certainly, foragers expend protein when they exert effort for foraging or for transporting goods to market, but protein is "spent" (metabolized) very slowly (Williams 1999:184), too slowly to affect these calculations. Cash may be spent when labor is hired to process or transport a product, and cash may be invested in retailing activities. Most of the time, however, the households profiled in this study could not afford such cash investments, so I do not consider these situations here.

The output variables are calculated as follows:

$$A_{kcal} = \frac{G_{kcal} - (c_{kcal} + \tau_{kcal})}{c_t + \tau_t} \qquad \text{(eq 7.3)}$$

$$A_{pro} = \frac{G_{pro}}{c_t + \tau_t} \qquad \text{(eq 7.4)}$$

$$A_{cash} = \frac{G_{cash}}{c_t + \tau_t} \quad \text{(eq 7.5)}$$

Where $G$ refers to gain and $\tau$ refers to transaction costs. Gain and transaction costs are calculated differently for market strategy (a) (consumption without marketing) than for other market strategies, as explained below.

### 5. Market strategy (a): Consumption without marketing

The first market strategy is always to eat the product without selling it. In this strategy the gain in calories and protein are equal to the original input quantity. The gain for cash is always zero, for no cash can be earned from eating the product at home. There are no transaction costs.

$$G_{kcal} = Q_{kcal}$$
$$G_{pro} = Q_{pro}$$
$$G_{cash} = 0$$
$$\tau_{kcal} = 0$$
$$\tau_t = 0$$

Note that because $\tau_{kcal}$ and $\tau_t$ are equal to zero, $A_{kcal}$ is calculated in the same way that I have calculated NAR elsewhere in this dissertation. Note also that $A_{cash}$ will always be zero for this strategy.

### 6. Other Market Strategies

Other market strategies have transaction costs and benefits. Transaction costs, measured in time and energy, may include any of the following:

a). Processing costs: Costs involved in processing the product to sellable standards, such as the time and energy spent smoking fish or boiling tenrecs.

b). Transport-to costs: Costs for transporting the product to the market venue. I assume that the subject is traveling by foot at a rate of 3.5 km per hour.  Time spent transporting depends on the distance to market.  Caloric expenditure per minute depends on the weight of the load that is carried and whether the route to market is over sand or hard ground.[7]

c).  Selling time:[8]  Once the forager arrives at the market, she must spend time hawking the product.  Different products sell at different rates, and small quantities sell out faster than large quantities.

d).  Transport-from costs:  Once products are sold, new products may be purchased with the cash earned.  These purchased products must then be transported home.

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[7] All the sources I consulted (Durnin and Passmore 1967; Passmore and Durnin 1955; McArdle, Katch, and Katch1986; Montoye et al. 1996; Coates and Meade 1960) agreed that caloric expenditure during walking is a function of the person's weight, their velocity, the weight of the load they carry, and the ground surface they traverse.  However, no source provided a single method for taking all these factors into consideration.  For simplicity, I decided to assume that the forager weighs about 55 kg and is traveling at 3.5 km/hr (this is the speed that we averaged when traveling in the Mikea Forest).  Durnin and Passmore (1967:45) state that men weighing 51 to 77 kg and walking at 4.0 km/hr spent 3.4, 3.5, 3.8, and 4.0 kcals/min transporting loads weighing 0, 10, 15, and 20 kgs respectively.  In another publication, Passmore and Durnin (1955:817) report the findings of a German research group (Glasow and Müller 1951) who found that a 72 kg man walking at 3.1 to 3.5 km/hr spent 9.4, 11.6, and 16.8 kcals/min when carrying loads weighing 55, 80, and 115 kg respectively.  Seeing as both sources refer to men of similar weights walking at similar speeds, I combined the seven observations together into one dataset and performed a regression of weight against caloric expenditure.  The linear regression equation had an $R^2$ of .985.  However, it is illogical that caloric expenditure should increase linearly with weight carried; certainly, it easier to carry additional weight when one's load is light than when one is already heavily loaded down.  The cubic equation provided the correct shape for the function—exponential and accelerating.  The $R^2$ for the cubic was .992.  The cubic equation is:

$$e = 3.0906 + (.0371 * w) + (.0015 * w^2) + (-.000007 * w^3)$$

where *e* is caloric expenditure rate in kcal/min and *w* is weight of the load carried in kilograms.  Although based on only seven data points from two different studies, this equation should yield reasonable results.  Durnin and Passmore (1967:40) found, in examining the relationship between velocity and caloric expenditure, that there was very little inter-individual variation for men and women of different "races" and from five different countries, as long as they were of similar body weight.  McArdle, Katch, and Katch (1986:150) report that walking on sand at a speeds greater than 5 km/hr is 1.8 times more energetically costly than walking on hard-packed ground.  I assume that foragers walking at the somewhat slower speed of 3.5 km/hr will spend about 1.5 times more energy walking on sand than on hard ground.

[8] Selling expends energy as well, but I do not consider this here because the vendor is not necessarily required to spend more than resting metabolic energy to sit by her products, tell people prices, and collect money.

For most products and markets,

$\tau_{kcal}$ = processing energy + transport-to energy + transport-from energy
$\tau_t$ = processing time + transport-to time + selling time + transport-from time

There are exceptions, however. Products sold raw such as crabs and honey have no processing costs. Sale to a mobile retailer involves no processing costs, transport costs, or selling time.

In most cases the majority of the transaction costs will come from transport costs, and therefore distance to market has a large affect on $\tau$.

The product is sold at a market price, $p$. I assume for simplicity that the forager is a price-taker so that $p$ is beyond her control (see Table 7.4). Her cash gain is simply

$$G_{cash} = p\,Q_{wt} \qquad \text{(eq 7.6)}$$

and $A_{cash}$ can be calculated accordingly (see eq 7.5).

The forager's energy and protein gain depend on what she purchases with her newly earned cash. If the forager wishes to maximize energy gain, she will choose to purchase the product that provides the largest number of calories per franc. The model allows her to purchase maize, manioc, or rice. If she wishes to maximize protein gain, she will choose to purchase the product that provides the most protein per franc. She can choose to purchase lima beans or vohem beans. Each product that may be bought ($b$) has its own weight ($b_{wt}$), calorie value ($b_{kcal}$), protein value ($b_{pro}$), and purchase price ($b_{cash}$). The food values used here are listed in Table 7.2, and purchase prices are given in Table 7.3. The quantity she purchases ($Q_b$) is equal to the price of the purchasable product divided by the amount of cash she has earned.

$$Q_b = b_{cash} / G_{cash} \qquad \text{(eq 7.7)}$$

Table 7.4: Prices (Malagasy francs) for each season.

7.4a. Vorehe[a]

| Product | sellable unit | wet season 97-98 | dry season 1998 | dry season 1999 |
|---|---|---|---|---|
| fish—smoked | pile | 400[b] | 500 | 500 |
| crabs | each | 500 | 450 | 750 |
| wild tubers—raw | pile | not in season | 1000 | 1000 |
| wild tubers—boiled | pile | not in season | 500 | 500 |
| honey | *kapoake* [c] | 1000 | not in season | not in season |
| small tenrec *tambotrike* | each | not in season | 500 | 500 |
| large tenrec *tandrake* | each | 4000 | 8000 | 8000 |
| maize | *kapaoke* | 160 | 150 | 75 |
| manioc | kilogram | 600 | 500 | 500 |
| rice | *kapaoke* | 500 | 500 | 500 |
| vohem beans | *kapaoke* | 500 | 375 | 250 |
| lima beans | *kapaoke* | 375 | 450 | 250 |

7.5b. The coast (Ankindranoke, Andavadoake)[d]

| Product | sellable unit | wet season 97-98 | dry season 1998 | dry season 1999 |
|---|---|---|---|---|
| fish—fresh | pile | 1000 | 1250 | 1000 |
| crabs | each | 250 | 250 | 250 |
| wild tubers—raw | pile | not in season | 1000 | 1000 |
| wild tubers—boiled | pile | not in season | 500 | 500 |
| honey | *kapaoke* | 2000 | not in season | not in season |
| small tenrec *tambotrike* | each | not in season | 500 | 500 |
| large tenrec *tandrake* | each | 3000 | 6000 | 6000 |
| maize | *kapaoke* | 250 | 300 | 200 |
| manioc | kilogram | 700 | 800 | 900 |
| rice | *kapaoke* | 750 | 750 | 700 |
| vohem beans | *kapaoke* | 600 | 500 | 500 |
| lima beans | *kapaoke* | 500 | 500 | 500 |

a. Based on price inquiries at 33 weekly markets in 1998 and 1999

b. The actual sales price of a pile of dried fish was 500 francs, but the pile itself tended to include more fish

c. A *kapoake* is a standard unit of measure in markets throughout Madagascar; it measured with a 354 mL Nestle condensed milk can, piled heaping full.

d. Based on price inquiries during 10 visits to Ankindranoke in 1998 and 1999.

The energetic and protein gain is:

$$G_{kcal} = Q_b \, b_{kcal} \tag{eq 7.8}$$

$$G_{pro} = Q_{pro} \, b_{pro} \tag{eq 7.9}$$

$A_{kcal}$ and $A_{pro}$ can be calculated by applying the $G_{kcal}$ and $G_{pro}$ values to equations 7.4 and 7.5.

## 7. Running the simulation

I set up the calculation described above in a Microsoft Excel spreadsheet. I then programmed a simple routine using MS Visual Basic macros. Once the parameters are input, the spreadsheet feeds a series of $Q$ values into the model, which then outputs a series of corresponding $A$ values. The spreadsheet automatically makes three graphs, one for energy, protein, and cash. In each graph, the $A$ from each market strategy is plotted for a range of $Q$ values (see Figures 7.2 and 7.3). Each graph produces a different solution. The strategy with the highest $A$ values is the predicted optimal choice.

## 8. Variation in parameters during different time periods

The predicted optimal marketing strategy may change if the input parameters change. I observed that many of the input parameters above varied over the course of this study. To the extent that variation in input parameters is unpredictable, this may be a source of risk for Mikea who would use markets. In order to understand how marketing decisions may have varied in time, I simulate market decisions during three time periods.

time period 1: the wet season (*litsake*) of 1997-1998 (December-February)
time period 2: the dry, cool season (*asotre*) of 1998 (May-July)
time period 3: the dry, cool season (*asotre*) of 1999 (May-July).

Each time period has different input parameters for *f*, *p*, and $b_{cash}$. These values are listed in Tables 7.2, 7.3, and 7.4.

I chose these time periods because they offer seasonal contrasts and interannual contrasts. The difference between time periods 1 and 2 is a seasonal contrast. These time periods differ in the products that are available and the *f* for those products. Prices (*p* and $b_{cash}$) remain more or less the same between these two seasons. On the other hand, the difference between time periods 2 and 3 is an interannual contrast. The same products are available at the same *f* rate, but prices are different. The seasonal contrast reveals the affects of variation in *f*, while the interannual contrast reveals the affects of variation in prices.

## 9. Example of the Mikea simulation: Fish caught with a line.

Figure 7.2 contains three graphs, one for each solution. The first graph (7.2a) displays the energy acquisition rates ($A_{kcal}$) for the three strategies. Strategy (a), eating the fish, yields a constant reward for all quantities, 12.8 net kcal/hr. The payoff function is flat. This is because the model assumes that the production rate (*f*) is constant for all quantities. The *f* value for fish caught with a line is assumed to remain 182 grams/hr, whether the forager spends one hour fishing or 152 hours. Obviously, this assumption is not too realistic as it ignores the phenomena of diminishing marginal productivity of labor (and see footnote 5). I have chosen to assume that *f* is a constant rate in order to keep the model tractable. The model examines only the post-production decision; it does not consider whether the input quantity was captured during one foraging trip or many, or whether it was produced by a single forager or a team.

The output function for strategy (b), selling the fish in Vorehe, rises asymptotically as quantity increases. The manioc symbol at the end of this function indicates that to maximize energy, the decision-maker sells the fish in Vorehe and purchases manioc with the earned cash. The marginal profitability of this strategy decreases with increasing quantity, for heavier quantities of fish and purchased manioc are increasingly costly to transport.

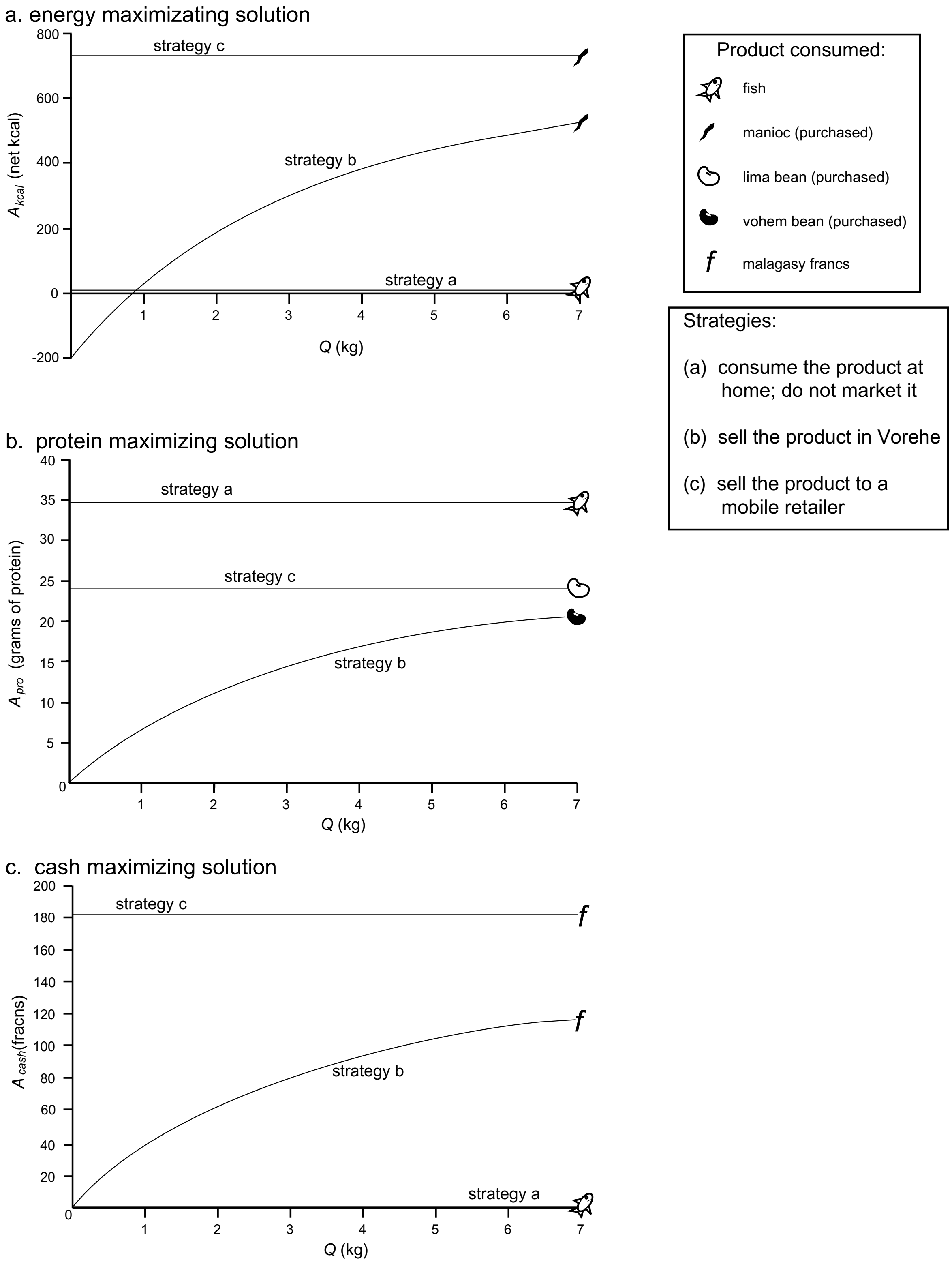


Figure 7.2: Example of Mikea market simulation output for fish caught with a line; time period 1. The decision-maker catches a quantity (*Q*) of fish. She can then follow one of three marketing strategies, each of which can be evaluated by the number of calories, grams protein, or francs it produces per hour (*R*). For strategies 2 and 3, the energy-maximizing solution demands they sell fish to purchase manioc. The protein maximizing solution demands that they sell fish to by lima beans or vohem beans.

For quantities of fish less than 1 kg, the transaction costs are high enough that $A_{kcal}$ is negative. A forager could not exchange .8 kg of fish for enough manioc to repay the energy he spent producing and marketing the fish.

The optimal strategy in Figure 7.2a is strategy (c), to sell the fish to a mobile retailer and then to purchase manioc with the earned cash. Even though the selling price to mobile retailers is quite low and the purchase price of manioc from the *doka* is quite high—relative to the prices in Vorehe—this strategy is more efficient for all quantities than strategy (b) because of strategy (b)'s high transaction costs. The output function for strategy (c) is flat due to the lack of transaction costs. $A_{kcal}$ is a function of constants: $(G_{kcal} - c_{kcal})/c_t$.

The protein maximizing solutions are shown in figure 7.2b. The optimal strategy is strategy (a), to eat the fish without marketing. Notice that in this case, the worst strategy from the perspective of energy gain is the best strategy for protein gain.

The cash maximizing solutions are displayed in the bottom graph, Figure 7.2c. The cash maximizing solution turns out to be the same as the energy maximizing solution: to sell the fish at Vorehe. Obviously, strategy (a) will never produce any cash.

Figure 7.2 displays the results of the simulation with input parameters from time period 1. In Figure 7.3 we see the output from the same model, only with the input parameters from the next time period, time period 2.

In 7.3a the energy-maximizing solution has changed. This is due to changes in the price of manioc; in time period 2, manioc has decreased in price in Vorehe and increased in price at the coast. The optimal strategy is now contingent on the quantity—that is to say, the output functions for strategies b and c intersect at $Q = 4.3$ kg. The model predicts that for quantities less that 4.3 kg, the forager will sell the fish to a mobile retailer and purchase manioc from the local *doka*. However, for quantities greater than 4.3 kg, the forager will find it profitable to haul the fish to Vorehe and to purchase manioc there.

The protein maximization solution has changed as well. In time period 2, the foraging acquisition rate ($f$) has decreased, so merely eating the fish (strategy a) is slightly

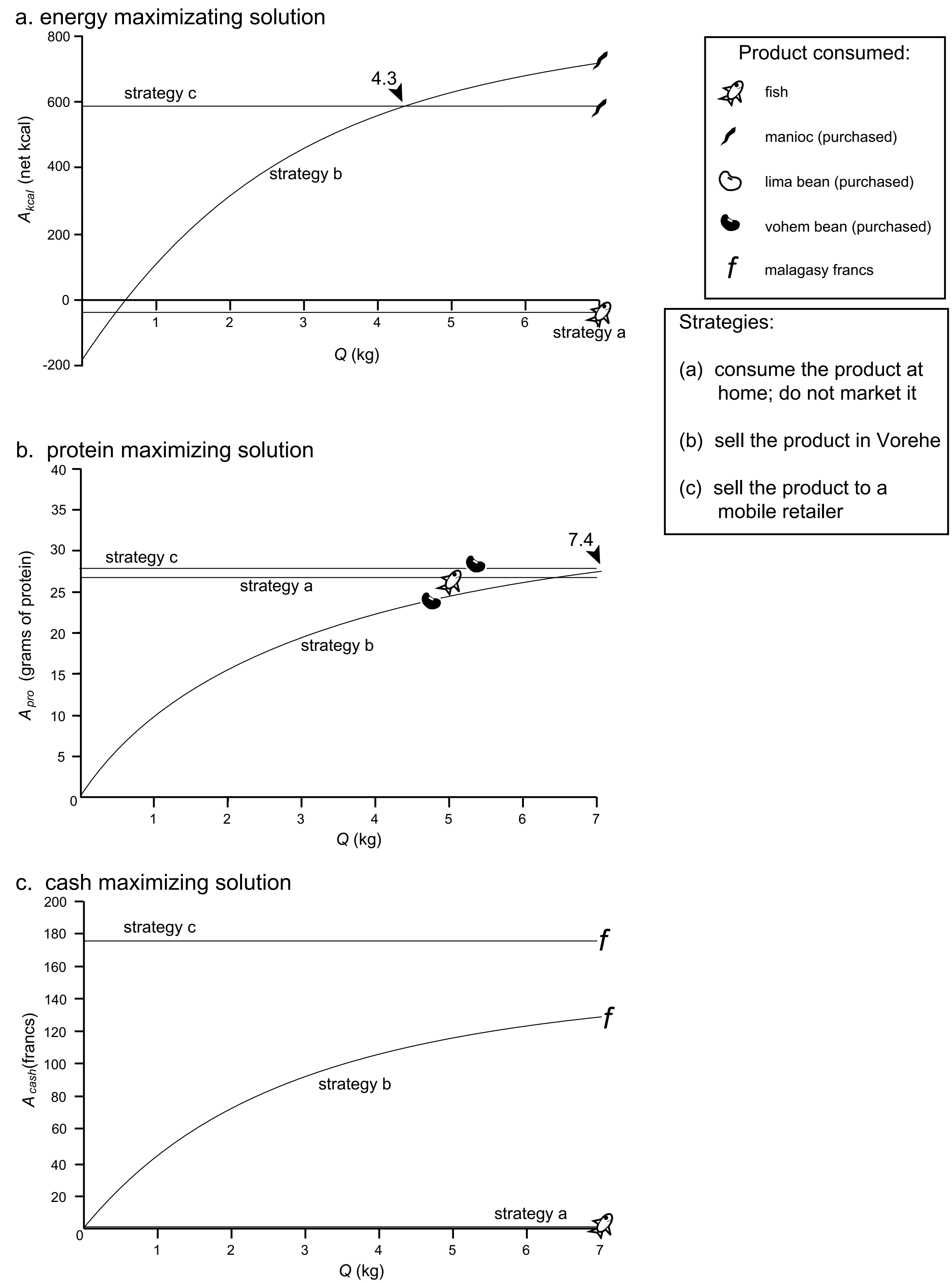


Figure 7.3: Example of Mikea market simulation output for fish caught with a line; time period 2

less profitable.  Meanwhile, vohem beans are considerably cheaper in Vorehe and slightly cheaper in Ankindranoke.  This makes strategies (b) and (c) more profitable than they had been in the previous time period.  For quantities less that 7.4, strategy (c) is only slightly more productive than strategy (a).  The outcomes are close enough that the decision-maker may not perceive the difference.  Strategy (b) becomes the protein-maximizing strategy for quantities greater than 7.4 kg.

The cash maximizing solution (Figure 7.3c) has not changed since the previous time period.

In sum: the model predicts that different strategies may be optimal for different currencies over which the household is optimizing.  The quantities at which output functions intersect change with the different input parameters of different time periods.

## D. Methods and hypotheses

### 1. Household market behavior

Of the 26 Mikea households whose economic lives I followed from November 1997 through July 1999 (Chapter 1), 15 of them were located at one of the four communities (Ankindranoke, Behisatse, Amondralambo, Namonte) during all three time periods examined in this study.  I compare the predictions of the model with the observed market behavior of these 15 households.

During 33 visits to the Vorehe market (twice or three times during each month that I was in the forest), I recorded whether each of these households was in attendance, and what they were selling or purchasing.  I recorded quantities sold or bought, but this was very difficult because many foraged goods sold quite rapidly in the early morning.  I did not witness firsthand many exchanges on the coast, but I did hear about them during 10 visits to Ankilimiavotse and Ankindranoke.

For consistency, I refer to these households with the same codes used throughout this dissertation.  The 15 households include three coastal households: R01, R02, and R03 (R03 was absent in time period 1); and 11 forest households: B01, B02, B03, B05, B06, B09, M01, M02, M03, M04, L01, and L02.

## 2. Households, utility, and risk

The model offers three possible solutions: an energy-maximizing solution, a protein-maximizing solution, and a cash-maximizing solution. The household, however, does not maximize any one currency exclusively. Instead, it seeks an optimal balance of all three currencies, plus currencies not mentioned here (water, salt, lipids, vitamins, prestige, safety, etc.), subject to time and resource constraints, so as to maximize utility (and ultimately, I presume, to maximize fitness as well). However, a household may demonstrate emphasis on acquisition of one currency over another. If a household gains more utility by consuming energy than it does protein or cash, we would expect to see that the household practiced the energy-maximizing solution more often than the other strategies. Therefore, we can use concordance between observed behavior and model predictions to gain insights into how households valued food (energy, protein) and nonfood (cash) currencies at different moments.

One of the themes in this dissertation is that the total utility function is sigmoidal in shape (Chapter 1; Friedman and Savage 1948; Winterhalder, Lu, and Tucker 1999). When considering the utility of food, the inflection point represents the minimum quantity of food that the decision-maker must consume to avoid starvation ($R_{min}$). For quantities greater than $R_{min}$, the decision-maker experiences diminishing marginal utility; each addition unit of food eaten imparts less value to the consumer than the last unit. For quantities less that $R_{min}$, the consumer experiences increasing marginal utility; each additional food unit imparts greater utility than the last unit.

In the analysis that follows, I have classified each household during each time period according to where they are on a sigmoidal utility function for food consumption; which is to say, their access to food relative to their requirement for food, $R_{min}$ (Figure 7.4). As no good term exists to describe this placement, I refer to it as the household's Utility/Risk Condition, or U-R condition. The classification works as follows:

- Poor U-R condition: Household is experiencing food shortage. Food consumption delivers increasing marginal utility. The household is risk-seeking.
- Fair U-R condition: Household is threatened by food shortage but may or may not be experiencing it. Food consumption delivers a constant marginal utility. The household is risk-indifferent.
- Good U-R condition: Household is not threatened by food shortage. Food consumption delivers diminishing marginal utility. The household is risk-averse.

## 3. Hypothesis

Presumably, the household's ultimate goal is to maximize fitness. This is achieved by optimizing survivorship and reproduction. Just as a body must divide its resources between maintenance, growth, and reproduction, so must the household. I predict that households prioritize their objectives in the same order as do bodies. If this were true, then maintenance would be the household's top priority. Households in poor U-R condition ought to emphasize acquisition of food value, energy and protein. I predict that households in good U-R condition ought to emphasize acquisition of nonfood value. Nonfood items may contribute to household reproduction. Cash can buy soap, clothing, and assets, or be used to buy rounds of coffee or alcohol for fellows, that may increase the social acceptability and prestige of household members, thus making them appear to be more worthy mates. Cash and nonfood goods may be used for what Smith and Bliege Bird (2000) have called "costly signaling."

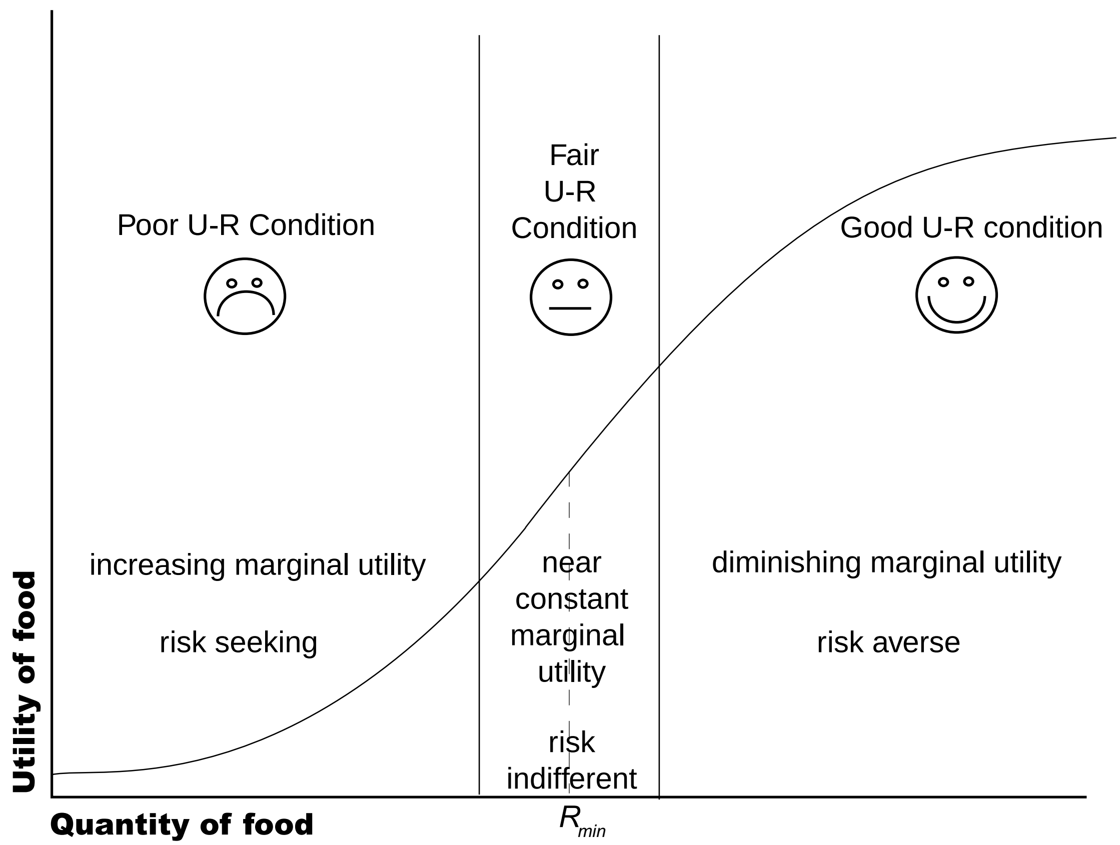


Figure 7.4: Utility-Risk conditions.

## E. Results

Results of the simulations for the coastal and forest scenarios are summarized in Tables 7.5, 7.6, 7.7, and 7.8. Below, I compare these results with the observed behavior of the 15 households (see Table 7.9).

### 1. The coast

Time period 1: The rainy season, 1997-1998. The model predicts that energy maximizers would have sold fish caught with a line or net and crabs to mobile retailers to purchase dried manioc. Protein maximizers are predicted to have eaten fish, but have sold crabs to mobile retailers to purchase lima beans. Cash maximizers are predicted to have sold all goods to mobile retailers.

Consistent with the predictions of the model, I never saw any person that I knew from Ankindranoke at the Vorehe market during this season, with the exception of a few fulltime mobile retailers.

This time period was economically difficult for the resident households. R01 was threatened by food shortage but was not experiencing it (fair U-R condition). In December R01 had just finished planting their maize in a swidden field near Ankindranoke. It was to be an extraordinarily dry year, and by early January the rains had still not started in earnest. The maize planted by R01 had not germinated, so they decided to replant, which consequently depleted their store of grain. However, while the male head worried about his corn, his wife and children were busy foraging in the bay. They caught fish and crabs, most of which they sold to mobile retailers, earning them a constant stream of cash. The female household head and her young adult niece earned cash income through the sea cucumber trade. The female household head ran a small coffee snack stand, where she sold coffee and rice cakes. Plus, the local shopkeeper was renting one of R01's buildings to use as a storage shed for his manioc. When we visited in December 1997, the male head complained that they had eaten nothing but manioc with lima beans for weeks—he was pleased that our visit gave them an

Table 7.5: Ankindranoke model results.

Possible market strategies:
(a). consume; do not market
(b). sell in Vorehe, buy in Vorehe
(c). sell to mobile retailer in Ankindranoke, buy from mobile retailer or shop

**Time unit 1: Wet Season 1997-1998**

| | Energy Max | Protein Max | Cash Max |
|---|---|---|---|
| fish caught with a line | (c), buy manioc | (a) | (c) |
| fish caught with a net | (c), buy manioc | (a) | (c) |
| crabs | (c), buy manioc | (c), buy lima beans | (c) |
| wild tubers (*balo*) | not in season | not in season | not in season |

**Time unit 2: Dry Season 1998**

| | Energy Max | Protein Max | Cash Max |
|---|---|---|---|
| fish caught with a line | $Q \leq 4.3$: (c), buy manioc<br>$Q > 4.3$: (b), buy manioc | (c), buy vohem beans | (c) |
| fish caught with a net | (c), buy manioc | (c), buy vohem beans,<br>but barely better than (a) | (c) |
| crabs | (c), buy manioc | (c), buy vohem beans | (c) |
| wild tubers (*balo*) | $Q \leq 15$: (c), buy manioc<br>$Q > 15$: (b), buy manioc | $Q \leq 23.3$: (c), buy vohem<br>$Q > 23.3$: (b), buy vohem | (c) |

**Time unit 3: Dry Season 1999**

| | Energy Max | Protein Max | Cash Max |
|---|---|---|---|
| fish caught with a line | $Q \leq 1.2$: (c), buy maize<br>$Q > 1.2$: (b), buy maize | $Q \leq 2.5$: (a)<br>$Q > 2.5$: (b), buy vohem | (c) |
| fish caught with a net | $Q \leq 14$: (c), buy maize<br>$Q > 14$: (b), buy maize | (a) | (c) |
| crabs | $Q \leq 4.7$: (c), buy maize<br>$Q > 4.7$: (b), buy maize | $Q \leq 7.1$: (c), buy vohem<br>$Q > 7.1$: (b), buy vohem | (c) |
| wild tubers (*balo*) | $Q \leq 5.8$: (c), buy maize<br>$Q > 5.8$: (b), buy maize | $Q \leq 9.2$: (c), buy vohem<br>$Q > 9.2$: (b), buy vohem | (c) |

Table 7.6: Behisatse model results.

Possible market strategies:
(a). consume; do not market
(b). sell in Vorehe, buy in Vorehe

**Time unit 1: Wet Season 1997-1998**

| | Energy Max | Protein Max | Cash Max |
|---|---|---|---|
| wild tubers (*ovy*) | not in season | not in season | not in season |
| small tenrec *tambotrike* | not in season | not in season | not in season |
| large tenrec *tandrake* | $Q \le 0.6$: (a)<br>$Q > 0.6$: (b), buy manioc | $Q \le 1.4$: (a)<br>$Q > 1.4$: (b), buy lima b | (b) |
| honey—from hive | $Q \le 2.6$: (a)<br>$Q > 2.6$: (b), buy manioc | (b), buy lima beans | (b) |
| honey—wild | $Q \le 11.5$: (a)<br>$Q > 11.5$: (b), buy manioc | (b), buy lima beans | (b) |

**Time unit 2: Dry Season 1998**

| | Energy Max | Protein Max | Cash Max |
|---|---|---|---|
| wild tubers (*ovy*) | $Q \le 2.5$: (a)<br>$Q > 2.5$: (b), buy manioc | $Q \le 1.7$: (a)<br>$Q > 1.7$: (b), buy vohem | (b) |
| small tenrec *tambotrike* | $Q \le 0.1$: (a)<br>$Q > 0.1$: (b), buy manioc | $Q \le 0.2$: (a)<br>$Q > 0.2$: (b), buy vohem | (b) |
| large tenrec *tandrake* | $Q \le 0.1$: (a)<br>$Q > 0.1$: (b), buy manioc | $Q \le 0.2$: (a)<br>$Q > 0.2$: (b), buy vohem | (b) |
| honey—wild | not in season | not in season | not in season |
| honey—from hive | not in season | not in season | not in season |

**Time unit 3: Dry Season 1999**

| | Energy Max | Protein Max | Cash Max |
|---|---|---|---|
| wild tubers (*ovy*) | $Q \le 1.2$: (a)<br>$Q > 1.2$: (b), buy maize | $Q \le 1.0$: (a)<br>$Q > 1.0$: (b), buy vohem | (b) |
| small tenrec *tambotrike* | (b), buy maize | (b), buy vohem beans | (b) |
| large tenrec *tandrake* | (b), buy maize | (b), buy vohem beans | (b) |
| honey—wild | not in season | not in season | not in season |
| honey—from hive | not in season | not in season | not in season |

Table 7.7: Amondralambo model results.

Possible market strategies:
(a). consume; do not market
(b). sell in Vorehe, buy in Vorehe

**Time unit 1: Wet Season 1997-1998**

| | Energy Max | Protein Max | Cash Max |
|---|---|---|---|
| wild tubers (*ovy*) | not in season | not in season | not in season |
| small tenrec *tambotrike* | not in season | not in season | not in season |
| large tenrec *tandrake* | $Q \leq 0.3$: (a)<br>$Q > 0.3$: (b), buy manioc | $Q \leq 0.9$: (a)<br>$Q > 0.9$: (b), buy lima b | (b) |
| honey—from hive | $Q \leq 1.3$: (a)<br>$Q > 1.3$: (b), buy manioc | (b), buy lima beans | (b) |
| honey—wild | $Q \leq 5.8$: (a)<br>$Q > 5.8$: (b), buy manioc | (b), buy lima beans | (b) |

**Time unit 2: Dry Season 1998**

| | Energy Max | Protein Max | Cash Max |
|---|---|---|---|
| wild tubers (*ovy*) | $Q \leq 1.5$: (a)<br>$Q > 1.5$: (b), buy manioc | $Q \leq 1.0$: (a)<br>$Q > 1.0$: (b), buy vohem | (b) |
| small tenrec *tambotrike* | (b), buy manioc | $Q \leq 0.1$: (a)<br>$Q > 0.1$: (b), buy vohem | (b) |
| large tenrec *tandrake* | (b), buy manioc | $Q \leq 0.1$: (a)<br>$Q > 0.1$: (b), buy vohem | (b) |
| honey—from hive | not in season | not in season | not in season |
| honey—wild | not in season | not in season | not in season |

**Time unit 3: Dry Season 1999**

| | Energy Max | Protein Max | Cash Max |
|---|---|---|---|
| wild tubers (*ovy*) | $Q \leq 0.7$: (a)<br>$Q > 0.7$: (b), buy maize | $Q \leq 0.6$: (a)<br>$Q > 0.6$: (b), buy vohem | (b) |
| small tenrec *tambotrike* | (b), buy maize | (b), buy vohem beans | (b) |
| large tenrec *tandrake* | (b), buy maize | (b), buy vohem beans | (b) |
| honey—from hive | not in season | not in season | not in season |
| honey—wild | not in season | not in season | not in season |

Table 7.8: Namonte model results.

Possible market strategies:
(a). consume; do not market
(b). sell in Vorehe, buy in Vorehe
(c). sell in Andavadoake, buy in Andavadoake

**Time unit 1: Wet Season 1997-1998**

| | Energy Max | | Protein Max | | Cash Max |
|---|---|---|---|---|---|
| wild tubers (*ovy*) | not in season | | not in season | | not in season |
| small tenrec *tambotrike* | not in season | | not in season | | not in season |
| large tenrec *tandrake* | $Q \leq 1.6$:<br>$Q > 1.6$: | (a)<br>(b), buy manioc | $Q \leq 2.7$:<br>$Q > 2.7$: | (a)<br>(b), buy lima b | (b) |
| honey—from hive | $Q \leq 2.0$:<br>$Q > 2.0$: | (a)<br>(c), buy manioc | (c), buy vohem beans | | (c) |
| honey—wild | $Q \leq 1.8$:<br>$Q > 1.8$: | (a)<br>(c), buy manioc | (c), buy vohem beans | | (c) |

**Time unit 2: Dry season, 1998**

| | Energy Max | | Protein Max | | Cash Max |
|---|---|---|---|---|---|
| wild tubers (*ovy*) | $Q \leq 11$:<br>$Q > 11$: | (a)<br>(c), buy manioc | $Q \leq 2.2$:<br>$Q > 2.2$: | (a)<br>(c), buy vohem | (c) |
| small tenrec *tambotrike* | $Q \leq 2.4$:<br>$Q > 2.4$: | (a)<br>(b), buy manioc | $Q \leq 0.5$:<br>$Q > 0.5$: | (a)<br>(b), buy vohem | (b) |
| large tenrec *tandrake* | $Q \leq 1.5$:<br>$Q > 1.5$: | (a)<br>(b), buy manioc | $Q \leq 0.9$:<br>$Q > 0.9$: | (a)<br>(b), buy vohem | (b) |
| honey—wild | not in season | | not in season | | not in season |
| honey—from hive | not in season | | not in season | | not in season |

**Time unit 3: Dry season, 1999**

| | Energy Max | | Protein Max | | Cash Max |
|---|---|---|---|---|---|
| wild tubers (*ovy*) | $Q \leq 5.8$:<br>$Q > 5.8$: | (a)<br>(b), buy maize | $Q \leq 2.1$:<br>$Q > 2.1$: | (a)<br>(b), buy vohem* | (c) |
| small tenrec *tambotrike* | $Q \leq 1.0$:<br>$Q > 1.0$: | (a)<br>(b), buy maize | $Q \leq 0.3$:<br>$Q > 0.3$: | (a)<br>(b), buy vohem | (b) |
| large tenrec *tandrake* | $Q \leq 0.8$:<br>$Q > 0.8$: | (a)<br>(b), buy maize | $Q \leq 0.6$:<br>$Q > 0.6$: | (a)<br>(b), buy vohem | (b) |
| honey—wild | not in season | | not in season | | not in season |
| honey—from hive | not in season | | not in season | | not in season |

* result is very close: sell in Andavadoake, buy vohem beans.

Table 7.9: Household U-R condition and household behavior (emphasis on acquisition of food or nonfood value) for each time period

7.9a: Ankindranoke

| | Time period 1 | Time period 2 | Time period 3 |
|---|---|---|---|
| HHC1 | U-R C = fair<br>food | U-R C = poor<br>food | U-R C = good<br>nonfood |
| HHC2 | U-R C = fair<br>nonfood | U-R C = poor<br>food and nonfood | U-R C = poor<br>subsistence |
| HHC3 | | U-R C = good<br>food | U-R C = fair<br>food |

7.9b. Behisatse

| | Time period 1 | Time period 2 | Time period 3 |
|---|---|---|---|
| HHF1 | U-R C = good<br>nonfood | U-R C = poor<br>nonfood | U-R C = good<br>nonfood |
| HHF2 | U-R C = fair<br>nonfood | U-R C = poor<br>nonfood | U-R C = fair<br>nonfood |
| HHF3 | U-R C = fair<br>nonfood | U-R C = poor<br>nonfood | U-R C = fair<br>nonfood |
| HHF4 | U-R C = good<br>nonfood | | |
| HHF6 | U-R C = fair<br>nonfood | | |
| HHF7 | | U-R C = poor<br>nonfood | U-R C = fair<br>nonfood |

7.9c. Amondralambo

| | Time period 1 | Time period 2 | Time period 3 |
|---|---|---|---|
| HHF7 | U-R C = good<br>nonfood | | |
| HHF8 | U-R C = good<br>nonfood | U-R C = good<br>nonfood | |
| HHF9 | U-R C = good<br>nonfood | U-R C = good<br>nonfood | |
| HHF10 | U-R C = good<br>nonfood | U-R C = good<br>nonfood | U-R C = poor<br>food |

7.9d. Namonte

| | Time period 1 | Time period 2 | Time period 3 |
|---|---|---|---|
| HHF4 | | U-R C = poor<br>food and nonfood | U-R C = poor<br>food |
| HHF5 | U-R C = poor<br>food and nonfood | U-R C = poor<br>food and nonfood | U-R C = poor<br>food |
| HHF6 | | U-R C = poor<br>food and nonfood | U-R C = poor<br>food |
| HHF8 | | | U-R C = poor<br>food |
| HHF9 | | | U-R C = poor<br>food |
| HHF11 | U-R C = fair<br>food | U-R C = poor<br>food | U-R C = fair<br>food |
| HHF12 | U-R C = fair<br>food | U-R C = poor<br>food | U-R C = fair<br>food |

## Notes:

U-R C = welfare

Blank cells indicate absence from the site during this time period.

excuse to eat fish. Even when they served crabs to us, as their guests, the household did not eat crabs themselves. It appears, then, that this household was converting the better part of their cash income from fishing and crabbing into manioc and lima beans, consistent with the energy maximizing and protein maximizing solutions. Their objective appears to have been to emphasize food value acquisition, for which they used the local market of mobile retailers and shopkeepers.

Household R02 occasionally failed to meet its own food needs (fair U-R condition) R02 was headed by a single mother and a dynamic personality, was clearly emphasizing cash acquisition—she sold almost all that she caught to mobile retailers. Among her projects during this period was the construction of a new reed house that she intended to use as a sort of guesthouse for mobile retailers from Vorehe. She hoped to fix exclusive relationships with mobile retailers by hosting them. She sank considerable time into their social needs and money into coffee beans, sugar, and rice for their palates. Meanwhile, she spent several hours each day fishing with a line or crabbing. Although reputed to be one of the best fishers in the village, she herself complained to us in December 1997 that her hosting responsibilities often caused her to enter the bay late and suffer low return rates. She and her children lived mostly on manioc and *aofa,* the small shellfish that is leftover bait from line fishing. In the end, she often failed to feed her own family. When this occurred, her three children dined with R01, adding additional burden to that household.

Time period 2: The dry season, 1998. The model predicts that energy maximizers sell fish caught with a line and wild tubers to mobile retailers unless the quantity was quite large, in which case these products would have been profitably sold in Vorehe. For all quantities, fish caught with a net and crabs were best sold to mobile retailers. Manioc was reasonably priced in Vorehe as well as Ankindranoke, and served as the purchase medium for energy-maximization. Protein maximizers were not predicted to have eaten seafood during this period. They would have sold all marine products to mobile retailers to purchase vohem beans. Wild tubers should also have been sold for beans to mobile retailers, unless the quantity was extremely high, in which case they can be sold in Vorehe. The cash maximizer was predicted to sell all products to mobile retailers.

For the most part, R01, R02, and R03 did not sell goods at the Vorehe market during this time period, although all three households did attend the market at least once. Other Ankindranoke households sold fish and crabs at Vorehe during this time period, but not wild tubers. This is consistent with the model—households should sell in Vorehe when they have sufficiently large quantities to sell. The quantity of wild tubers that render them profitable to sell in Vorehe is very high (14.6 kg for energy maximization, 23.3 kg for protein maximization), representing more than one day's foraging effort.

Most everyone agreed that 1998 was a *baintao*—a bad year. Rain in Ankindranoke totaled an insufficient 250 mm from November through February (see Chapter 3). The corn that did manage to grow was then wiped out by swarms of grasshoppers. Few farmers produced any maize at all. The market prices for agricultural foods, which normally drop during the dry season, remained more or less at their wet-season values.

This was a dire time for R01 (poor U-R condition). The male head had hoped to rely primarily on his maize production this year; however, he had no maize production to speak of. Still lacking sinkers for his net, the male head found little productive to do with his time. Meanwhile, an adult grandchild with epilepsy came to live with the family; he contributed little to household subsistence and required near constant supervision, which reduced the amount of time adults and young adults could spend foraging. Plus, the shopkeeper had begun construction of his own house, which meant that his rental agreement would soon expire. The household struggled to make ends meet. The adults and young adults fished and crabbed. They ate almost exclusively manioc only rarely with lima beans or vohem beans, which they got in exchange with mobile retailers (and at a special price from the shopkeeper, who took pity on them). Their behavior was largely consistent with the predictions of the energy maximization solution. Thus, this household continued to emphasize food value acquisition with increased use of the local market.

R02 was experiencing poor U-R condition. She had still not finished construction of her guest house; the reed roof that had kept the sparse rain off her guests four months ago now served as a shady spot where mobile retailers happily drank the coffee and ate the rice that she continued to serve to them. Increasingly discouraged, the household head increased the amount of time she spent fishing and crabbing. She brokered deals between other foragers and the mobile retailers who stayed at her house, so as to maintain the loyalty of the clientele she hoped to build. Nonetheless, the mobile retailers began to feel neglected and complained about their hostess. She also lead an expedition to the Famata region to excavate wild tubers. Some of the tubers were eaten by the household and shared with her guests, while much of it was sold in Ankindranoke to consumers. She still frequently failed to meet the food needs of her family. Her juvenile son would fish with a half sized net, sell the fish to mobile retailers, and then use his profits to buy manioc for his own dinner; the alternative sought by his younger sisters was to beg a meal from R01. The head's behavior was again consistent with the cash maximization solution (in contrast to my hypothesis), so it appears that she continued to pursue nonfood objectives during this time period. Meanwhile, her juvenile son had switched to food acquisition, for which he used the market of mobile retailers collected by his mother.

R03 was in a better circumstance (good U-R condition). This young couple had spent the wet season at a forest camp attending about 2 hectares of swidden maize, a crop that was obliterated by grasshoppers. In May the household had the opportunity to sell its own labor, an opportunity that was unavailable to R01 and R02.[9] The male head of R03 traveled to the

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[9] Chopping new *hatsake* is an activity performed by young men (see Chapter 5). Neither R01 nor R02 had any young adult or adult men. The old adult male in R01 was rather frail and may or may not have been physically capable of this kind of labor. Undoubtedly, he would have been ashamed to work for others in this capacity, given his age and prestige.

southern part of the Mikea Forest where he received wages for clearing forest to create new cornfields. By late June wage opportunities in the southern forest had dried up; after a trip to Vorehe to purchase new clothing for his family as well as a flashlight, he returned to Ankindranoke and found work making planks for the shopkeepers' new house. Meanwhile, his wife spent her days fishing with a line, net fishing with her siblings, or crabbing. She never sold her products in Vorehe. They ate fish and crabs or sold them to mobile retailers, and purchased manioc. Their behavior was inconsistent with maximization of any one currency; rather, it represents some kind of balance among numerous currencies. The household appears to have been pursued nonfood objectives through wage labor, while foraging provided energy and protein simultaneously, fulfilling subsistence objectives.

Time period 3: The dry season, 1999. The model predicts that energy maximizers ought to have sold any reasonably-sized quantity in Vorehe, while cash maximizers ought to have sold to mobile retailers. Protein maximizers may have eaten fish, but probably sold crabs to mobile retailers when the quantity was small and sold crabs in Vorehe when quantities were large.

Ankindranoke received more than 700 mm of rain from December 1998 through March 1999. Grasshoppers frequently appeared in the sky, but they seemed to have no appetite for maize. By May 1999, maize harvest was complete and most households, including R01, found themselves in good U-R condition.

R01 now had an operable fishing net (obtained through livestock sales and profits from mobile retailing of maize in October 1998)[10] and so the male head and the boy from R02 often went net fishing together. The female head fished and crabbed only recreationally; she was making good profits from her coffee stand, for Ankindranoke residents now had

[10] Interestingly, households that suffered food shortage sometimes had livestock—in some cases, sizable herds. The decision to eat livestock was not taken lightly. This may have something to do with the way in which future livestock rewards were evaluated in comparison with short-term emergency food acquisition strategies. Future discounting models like that presented in the next chapter could be applied to this issue.

money to spend on her tasty rice cakes and beverages. Yet, the household still rarely ate fish or crabs, but sold them instead to mobile retailers. They were not spending this money on maize, but rather, on new clothing, coffee beans, and sugar. This is consistent with the cash maximization solution. Unlike the previous time periods, the household was now pursuing nonfood objectives.

R02 planted nothing in 1999 and so did not share in the year's maize bounty, although she did benefit from the extraordinarily low buying price of maize in Vorehe and on the coast. Household U-R condition remained poor. The roof of her guesthouse was now falling apart and so was her base of guests. She spent even more time fishing and crabbing, and her son frequently went net fishing with the male household head from R01. We saw her at almost every weekly market in Vorehe during this period. She was selling her own fish, and was also doing some mobile retailing of her own. Consistent with the model's predictions, the only time we saw her selling crabs was when she had a large quantity; she had hauled 100 of them in three gunny sacks on a friend's oxcart (she failed to liquidate all the crabs before some died). Her frequent attendance at Vorehe suggests that she had switched emphasis from cash acquisition to the pursuit of food value, in particular, energy maximization.

R03 enjoyed a good maize harvest. However, like many in 1999, they had an insufficient quantity of seed left from the previous year and so had not planted a very large field; household U-R condition remained fair. The male head again did some wage labor clearing forest in the southern part of the Mikea Forest, but he found that the wage rate was lower than it had been in the previous year. He also made frequent trips to the Famata region to dig wild tubers. He and his wife and her siblings engaged in net fishing, and his wife practiced line fishing and captured crabs. This household never sold any of their foraging production in Vorehe during this time period. Instead, they either ate their produce or sold them to mobile retailers to purchase maize. This behavior is consistent with energy and protein maximization solutions, which is to say, the acquisition of food value.

### 2. The forest

**Time period 1: The rainy season, 1997-1998.** The model predicts that both subsistence and nonfood objectives could have been met by selling the products. Households emphasizing energy or protein are predicted to have eaten a few *tandrake* or a couple cups of honey (or lots of honey, if they had their own hive), but would have marketed the surplus to purchase manioc or lima beans.

The rainy season is usually a difficult time for forest residents. Wild tubers are not available during this season, and so Mikea households must obtain all their carbohydrates from their own stores of maize or manioc or through exchange. However, several of the households considered here entered the season in good U-R condition. In December 1997, households B01, B02, B03, B06, and B09 were living at Behisatse, where they were busy planting maize. B01 and B06 had enjoyed bountiful manioc harvests a few months earlier, and planned to survive the rainy season on their stores. The other three households had limited stores and experienced fair U-R condition. B09 was a young household consisting of a newly-wed couple; they cohabitated with B05 so as to exploit (demand share) that household's store of manioc. B02 had stores of maize from the previous year, although these dwindled as the drought forced him to replant his fields. B03 had traded a large quantity of fish that they had captured in a lake near Namonte for 60 kg dried manioc in November.

Meanwhile, M01, M02, M03, and M04 had just finished planting maize at Amondralambo. All these households were in good U-R condition due to bountiful maize stores from the previous year.

All the households resident at Behisatse and Amondalambo attended the Vorehe market almost every week during this time period to sell honey. I never observed that any of these households purchased manioc with these funds, as the energy maximizing solution predicts. Instead, these households used the money to purchase tobacco, soap, mangoes, and very occasionally, clothing. This behavior is consistent with cash maximization and the pursuit of nonfood goals.

However, these households rarely sold *tandrake* even though they frequently captured this animal. When foragers caught one or two *tandrake* they usually ate them, whereas larger quantities were sold in Vorehe. This behavior is partially consistent with energy and protein maximization. However, I never saw that foragers actually sold *tandrake* to buy manioc or beans, as the energy and protein maximization solutions predict. This inconsistency between model predictions and observed behavior suggests that Mikea decision-makers value *tandrake*, manioc, and beans in ways not considered nor calculated by the model. Meat may be valued more highly than vegetal products even when the caloric and protein value of quantities of the later procured through exchange outweigh the quantities of the former.

The male household head from B05, a widower, disdained agricultural labor—he had not planted maize or manioc once during the past decade. His teenaged son was more enterprising. He planted maize at Behisatse, and manioc and sweet potatoes in a lakebed garden at Namonte. The household lived at Namonte because the household head claimed that this was a better home base for commercial foraging, because they had access to both Vorehe and Andavadoake. Most people agreed that B05 lived at Namonte because of disagreements with family members living at Behisatse, Bevondro, and Vorehe, who generally considered this man to be lazy. This household had nothing in storage at the beginning of the rainy season, and so was in poor condition.

L01 and L02 lived at Namonte year round. L02 was the smallest household in this study, consisting of a mature woman twice divorced, without children. L01 included a husband and wife and children. These households cultivated manioc and maize in lakebed gardens at Namonte and tended small *hatsake* fields in the nearby forests. Both had a small store of very bitter manioc. L01 had done wage labor in rice fields the past year and L02 had sharecropped rice, so both had stores of rice as well. Their U-R condition was fair.

During this period, B05 and L02 both made frequent trips to Andavadoake where they sold honey and purchased dried manioc. This is consistent with the energy maximization prediction. We did not witness Namonte households selling *tandrake* at Vorehe; instead, *tandrake* were consumed. Both the energy maximization solution and the protein max solution allow for consumption of quantities equivalent to several animals. The Namonte households, unlike their forest peers, were focusing more on energy acquisition and the pursuit of subsistence objectives than cash and nonfood goods.

Interestingly, the claim by the household head of B05 that Namonte is a better base for a commercial forager is supported by the model, at least in regards to the commercialization of honey. The model predicts that 6 kg wild honey sold at Vorehe would have yielded 546 francs/hr for a Behisatse resident and 693 francs/hr for a resident of Amondralambo. Meanwhile, Namonte residents could have sold honey at Andavadoake at a rate of 969 francs/hr. The people at Behisatse and Amondralambo were accepting lower $A_{cash}$ for their honey, perhaps to remain close to their cornfields.

Time period 2: The dry season, 1998. As above, the model predicts that both subsistence and nonfood objectives were pursued by selling wild tubers and tenrecs. For the forest camps, food value acquisition goals were met by selling all except for the smallest quantities of tubers and tenrecs and purchasing manioc and vohem beans. Namonte residents pursuing subsistence objectives are predicted to consume larger quantities of foraged goods. The energy maximization solution predicts that up to 11 kg of tubers or 2.4 kg of *tambotrike* were consumed by the household; these quantities exceed the amount a forager is likely to produce in one foraging day.

The drought of 1998 did not affect Behisatse and Amondralambo residents in the same manner. Although located only 8 kilometers from one another, the two sites received different amounts of rainfall at different times. At Amondralambo, consistent rainfall began in December and so the crop was mature by late February. At Behisatse, rainfall was not consistent until mid-January. Fields planted in December had to be replanted. In February, grasshopper swarms descended on maize fields throughout the forest. At Amondralambo the grasshoppers found mature, dry maize which they left alone; at Behisatse, they found green maize, which they quickly devoured (see Chapter 3).

The complete loss of maize was devastating to the Behisatse residents, and for several months all households abandoned their camp completely. At the beginning of the dry, cool season in May 1998, B01, B02, and B03 decided to move back to Behisatse. They were joined by M03, a household from Amondralambo who had lost their maize to a herd of uncontrolled cattle. This was an extremely difficult time for these households; U-R condition was poor. Foragers spent from dawn to dusk each day digging wild tubers, while their young children cried from hunger back in camp. Other household members went on multi-day foraging expeditions to capture tenrecs, especially *tambotrike*. The male head of B03 and his younger brother (also part of his household) were among the few foragers in the region skilled in locating hibernating *tandrake*, a skill they made use of during this time period.[11]

Despite their poor U-R condition and the imminent threat of starvation, the Behisatse residents frequently sold *tambotrike* and *tandrake* in Vorehe, and purchased nonfood items in return—behavior consistent with the cash maximization solution. They rarely ate these animals, but sold quantities of 10 to 30 *tambotrike*. The energy maximization solution predicts that a quantity of 30 tambotrike (3.7 kg) could be exchanged for 29 kg manioc, yielding a $A_{kcal}$ of 2840 kcal/hr—which is more than twice the return rate for digging wild tubers! It is unclear, then, why Behisatse foragers in need of food did not specialize in tenrec foraging and commercialization instead of spending long hours each day digging wild tubers from the ground.

[11] This was a very difficult time for our research team as well. We had come to Behisatse to observe the behavioral strategies of peasant-forager households during times of food shortage. But we felt that it would have been irresponsible of us not to help these people at the same time. We decided to cook extra rice each day to feed to the young children who were left behind by the wild tuber foragers. Meanwhile, we secretly arranged with a farmer near Vorehe to have 100 kg of dried manioc delivered to Behisatse, to divide among its residents. This plan took a week to implement, so in the meantime we were able to observe the adults' strategies for coping with shortfall.

Behisatse foragers consumed great quantities of wild tubers and almost never sold them, although Mikea from other communities sold *ovy* regularly. Occasionally a Behisatse resident would sell one or two raw tubers alongside her tenrecs, but never did I witness Behisatse folks going to market for the purpose of selling tubers during this time period. This behavior is inconsistent with any of the model's predictions. The model predicts that if the household was pursuing subsistence goals then it would have been better off selling all but a few wild tubers and purchasing manioc and vohem beans in return.

Meanwhile, M01, M02, and M04 remained at Amondralambo, where they subsisted on maize, and enjoyed relatively good U-R condition. In constrast with Behisatse residents, these households sold the wild tuber *ovy* almost every week at Vorehe. The model predicts that Amondralambo residents ought to have sold wild tubers more frequently than Behisatse residents—Amondralambo residents are predicted to have sold quantities in excess of 1.5 kg, and Behisatse residents were predicted to have sold quantities in excess of 2.5 kg. This is because transaction costs are cheaper for Amondralambo, which is closer to Vorehe. For a 6 kg load, Amondralambo tuber sellers could have gained 433 francs/hr whereas Behisatse foragers could gain 314 francs/hr.

Amondralambo residents also sold *tambotrike* in similar quantities to their peers at Behisatse, although no one in these households was skilled in finding hibernating *tandrake*.

The sale of wild tubers and *tambotrike* by Amondralambo residents generated revenue that was for the most part spent on nonfood goods. With their subsistence needs met with maize, Amondralambo households used the market to turn foraged goods into nonfood resources.

Discouraged by the loss of their maize crop and their poor U-R condition, B06 and B09 moved back to their homeland, Namonte. Here they worked together with their close kin in B05 to excavate wild tubers and capture *tambotrike*. The majority of what they procured was consumed by the households themselves. This behavior is consistent with both energy and protein maximization solutions, which predict that quantities of tubers and tenrecs available from one day's foraging (up to 11 kg tubers, 2.4 kg *tambotrike*) should be consumed by the household. However, at times they appear to have been driven by nonfood objectives as well. They made occasional trips to Andavadoake to sell tubers. Two of these households, B06 and B09, sold *tambotrike* at Vorehe on a few occasions, in each case selling over 100 cooked animals. Like their fellows, they did not purchase food in return, but rather, spent their earnings on nonfood goods, especially tobacco—consistent with the cash maximization solution.

The decision by B03 and B06 to move back to Namonte was neither favored nor discouraged by the exchange economy. A 6 kg load of wild tubers could gain them 348 francs/hr at Andavadoake, which is similar to the $A_{cash}$ for the forest camps at Vorehe discussed above. A 3 kg load of *tambotrike* sold at Vorehe, given the higher return rate for these animals in Namonte, would have gained them 359 francs/hr, which is little different than Behisatse's $A_{cash}$ of 406 francs/hr.

L01 and L02 sold neither tubers nor tenrecs, but ate them instead. These households had suffered a total loss in terms of maize and their lakebed gardens had been menaced by goats; they were experiencing grave food shortages. Their behavior was consistent with the energy and protein maximization solutions, the pursuit of subsistence goals.

Time period 3: The dry season, 1999. The model predicts a universal increase in use of markets during the dry, cool season of 1999. The abundant rainfall of 1999 lead to bountiful harvests of maize, which in turn drove the price of maize down to 75 francs/cup at Vorehe, a full 50 percent decrease from time period two. The price for vohem beans declined by 33 percent from its price in time period two. The model predicts that forest camp residents ought to have sold nearly any quantity of tubers and tenrecs to purchase maize, beans, or nonfood goods. At Namonte, where transaction costs were greater, the model still predicts an increase in commercial activity in contrast with time period two. However, the required quantities of tubers and *tambotrike* needed to make commercial trade worthwhile are still quite high—easily equivalent to one day's foraging payoff (5.8 kg tubers, 1 kg *tambotrike*). Namonte foragers may still maximize subsistence objectives by consuming their foraged goods rather than selling them.

The abundant rainfall during 1999 resulted in bountiful maize crops throughout the region. However, the ample rainfall did not favor all households equally. A tragedy struck M01 and all the people of Amondralambo in October 1998 when the female household head died of tuberculosis. The male household head, a respected spirit medium, declared that the site of the Amondralambo camp was cursed with evil magic. As a result, M01 and M04 spent the wet season of 1998-1999 practicing *mihemotse*, nomadic foraging; they did not plant maize. M01 decreased considerably in size during this period, as the male head's teenaged sisters and his teenaged sons took spouses and moved to other communities. Eventually, the remaining members of M01 and M04 resumed residence at their ancestral homeland in Namonte.

Only M02 remained in the Amondralambo region, moving to another new camp in the same area, this one created by Vorehe residents for the purposes of swidden maize agriculture. Their maize harvest was lousy due to predation by cattle during a time when the female head was nine months pregnant and the male head was on the coast attempting to sell his mangoes. This left M02 experiencing poor U-R condition. The Amondralambo household sold tubers at each weekly market and used their earnings immediately to purchase maize and beans. They rarely sought *tambotrike* but occasionally encountered them while tuber foraging. They chose to eat *tambotrike* rather than to sell them. Their behavior was consistent with energy and protein maximization solutions, so it appears this household was emphasizing subsistence objectives.

At Behisatse, maize harvests were bountiful. However, only B01 had possessed enough seed at the end of 1998 to plant a large field (about 4 hectares), and experience good U-R condition. The other Behisatse households—B02, B03, and M03—planted less than a hectare each, and soon found themselves facing the threat of food shortage (fair U-R condition). As in the previous year, Behisatse residents sold *tambotrike* and *tandrake* at Vorehe and purchased nonfood goods; they never sold tubers. The sale of tenrecs appears to be consistent with cash maximization, while their failure to commercialize tubers remains unexplained by the model.

The majority of households at Namonte had been too discouraged by the previous year's loss of maize to plant in 1999; as a result, they gained little benefit from the year's bountiful maize harvest. These households had nothing in storage and no cash income. Although they met their daily needs for food without too much worry through foraging, the threat of food shortage was a constant concern. Therefore, I classify their U-R condition as poor. These households ate the large part of the tubers and tenrecs they produced themselves; this is consistent with the pursuit of subsistence objectives via energy and protein maximization. However, as described for the last time period, some of these households would occasionally sell tubers in Andavadoake and tenrecs in Vorehe, and use the profits to pursue nonfood goals.

The uneven success of the maize harvest created a new market for some Namonte foragers. B06, B05, and B09 foraged for fresh water fish as well as *tambotrike*. Rather than transport these goods all the way to Vorehe, they traded them to prosperous farmers at forest camps such as B01 at Behisatse, in exchange for maize.

The household head of M01 frequently sold wild tubers in the Vorehe market—a suboptimal behavior according to any of the model's predictions. The reason for this behavior was that this man was courting a new wife, a woman who lived in Vorehe. Thus, he accepted the large transaction costs of hauling tubers from Namonte to Vorehe, and the even greater opportunity cost of not selling them at Andavadoake, so as to pursue future reproductive goals. Although his behavior was inconsistent with the model's predictions, it is consistent with the neodarwinist suppositions that underlie the model.

Two Namonte households, L01 and L02, did plant maize in 1999 and enjoyed profitable harvests. However, like their fellows at Behisatse, they lacked enough seed to plant more than a hectare or so of maize. L02 had invested their time and energy into rice cultivation in the lakebeds, but these crops were destroyed by flooding. As a result, household U-R condition was fair. Interestingly, these households had almost no commercial activity during this time period.

## F. Conclusions

Models such as the one used in this paper are a heuristic tool for defining problems, organizing data, testing understanding of data, and for making predictions. As Starfield and Bleloch put it "models are an abstraction, a simplification of a process rather than a replication of the process. They never describe the real world *exactly* and often do not even attempt to do so" (1986:1). In this case, the decision of what, where, and at what quantities to sell foraged products have been abstracted into a tally of costs and benefits, measured in currencies of food and trade value. Where the model succeeds at predicting actual observed behavior, the hypothesized relationships within the model that most strongly influenced the prediction are retained as plausible. The model's successes often suggest surprising trends that are not immediately intuitive. Where the model fails to explain observed behavior may also be useful, for it indicates that some of the hypothesized relationships within the model are inappropriate and should be reworked or rejected (Winterhalder and Smith 1992:12-14). I begin here by discussing the successes of the model. Then I discuss some surprising suggested trends implied by the model's results. I conclude with an examination of the cases in which the model predictions contrast with observed behavior.

### 1. Successes

The model succeeds in a very general way of explaining differences in marketing behavior at the community level. This success lends credence to the supposition by de Janvry, Fafchamps, and Sadoulet (1991) that large transaction costs coupled with insufficient market benefits (a low selling price, high prices for purchased goods) discourage market participation.

Two contrasts between communities demonstrate this point. The first contrast is between Amondralambo and Behisatse. Both of the forest camps sold the same products in Vorehe. But because Behisatse was twice the distance as Amondralambo from Vorehe, the transaction costs for Behisatse households were greater than the transaction costs for Amondralambo folks. The model predicts that Behisatse households must have had a greater quantity of honey, tubers, and tenrecs than Amondralambo foragers before they would have found it profitable to sell this quantity in Vorehe. Observation confirms that Amondralambo residents participated in the Vorehe market much more frequently than do Behisatse foragers.

The second contrast is between Ankindranoke and Namonte. Both of these village communities were about the same distance from Vorehe, so transaction costs should have been about the same. However, observation demonstrates that money is omnipresent in the Ankindranoke economy—nearly all the fish and crabs produced were sold, and cheaper foodstuffs purchased in exchange. Meanwhile, money plays very little role in the economy of Namonte, where households produce the majority of what they consume and only sell when they have nonfood needs. Some households, such as L01 and L02, almost never marketed anything. The model shows that the ubiquity of money at Ankindranoke was due to the presence of a profitable second market with no transaction costs—sale to mobile retailers. Likewise, the model demonstrates for Namonte foragers that the quantity of tubers and tenrecs necessary to make market exchange worthwhile is greater than a single days' foraging income, even during a range of seasonal and interannual fluctuations in production rate and market prices. Transaction costs effectively removed Namonte residents from the market economy, while a lack of transaction costs enabled Ankindranoke foragers to sell everything profitably.

The input parameters to which the model is most sensitive are production rate, sales price, and the purchase price of agricultural goods. In a dry year such as 1998 when

Table 7.10: Crosstablation of household U-R condition and behavior.

| | | Food | both | Nonfood |
|---|---|---|---|---|
| U-R C: | Poor | 10 | 5 | 4 |
| | Fair | 6 | 0 | 7 |
| | Good | 0 | 1 | 11 |

| | value | df | asymptotic 2-sided sig |
|---|---|---|---|
| Pearson Chi Square | 17.739 | 4 | .001 |
| Likelihood ratio | 23.298 | 4 | .000 |
| Linear-by-linear assoc | 12.474 | 1 | .000 |
| N | 44 | | |

agricultural failure was an issue, the prices of maize, manioc, vohem beans, and lima beans were quite high. The model predicts that foragers interested in maximizing energy or protein should have eaten larger quantities of their own catch rather than selling to buy agricultural staples. In 1999, harvests of maize and beans were large enough that their purchase prices fell precipitously. Suddenly, energy and protein maximizers who were content to eat their catch are predicted to sell smaller quantities purchase these cheaper staples instead.

There appears to be a general relationship between household U-R condition and currency maximization, although the relationship is not without ambiguity. The hypothesis advanced above was that households with poor U-R condition ought to pursue primarily subsistence goals, while households with good U-R condition ought to be more likely to emphasize nonfood goals. Table 7.10 totals the number of observed cases in which households at different U-R condition levels were observed to emphasize food value, nonfood value, or both. Each "case" tallied in this table is a household in one season (n=44).[12] Consistent with this prediction, the majority of the cases coded as being in poor U-R condition were observed to emphasize acquisition of food value, where as the majority of cases coded as experiencing good U-R condition were observed to be emphasizing nonfood acquisition. A chi square test confirms that this trend is statistically-significant (2-sided sig. = .001).

[12] 15 households x 3 seasons = 45 cases, minus one for R03 which was absent during time period one.

However, this trend was far from universal. In four cases, households with poor U-R condition were observed to emphasize non-food objectives. It is possible that in some of these cases, the nonfood objective pursued by the household was one that is, for some people at least, as biologically necessary as food: nicotine, caffeine, or alcohol acquisition. By far, the number one use for cash by these particular households (B01, B02, B03, M03) was to purchase tobacco. Foragers frequently complained that it was difficult to concentrate on foraging when *sijy* (jonesing) for tobacco.

## 2. Surprises

The first surprise pertains to household reaction to risk and shortfall. Anthropologists commonly assume that during times of food shortage or when the risk of food shortage looms near, peasant households decrease their participation in the market economy and “revert” back to a “safer” subsistence economy. The model predictions and behavioral observations both negate this assumption. In many situations, the acquisition of food value is facilitated by market exchange. For example, marine foragers in Ankindranoke find that the trade value of their products is often greater than the food value. The only time they can afford to eat fish and crabs (practice subsistence economics) is when times are good. In tough times, optimizing foragers must follow the strategy of exchanging fish for beans and manioc. Line-caught fish during the wet season (time period 1) yielded a mere 13 kcal/hr when eaten, but if they were sold in Vorehe they would yield 504 kcal/hr in the form of purchased manioc; if sold to a mobile retailer in Ankindranoke, they would yield 730 kcal/hr in the form of purchased manioc. As discussed above, there appears to be a relationship between shortage (poor household U-R condition) and pursuit of subsistence goals, acquisition of food value. Pursuit of subsistence goals should not be confused with practicing a “subsistence economy” in which markets are not used.

The second surprise is that increasing the production rate, as occurs when new technologies are introduced, increases $A_{kcal}$, $A_{pro}$, and $A_{cash}$ rates for all strategies, including the strategy of not marketing the product at all. The result of increasing production rate is that the household must harvest a greater quantity before it will consider the quantity to be worth selling.

The examples of increased production rate for the same product are fish and honey. Fish may be caught with a line or by net; honey may be gathered from a known location (a hive) or an unknown location (wild). Fish caught by either method have the same transaction costs and sell for the same price in markets. Likewise, honey gathered from either context is equally costly to transport and sell, and sells at the same price. The only difference in both cases is the production rate—net fishing is considerably more productive per hour than line fishing, and collecting honey from a hive is considerably more productive per hour than is searching for wild honey.

For time period 3, the model predicts that protein-maximizing line fishers ought to sell all quantities greater than 2.5 kg. On the contrary, it predicts that net fishers ought to avoid selling unless the quantity is 7.1 kg or greater.

Likewise for honey: in time period 1 at Behisatse, the model predicts that an energy maximizing forager ought to sell quantities of wild honey greater than 2.6 kg, and should avoid selling hive honey unless the quantity is greater than 11.5 kg.

Increasing the production rate increases the payoff rate for selling a product, but it increases the payoff rate for eating the product in step. This implies that new techniques that improve production rate do not necessarily translate into increased market activity.

### 3. Shortcomings of the model

In a few cases, forest foragers in poor U-R condition were not observed to maximize food value as I had expected. In the first case, foragers at Amondralambo and Behisatse during the wet season rarely marketed *tandrake*, even though they could have received more food value by selling these animals in Vorehe and purchasing manioc and lima beans. In the second case, foragers at Behisatse during the dry season of 1998 and 1999 almost never sold wild tubers, even though the model demonstrated that more food value could be obtained through sale of tubers and purchase of manioc or maize and beans. During the dry season of 1998, Behisatse foragers were in very poor U-R condition—adults dug tubers from dawn till dusk while children cried from hunger—and yet they still did not use their earnings from tenrec sales to purchase food, even though doing so would have been easier than digging tubers at all.

One possible reason that Behisatse foragers may have sold *ovy* less often than predicted is that they faced some hidden transaction cost that is not considered within the model, perhaps something that is not measurable. There were certain social costs for Behisatse foragers of attending the Vorehe market. Even though many people at the Vorehe market call themselves "Mikea," there is something of a social stigma attached to those Mikea like the Behisatse residents who chose to live in the forest year round. Tattered clothing, poor hygiene, and shyness around crowds are thought to label one as a forest forager. Forest foragers are stereotyped as being particularly uneducated, unintelligent, dirty, and primitive by their fellow peasants. The Amondralambo residents may have faced derision as well, although the male household heads of M03, M01, and M04 were fathered by a man from Vorehe and so had closer social ties to people there.

A more serious social cost to market participation for Behistatse residents was the risk of being caught by gendarmes or military without national identity papers. While all Malagasy citizens are required to carry national identification cards and internal passports, many forest-dwelling Mikea have never undergone the process necessary to obtain one. There were three military officers stationed at Vorehe (at the request of the village council and the Lutheran community) to protect the citizenry from cattle thieves and to break up the drunken brawls that often occurred after market days. The military men performed occasional spot-checks of ID cards at the market, especially when they were trying to locate cattle thieves. On one occasion, I was chatting with the male head from B03 in the Vorehe market when he spotted a military officer checking ID cards at the other end of the marketplace. When I turned my head to invite my friend to join me for a cup of coffee, he had disappeared! He later admitted that he had fled into the forest to avoid the ID check. His market plans for that day were ruined.

These social costs may account for why Behisatse foragers participated in the market less frequently than expected, but this explanation does not account for market non-participation for specific goods. In regards to the wild tubers that Behisatse residents were mysteriously not selling, another possible explanation is that I mismeasured the quantities of typical sales units. While the unit of sale for some products was standardized, such as maize which was always sold in a 354mL can (a *kapoake*), the unit of sale for wild tubers was not standard; it was sold by the piece. I observed that the price per unit remained more or less constant over time. It is possible, however, that the size of the sale unit may have varied. I confirmed this phenomena for other products that was sold in unstandardized units. Manioc was sold in piles ranging in weight from .6 to 1.4 kg, and piles consistently cost 500 francs. Likewise, piles of mangoes or oranges consistently sold for 500 francs, although sometimes the pile contains two pieces of fruit and other times in contains six. Since the price to weight ratio is among the more sensitive input parameters in the model, it is possible that an inappropriate input parameter could have throw off the model's predictions. By the closest measure I could come up with, a 500 franc cooked piece of *ovy* weighed an average of 420 grams and a 1000 franc raw piece of *ovy* weighed an average of 1350 grams. If I were to double the weight of the sellable unit or halve the price and then rerun the model, suddenly it predicts market non-participation for quantities of *ovy* less than four to eight kg. The average quantity of tubers produced per day at Behisatse was 7.6 kg. Therefore, an inability to account for variation in the weight of sold tubers may have possibly biased the model's predictions.

There is also the issue of food preference. Among the first phrases I learned to speak in Malagasy was, *aia soa amin'nao*? Which is better in your opinion? After which I would list types of food: *balahazo sa ovy?* Manioc or wild tubers? Thus began many casual conversations about food preferences. Although I found variation among individuals, nearly everyone I polled insisted that wild tubers were more tasty and satisfying than domestic maize or manioc (especially dried manioc, which feels and tastes like chalk). A frequent response was that *ovy* is delicious even when eaten plain, while manioc and maize demand some kind of accompaniment or *laoke*—beans, fish, honey, or sugar. Likewise, those that I polled universally preferred any meat product to beans. The cultural preference for the taste of foraged goods versus agricultural staples was further demonstrated by the fact that foraged goods had a higher market price per calorie or gram of protein than their agricultural substitutes (recall Table 7.1). While the model makes no distinction between calories in the form of wild tubers and those in dried manioc, or protein in meat versus protein in beans, it is likely that Mikea foragers would make that distinction. My guess is that most Mikea would find the idea of selling *ovy* to buy manioc, or selling *tambotrike* to buy beans, to be laughable. The same may not true for coastal foragers, who are forever indifferent dried fish. Finally, given that the Vorehe market has only existed for about a decade, it is possible that Behisatse residents simply haven't explored the full potential of the Vorehe market to acquire food value. I almost never witnessed residents of Behisatse, Amondralambo, or Namonte purchasing foodstuffs in Vorehe. One man from Behisatse told me that food is not something that should be purchased; it is available for free in the forest and under the ground. The value of cash, he explained to me, is the value of tobacco.