

Household and Argan Forest Impacts of Morocco's Argan Oil Bonanza*

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ABSTRACT

Argan oil is now the most expensive edible oil in the world. The oil, which has been a mainstay for Berbers in southwestern Morocco for centuries, was propelled out of obscurity in the 1990s by favorable findings about its culinary, cosmetic and even medicinal virtues. Growing high value argan markets have sparked a bonanza of argan activity. NGOs, international and domestic development agencies, and argan oil cooperatives have played a central role in this bonanza with the win-win aim of benefiting locals and thereby benefiting the argan forest. We test the credibility of the popular win-win argan story by assessing the impact of the argan boom on rural households in the argan forest. We do this by surveying households before and after the boom. We conclude that the argan boom has benefited some rural households. Encouragingly, households that stood to benefit from the boom in 1999 were significantly more likely to send their girls to secondary school in subsequent years. Results for the argan forest are more mixed. While locals are keeping their goats out of argan trees during the fruit harvest which is good for the trees, they may also be resorting to more aggressive harvesting techniques. With the argan boom, households have become vigilant guardians of fruit on the tree, but seem much less eager to invest in longer term tree and forest health. We close this section with a few observations and recommendations about the future of conservation and development in the Morocco's argan region.

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I INTRODUCTION

Argan oil is now the most expensive edible oil in the world. It is even more expensive as a cosmetic product and is the subject of several US and European cosmetic patents. The oil, which has been a mainstay for Berbers in southwestern Morocco for centuries, was propelled out of obscurity in the 1990s by favorable findings about its culinary, cosmetic and even medicinal virtues. Growing high value argan markets have sparked a bonanza of argan activity. NGOs, international and domestic development agencies, and argan oil cooperatives have played a central role in this bonanza with the win-win aim of benefiting locals and thereby benefiting the argan forest. These win-win claims appear on virtually every argan product label and have been showcased widely by media outlets worldwide, including the New York Times, Elle Magazine, TV5, National Geographic, among countless others. The win-win argan story is indeed compelling, but is it true?

Since Evans (1988) put forth the “conservation through commercialization theory” pertaining to oils and other non-timber forest products, the prevalence of the win-win outcome of economic development and environmental conservation has been put under increasing scrutiny by researchers and policymakers in the past few decades (see Neumann and Hirsch, 2000 and Arnold and Perez, 2001 for a review and synthesis). The ability of resource extraction to result in conservation depends on the impacts of extraction on regeneration¹ (Peters, 1994), property rights regimes within indigenous communities (Ostrom, Gardner, and Walker, 1993; Arnold and Perez, 2001; Lopez Feldman and Wilen, 2008), and sovereignty over the resource (Dove, 1993). The majority of the empirical literature on non-timber forest product extraction is based in the tropics, with little attention paid to forests in dry areas such as southwestern Morocco. This study will broaden the geographic scope of the literature, in addition to applying panel data to study the development and conservation outcomes of increased resource commercialization.

The literature has shown mixed impacts of forest product extraction on poverty and inequality. Lopez-Feldman, Mora, and Taylor (2007) show that extraction of the *xate* palm in southern Mexico contributes greatly to economic equality. Reddy and

¹ Witkowski and Lamont (1994) and Peters (1994) suggest that fruit extraction, as is the case in the argan forest, is particularly detrimental to forest regeneration and conservation.

Chakravarty (1999) show that without forest income poverty would increase 28 percent in India. Jodha (1986) and Fisher (2004) demonstrate that without forest income inequality would increase 36 percent in India and 12 percent in southern Malawi, respectively. In a related vein, Pattanayak and Sills (2001) show that access to non-timber forest products act as a natural insurance in the Brazilian Amazon, increasing welfare by mitigating agricultural risk.

In many other cases, the impact of forest resource commercialization on poverty and inequality has been ambiguous or negative. Neumann and Hirsch (2000) present evidence from an array of studies that show that non-timber forest product extraction is an activity of the poor, and Wunder (2001) and Angelson and Wunder (2003) argue that there optimism about a win-win development and conservation outcome is unwarranted, and that non-timber forest product extraction is generally a low income activity that may even result in a poverty trap. In the case of argan products, Lybbert, Barrett, and Narjisse (2002) offer a cautionary assessment of the potential for argan commercialization to stimulate development or decrease poverty. To our knowledge, all of the existing studies on the benefits of non-timber forest product extraction have been done with cross sectional data that makes it difficult if not impossible to see how changes in market conditions affect household welfare.

We test the credibility of the popular win-win argan story by assessing the impact of the argan boom on rural households in the argan forest by surveying households before and after argan prices skyrocketed. This panel dataset allows for a unique assessment of the causal impacts of increasing argan oil prices. While earlier analysis of these households included some nascent changes in markets (Lybbert, Barrett and Narjisse 2003; Lybbert, Barrett and Narjisse 2002), the subsequent evolution of argan markets and commercialization represents a dramatic departure from 1999 trends. We use a difference-in-difference approach that uses this dramatic shock to argan markets as a treatment effect of sorts. We conclude that the argan boom has benefited some rural households. Encouragingly, households that stood to benefit from the boom in 1999 increased their weekly consumption spending at *souk* (market) and goat herd size more than households that did not stand to benefit. These households were also significantly more likely to send their girls to secondary school in subsequent years. Results for the

argan forest are more mixed. While locals are keeping their goats out of argan trees during the fruit harvest which is good for the trees, they may also be resorting to more aggressive harvesting techniques. With the argan boom, households have become vigilant guardians of fruit on the tree, but seem much less eager to invest in longer term tree and forest health.

We begin in the next section by briefly reviewing the literature on non-timber forest resource extraction, focusing on where it has resulted in the aforementioned win-win result and where it has not. In section III we characterize argan oil and the dramatic changes that occurred in argan markets since the late 1990s. In Section IV we describe the data we use to assess the impacts of the recent argan oil bonanza on local households and on the forest. Since our empirical approach hinges on changes that occurred between our 1999 and 2007 rounds of data collection, we also include in this section a discussion of general trends in the argan region and compare these two years in the context of these trends. Section V describes our empirical approach in detail and presents and discusses results. We conclude in section VI with key conclusions and a post script about the impact of the 2008 drought on the region. We close this section with a few observations and recommendations about the future of conservation and development in the Morocco's argan region.

II THE ARGAN OIL BONANZA

The argan tree (*Argania spinosa* (L) Skeels) is endemic to Morocco, where it is second in coverage only to the cork oak tree and is ecologically indispensable. Its deep roots are the most important stabilizing element in the arid ecosystem, providing the final barrier against the encroaching deserts (see Morton and Voss 1987). The tree resists domestication and remains extremely difficult to transplant or establish on any meaningful scale outside Morocco. In recognition of its ecological value and local economic importance, the argan forest region was declared a UNESCO Biosphere Reserve in 1998.

Argan forests are invaluable to the indigenous Berber tribes who rely on the peculiar tree for firewood and charcoal for heating and cooking; wood for carpentry and construction; fodder for livestock; and oil for culinary, cosmetic and medicinal purposes.

Indeed, nearly 90 percent of the rural economy in the region depends on argan-based agroforestry (Benchebkroun 1990). This heavy local dependence on the argan tree has shaped clear and well-established, albeit complex, tenure arrangements that grant usufruct rights to the fruit of sections of the forest to specific villages and households (see Lybbert, Barrett and Narjisse 2002). Some households have argan trees on their private land, but most access argan fruit on land that is collectively exploited during most of the year. During the fruit harvest, portions of this collective forest are individually exploited for fruit collection under well-defined usufruct rights, called *agdal* rights. Other portions of the collective forest, called *azroug*, remain collectively exploited year round. Any household can collect argan fruit in its village's *azroug*. These spatial and temporal dimensions of fruit collection and other usage rights are depicted in Figure 1.

Despite its uniqueness and indispensability, the argan tree faces a variety of serious threats. Nearly half of the argan forest disappeared during the 20th century – and average density in the remaining half dropped from 100 to less than 30 trees per hectare. This historical pressure on the forest was driven by demand for high quality charcoal (especially important during the world wars) and, more recently, to conversion to agricultural production of export crops such as tomatoes.² While neither of these pressures emanated from locals in the argan forest, the important contemporary forest threats do. Particularly important among these threats are local intensification of livestock browsing and grazing and encroaching suburban and rural settlements – driven in part by recent European demand for rural real estate near popular tourist destinations such as Essaouira.

The oil extracted from the argan tree's fruit exhibits notable culinary and cosmetic properties. Growing appreciation for these properties during the 1990s – primarily driven by scientists, tourists, entrepreneurs, and cosmetic firms – set the stage for dramatic changes in the demand for argan oil. When the households included in our sample were first surveyed in 1999, some of these changes along with their implications for the extraction and commercialization of argan products were evident. Entrepreneurs had already started tapping into higher value tourist markets in 1999 and were laying plans

² As evidence of the latter, a change assessment from 1981-87 in two communes of the Province of Taroudant indicated a significant drop in vegetation cover, which is almost exclusively argan forest, on 43% of the land area (Bakkoury 1999).

for expansion into Europe and North America. By about this time, a few European cosmetic firms, including Yves-Roche and Colgate-Palmolive, were experimenting with argan-based moisturizers. While these for-profit operations helped to envision and develop high value argan markets, a far more potent early influence came from conservation and development interests that saw the potential to leverage high value argan markets to benefit locals and empower women³ (who are primarily responsible for argan activities), and thereby to promote local conservation of the threatened argan tree.

In 1999, there were two major conservation and development efforts based on argan oil in the region. The first was fueled by Zoubida Charrouf, a professor of chemistry at the Mohammed V University in Rabat, who had spent years researching the chemical properties of argan oil. In the mid-1990s, Professor Charrouf began organizing argan oil cooperatives for women in the argan forest region. The second effort was led by the German development agency GTZ, which also supported the development of argan oil cooperatives for women, albeit of a different form.⁴ These early cooperative initiatives substantially shaped the subsequent evolution of argan oil markets. Through investments in oil quality, testing to ensure purity, mechanical extraction, packaging and labeling, and in the distribution networks required to tap export markets these initiatives pioneered the path to high value argan oil commercialization. During our 1999 survey, nearly all commercialized argan oil was sold in re-used plastic bottles by small traders in small rural markets, but the writing was on the wall: some dramatic changes were in store for argan markets.

Since 1999 argan oil has frequently attracted the media's gaze and has appeared in a host of European and North American media outlets. It has been featured in its own French documentary, is showcased by just about any tourist publication or production on Morocco, and now has dozens of websites dedicated to it. Across this broad array of media attention, one strand is nearly always woven into the argan story: the wonderful win-win it offers consumers to protect trees and help local women all while enjoying the many virtues of this "liquid gold" (Larocca 2007). Not surprisingly, this compelling story

³ Some benefits to women included the opportunity to congregate with other women outside the household, the opportunity to earn a good wage (often more than their husbands), and attend literacy courses offered in argan cooperatives.

⁴ For a description of the differences between these initial argan oil cooperatives see Lybbert, et al. (2002).

has fueled a veritable frenzy of argan activity in the past decade with new argan oil producers, distributors, and cooperatives springing up at every turn. Most players are ultimately driven by the opportunity to make money by tapping high value argan markets. Most also actively leverage the win-win logic in this pursuit. Some include quaint references to the threatened tree and the women involved in extracting the oil on their labels. Others take a more proactive role by linking up with existing cooperatives or with one of the many conservation and development projects that have blossomed around all the argan attention. By far the most important such project is *Projet Arganier* funded jointly by the Moroccan *Agence de Développement Social* and the European Union. This seven year (2003-2010), €12 million initiative aims to empower and improve the lives of rural women in the argan region and to promote the protection and conservation of the forest by, among other things, supporting the expansion of argan oil cooperatives for women. As a result of this targeted investment in the region, cooperatives have exploded from a handful involving a few hundred women in 1999 to over 100 cooperatives involving nearly 4,000 women in 2007.⁵

Total fruit production in the argan forest can vary wildly from year to year due to rainfall fluctuations, but it is perfectly inelastic in the short and medium term. An argan sapling – very few of which typically survive beyond a few years – can take 20 years or more before producing fruit (see Lybbert, Barrett and Narjisse 2003). Good data on aggregate fruit production and collection in the argan forest does not exist, which makes it difficult to assess whether fruit collection could expand despite perfectly inelastic fruit production in the short to medium term. Anecdotally, locals seem to have become much more careful about how and how completely they collect fruit in the last several years. Historically, locals collected a portion of their fruit harvest by hand – picking up dried argan fruit that had ripened and fallen to the ground – and a portion by goat – letting their goats eat fruit directly from the thorny tree canopy, then picking argan stones from goat dung. As the fruit has become more valuable, locals are collecting much more fruit by hand, which has likely made fruit collection more complete and expanded slightly the amount of fruit available for oil extraction. This very modest fruit supply response,

⁵ Although not our focus here, there is anecdotal evidence that the influx of external funding for argan oil cooperatives has strongly shaped the characteristics and composition of these cooperatives, the so-called ‘Rockefeller Effect’ (Gugerty and Kremer 2004).

however, is swamped by the recent explosion in argan oil demand, and argan prices have skyrocketed as a result. As shown in figure 2, which is based on trader surveys we conducted in 2007, real argan fruit prices in rural markets nearly doubled between our 1999 and 2007 survey rounds. Moreover, fruit prices have increased much faster than oil prices in these markets. This was a change we anticipated in 1999 given that (i) the oil sold in local markets is unsuitable for sale in high value markets and (ii) high value producers must purchase fruit from local markets in order to extract oil that is suitable for these markets (see Lybbert, Barrett and Narjisse 2002).

Kernel prices have closely tracked oil prices. The kernel market was relatively thin in 1999, but has grown substantially in volume in recent years due primarily to demand from ABSIM, the largest private argan oil business. Established in the late 1990s by a Swiss entrepreneur as one of the first dedicated argan oil companies, ABSIM followed the lead of the semi-mechanized cooperatives and adopted a mechanical extraction process. Unlike the semi-mechanized cooperatives, however, which employ women to crack argan stones in order to harvest the kernel inside, ABSIM purchases massive quantities of kernels from rural markets and trucks them to their extraction facility in Casablanca. These direct kernel purchases by high value extractors are new to argan markets. In 1999, high value extractors insisted on purchasing only whole fruit in local markets as a guarantee that the kernel inside had not passed through a goat's gut (Lybbert, Barrett and Narjisse 2002). With substantially higher fruit prices, however, locals have a clear incentive to prevent their goats from ingesting whole fruit in the first place: all ingested stones ultimately come out the other end, but many will be lost ("an argan fruit in the hand is worth two in the goat"). Locals' rational shift toward collecting fruit by hand has effectively resolved an asymmetric information problem in the market for argan stones and nuts. Because there are far fewer "goat stones" and "goat kernels" in local markets as a result, high end extractors are increasingly willing to purchase stones and kernels in spot markets. This emerging high value kernel market may ultimately offer locals a way to capture more value added from high value oil markets.

Changes in argan oil demand have not only increased argan prices, but have also driven significant differentiation into argan markets. Presently, there are two broad argan oil markets, one culinary and the other cosmetic. Culinary argan oil, historically available

only in or near the argan forest region, is now marketed across Morocco, Europe, the Middle East, and North America. Since this market spans dusty village *souks* and upscale restaurants in New York and Paris, retail prices range widely from \$10/liter to twenty times this much, making it the most expensive edible oil in the world.

The market for cosmetic argan oil has likewise exploded over the past decade. The extensive traditional knowledge of the Berbers of the argan forest region, who have used argan oil cosmetically for centuries, has intrigued travelers for centuries (see M'Hirit et al. 1998) and began attracting attention from researchers decades ago. Introducing cosmetic argan oil into high value international markets has required research into both the chemical properties of the oil and potential extraction and processing technologies. Two distinct segments of the cosmetic argan oil market have emerged. The first consists of pure argan oil marketed as a natural moisturizer or added directly to a moisturizer or other cosmetic product. Vendors of culinary argan oil often offer cosmetic argan oil as well. Other firms specialize in argan-based cosmetic products. The second segment of the cosmetic argan market is more research-intensive, focuses on extracts from argan oil, leaves, fruit, and seeds that are marketed as active ingredients in cosmetic treatments, and has generated a variety of patents in Europe and the U.S. (see Lybbert 2007). Cognis, the leading firm in this segment, has agreed to purchase its argan materials at a premium from an established cooperative.

Improvements in packaging and labeling were the first step to tapping high value markets in the late 1990s. Labeling is again emerging as a potentially important aspect of differentiation in argan markets, this time in conjunction with certification. There are currently several argan oil products – both culinary and cosmetic – that are fair trade certified by organizations such as AlterEco and Max Havelaar. Many more products include label claims that locals benefit from the sale of the product without any fair trade certification. Similarly, many argan oil products are marketed as organic and some have discussed certification to this effect, although it remains unclear how argan oil could not be organic. There has also been a sustained effort in recent years to register argan oil as a geographic indication in Europe. There is currently no clear certification to distinguish argan cooperatives from private firms, and 90 percent of wives of household heads surveyed did not know the difference between the two. As a result, the argan forest

region is rife with small shops that pose as cooperatives, pay guides to bring tourists to their faux-cooperatives, and sell diluted argan oil to unsuspecting tourists while not providing the benefits actual cooperatives promise to their members.

III DATA

The data used in this paper was collected in two rounds of a household survey. The first was conducted in summer 1999 at the cusp of the dramatic changes in argan markets described in the previous section. The second round was conducted in summer 2007, after argan markets had changed substantially. The original sampling frame was constructed as a stratified cluster sample in the Smimou *Caidat*, a county-like administrative unit located in the Essaouira Province in southwest Morocco. Villages in the Smimou *Caidat* were stratified by forest density (low, average and high).⁶ We randomly selected two villages in each density class. We supplemented this list with four additional villages located near two of the original argan cooperatives. With the help of village officials, we sorted households within these selected villages into two categories, those with few or many *agdal* rights, and then randomly selected households from each category. The survey was fielded separately with the male and female heads of household.

We surveyed approximately 20 households in each of these villages in 1999, for a total sample size of 149 households in 1999. Of these 149 households we resurveyed, 46 were not resurveyed in 2007. In 22 of these households, the household head had either died between 1999 and 2007 or was extremely ill and no suitable replacement could be found. Another nine households migrated. Nineteen households were temporarily absent, and one household refused to participate in the 2007 survey. Of the 103 remaining households, nine only consisted of the wife of the household head and seven only consisted of the male household head. This leaves 87 households for which there is a complete set of data. As shown in table 1, there were no systematic differences in the baseline (1999) data of the households in the panel and those who are not. Besides age of household head, no key variables differed significantly to the 10% confidence level.

⁶ To sort villages in the Smimou *Caidat* into low, average and high argan forest density, we consulted local and regional forestry officials in conjunction with topographical maps and a 1996 forest inventory.

Table 1 also provides a few insights into our research context: Education levels are very low, goats are the most important form of livestock, and argan-based activities are generally very important.

Our empirical approach in this paper relies on changes that occurred in our surveyed households between 1999 and 2007 to shed light on the local welfare impacts of booming argan markets. Before turning to this analysis we look at broad trends in the argan forest region in order to understand what else – in addition to the argan price boom – may have changed between these years. Ideally, we would begin by comparing total argan fruit production in the forest, but annual fruit production estimates for the argan forest simply do not exist. Qualitative and anecdotal evidence, however, uniformly suggests that 2007 fruit production was higher than in most recent years including 1999, which was a mediocre year.⁷

Livestock play a central role in household welfare and put pressure on the argan forest, so we next consider changes in the aggregate goat herd. As shown in Figure 3, the goat herd trended upward after 1995, albeit with substantial yearly variability. Since pressure on the forest is a function of the interaction of rainfall and stocking rates, this figure also shows the evolution in the number of head per mm of rainfall received in a given year. Although argan prices, especially for argan fruit, have boomed since 1998, this has apparently not translated into an aggregate reduction in livestock pressure on the forest – something we investigate more closely in the next section.

Finally, the cost of living in the argan forest region increased between our survey rounds. Cost of living indices for urban areas in the region (Agadir and Marrakesh) increased nearly 25 percent between 1999 and 2007. Although this is well below the increase in argan prices (see Figure 2), rural households widely note that things are getting more expensive and the value of their production is not keeping up. This cost of living squeeze could easily force some rural households to modify their expenditure decisions.

⁷ Lacking total fruit production data, we turn to the best available proxy, rainfall, which heavily drives forest and crop productivity and, by extension, the local economy. While both seasons had rainfall totals below 250 mm and well below median rainfall, the seasons differed dramatically in the monthly timing of this rainfall. Abnormally high rainfall received in the crucial early months of the season in 2006-07 seems partly responsible for the excellent 2007 fruit production.

IV ANALYSIS & DISCUSSION

We begin our analysis in this section by looking at how wealth has changed in our surveyed households between 1999 and 2007. Next, we assess changes in households' production of and reliance on argan products. We then analyze the impact of booming argan markets on household welfare and on the forest.

A. Household wealth trends

We begin with an assessment of changes in household wealth in our sample. If the argan boom has broadly benefited rural households in the region, we would expect to see some encouraging improvements in household wealth. As a descriptive test of household wealth trends among our surveyed households, we construct a household wealth index and depict distributions of this index for 1999 and 2007. Specifically, we construct a factor analytic index based on a household's number of *agdal* rights, land holdings, sheep, goats, cows, weekly spending at market, and weekly *souk* spending on goat meat. Distributions of this wealth index for 1999 and 2007 are shown in figure 4. T-tests show that there is a slight significant aggregate improvement in rural household wealth in the region. Whether this improvement can be attributed to the booming argan market is uncertain. A closer look shows that the biggest increases in wealth were concentrated in the medium density areas of the forest, although the results are not significant for the individual density regions of the forest (Figure 5). There was no clear evidence that coop villages experienced a greater increase in wealth than non-coop villages.

B. Aggregate trends in household argan activities

Having described changes in household wealth between 1999 and 2007, we now assess how argan production, storage, sales, and consumption have changed during this time of argan market evolution. We consider how argan activities have changed for the sample as a whole and for sub-samples of households based on density class. Table 2 shows how these have changed on average and suggests a few notable fruit and oil trends.

Based on our full sample, household argan oil production was nearly three times higher in 2007 than in 1999. Oil production was very consistent across density classes in both 1999 and 2007. Table 2 also suggests that households are storing significantly more

oil – likely the result of higher oil production between periodic sales – and consume argan oil almost half as frequently as before.

Fruit collection was nearly ubiquitous in the argan forest in both 1999 and 2007 but the amount of fruit collected per household increased significantly in the low (from 127 kg to 706 kg) and medium density (100 kg to 371 kg) areas of the forest. Mean household fruit collection did not change significantly in the high density area of the forest (636 kg to 598 kg). As discussed above, 2007 was one of the best argan fruit production years in memory – so it is not surprising that fruit collection is higher in 2007 than in 1999, but the most striking change in fruit collection involves *where* households collected fruit.

The number of households collecting fruit from the village commons called *azroug* (see Figure 1) more than doubled from 1999 to 2007. This increase occurred as households already using the *azroug* in 1999 increased collection (a statistically insignificant two-fold increase) and households that did not collect fruit in the *azroug* in 1999 began collecting there since (a statistically significant two-fold increase in participation). This bolsters the argument that households were harvesting from their own trees at a maximum in 1999 and that expansion occurred in the *azroug*. Increased *azroug* participation was most prevalent in middle density villages, where participation was lowest in 1999 and highest in 2007 (Table 3). The likely explanation for increased fruit collection in the *agdal* is that households venturing far into the *agdal* with their herds are now far more interested in collecting fruit by hand than in letting their goats eat the fruit directly from the tree canopy. Of course, the common property structure of usage rights in the *azroug* shapes exactly how these changes occur – a theme to which we will return.

Argan fruit can be stored for many years without deteriorating the quality of oil extracted from the kernel. Even under ideal conditions – cool and dark – however, argan oil begins to oxidize in a matter of months. Consequently, households have always relied on fruit storage to smooth their oil production over a given year. Since fruit collection can fluctuate wildly by year according to rainfall, households have often tried to build up a surplus of fruit in storage in order to smooth oil production across years. One of the most dramatic recent changes in household argan activity is the enormous surge in fruit storage, which has nearly tripled from 207 kg per household in 1999 to 581 kg in 2007 .

Fruit storage has become a sort of bank account for argan forest residents – especially those close to markets. The increase in storage came almost entirely from the low (39 to 862 kg) and medium (9 to 292 kg) density areas of the forest; in the high density area average household fruit storage was already substantial and did not increase significantly (414 to 510 kg). Table 3 indicates how argan oil and fruit sales behavior has changed between 1999 and 2007. While some increase in both would be expected given how productive the argan forest was in 2007, the proportion of households in our sample that sells argan oil more than doubled between these years. The proportion selling fruit increased more than six-fold. In both 1999 and 2007, we asked households to rank their most important sources of household income. Based on the summary of these rankings in table 3, argan fruit has become a substantial component of household income, whereas argan oil did not become more or less important. These findings are consistent across density classes. While more households continue to rank argan oil as their most important income generating activity, the booming argan fruit market (Figure 2) has turned argan fruit from a triviality into an important income generator. The divergence between argan oil prices on local markets and on high value markets is clearly inciting households to sell their fruit to cooperatives and firms that can tap these higher prices.

C. Impacts of the argan boom on household welfare

Beyond examining how the argan boom has shaped household participation in argan markets, we are interested in how the boom has affected household welfare. We consider how a household's access to argan fruit in 1999 – an indicator of its *ex ante* potential to benefit from the argan boom – affected three types of household welfare outcomes: consumption, assets, and children's education. This subsection motivates and describes this empirical approach. We discuss first our chosen welfare outcomes and then our measure of *ex ante* access to argan fruit. We then present and discuss estimation results.

Welfare outcome variables

In the argan forest, most household purchases (and sales) are made at a *souk*. Since *souk* spending is readily known by households, we use the change in household *souk* spending from 1999 to 2007 as a measure of consumption changes. Households in this region hold

livestock as a primary productive asset and as a store of wealth since they do not have easy access to financial markets. We therefore use the change in herd size from 1999 to 2007 as a measure of asset changes. Although many households have cattle and even camel in their herds, small livestock – especially goats – are most prominent. Moreover, goats are the primary grazing threat to the forest. Since goats are both a key productive asset that captures an important dimension of household wealth and a primary threat to the forest, we use the change in household goat herd as an additional and particularly relevant measure of asset change.

Formal education in rural Morocco lags far behind urban areas. Based on data from 1998-99, 57 percent of 7-12 year old rural children (47 percent of girls and 67 percent of boys) – compared to 86 percent of urban children – were in primary school. Most rural villages, including those in our sample, have easy access to a primary school, but secondary schools are further away. Along with additional fees, this means the transition from primary to secondary school often requires a substantial investment. According to the Moroccan *Direction de la Statistique* (1999), Roughly 80% of rural children that begin primary school fail to make this transition. Nationwide, nearly 60% of rural children attend primary school (47% of girls and 67% of boys), but only 12% attend secondary school (8% of girls and 17% of boys). Given the difficulty and importance of this transition, we use the advancement of children in the household from primary to secondary school during the period 1999 to 2007 as our education outcome. In contrast to our consumption and asset outcomes, which are measured at the household level, we measure secondary school advancement at the individual level and include all children who could have advanced to secondary school between 1999 and 2007.⁸ Differences in gender roles in Morocco imply that the decision to send a daughter to secondary school is quite different than the decision to send a son, so we analyze secondary advancement overall and by gender. An educated son may be expected to yield greater benefits than an educated daughter in the future. Furthermore, the opportunity cost of a son's labor and daughter's labor will also differ, particularly in regards to argan work which is primarily done by women. It is unknown, however, if the presumably higher opportunity cost of sending a daughter to school will offset the benefits to the household that would facilitate

⁸ Children aged 4 to 14 in 1999.

sending a daughter to secondary school. Our analysis will attempt to shed some light on this question.

Ex ante potential to benefit from the argan boom

Defining a household's *ex ante* potential to benefit from high argan prices is complicated by varying tree productivity, *agdal* size, and collection effort. As described above, our data suggest that in 1999 the majority of households were harvesting fruit from their own trees, both private and *agdal*, at capacity, but that increased collection was possible in the common *azroug* portion of the forest. The most direct way of defining *ex ante* potential to benefit from the argan boom is by the amount of fruit they could potentially collect from all the trees they access, including private trees, *agdal* trees and *azroug* trees (see Figure 1). Fruit collection, however, is also endogenous. It is determined by a combination of exogenously determined resources (e.g., the number of trees and *agdals* accessed by a household, which are practically never traded) and endogenously determined by effort, particularly in the case of *azroug*. To deal with the endogeneity of this independent variable of interest, we use an instrumental variables (IV) approach. As instruments we use exogenous measures of access to argan trees: total trees, private trees, and number of *agdals*. In addition to directly affecting welfare outcomes, the exogenous control variables discussed below could explain fruit harvest and therefore also instrument for fruit collection in the first stage.

Control variables

In addition to the independent variables above, we introduce several others that could plausibly affect outcomes. These include household size, land, age and education level of household head, the presence of an argan cooperative within the village, and distance to secondary school (for education regressions). For robustness we also run the regressions without the coop variable and the distance to secondary school variable, which is a village level fixed effect for four villages.

Results

The first stage regression results indicate that fruit collection was primarily driven by the household's total treeholdings, and was actually negatively impacted by the household's private treeholdings. Private treeholdings, however, constitute around 10 percent of total treeholdings on average, and are 42 percent correlated with land (which has a positive, although insignificant, effect on fruit collection). There is also some evidence that advanced age of the household head has a negative impact on fruit collection, which is understandable as they (and their wives) might be less able to collect large amounts of fruit or venture far into the *azroug*. Table 4 contains the complete estimation results of the first stage equation used to instrument for fruit collected in 1999.

Predicted fruit collection based on this estimated equation is then used as an exogenous variable in our welfare outcome regressions. Table 5 displays these results for changes in consumption and assets. Models 1 and 2 in this table indicate that households that were well positioned to benefit from the argan boom – as captured by fruit collected in 1999 – experienced a higher increase in household consumption relative to households with access to less fruit. Models 3 and 4 in table 3 suggest that the change in total herd size from 1999 to 2007 was not affected by the argan boom. In contrast, however, the results in models 5 and 6 tell a different story for goats: households that stood to benefit most from the argan boom have grown their goat herds more than others. In particular, a household that collected 650 kg in 1999 added 5 more goats to its herd than did a similar household that collected no fruit in 1999. This result may tell a troubling story: as households improve their earnings through argan exploitation they reinvest in goats, an asset that can have negative effects on forest health. This “killing the golden goose” story is not unique to the argan forest, as non-forest timber product extraction has enabled some households to purchase equipment for timber harvesting in Amazonia (Escobal and Aldana, 2003). We will discuss the environmental impacts of goats in greater detail in part D of this section.

Next, we use predicted fruit collected in 1999 as an exogenous variable in an IV probit estimation of our education outcome equation. We use advancement from primary to secondary school as our outcome variable. In our sample, 27 percent of children (20 percent of girls and 35 percent of boys) transition to secondary school. When we estimate the impact of potential to benefit from the argan boom on education of all

children, controlling for gender, we find no effect. In the gender-pooled regression we do find that boys are significantly more likely to advance to secondary school than girls. We then estimate this equation for all children and for girls and boys separately. As shown in Table 6, the results from this estimation are very different for girls and boys. Girls from households that stood to benefit from booming argan prices were significantly more likely to make the transition from primary to secondary school. Boys from households who stood to benefit from the argan boom, on the other hand, were significantly less likely to advance to secondary school. Given the important role that women's empowerment has played in motivating the development and deployment of argan oil cooperatives, it is encouraging to note that instead of girls being pulled out of school to work in argan markets the argan boom seems to have been positive for girls' education outcomes. The remaining question is why potential to gather fruit diminished boys' probability of advancement. One argument is that households face a decision of whether or not to send a son on to secondary school or a daughter. The balance has always been in the favor of sending a son, as evidenced in our results as well as census data, but the argan boom seems to have helped even up this education decision.

D. Impacts of the argan boom on the forest

Given the unique ecological role played by the argan tree and the fact that locals seem to pose the greatest threat to argan forests through their exploitation of the forest, argan forest conservation has always played a central role in the argan cooperative movement and in the development of high value argan oil markets as described above. We now turn to this important aspect and assess likely impacts of the argan boom on the way locals use and perceive the forest and, consequently, on the forest itself.

As the value of argan has increased, so has resident defensiveness over the trees and fruit they consider theirs. Table 7a shows that residents of the argan forest have noted significantly more conflicts over argan resources as well as the increased use of permanent barriers around *agdals* to clearly define their limits and discourage use by others year-round. Although such permanent barriers around *agdals* are technically illegal, residents were largely in favor of allowing them in 2007, whereas in 1999 they were soundly against them. These observations and opinions were consistent among

those that were engaged in argan production in 1999, those that started producing argan goods between 1999 and 2007, and those that have never participated in argan activities.⁹ Despite residents' efforts to protect their private fruit, their attitudes and behavior towards the forest does not show a general trend of conservationism.

In 1999 the residents surveyed were adamant that they collectively needed to take better care of the forest. In 2007 they still agreed that they needed to practice greater stewardship, but the stance softened significantly. This view was consistent across residents that produced argan goods since 1999, those that started producing argan goods between 1999 and 2007, and those that have not produced argan goods since before 1999. This could be because stewardship has improved and the residents feel less strongly that improvements are necessary, but it is more likely that they feel the forest needs to be taken care of because abuses have increased. The data show that forest residents perceive collective abuses to be increasing (Table 7b) and that they personally activities detrimental to the forest more frequently than in the past (Table 7c).

In 1999 forest residents did not collectively think that illegal tree cutting was problematic at all, but in 2007 they thought it was a slight problem. Resident views towards overgrazing of the forest were mixed: Overall, residents thought it was only a slight problem in both 1999 and 2007. However, residents that produced argan goods in 1999 did not perceive overgrazing to be a problem in 1999, but did perceive it to be a problem in 2007.

Even more revealing than residents' views on how they collectively treat the forest was their views on how they individually treat the forest. On one hand, grazing goats in argan trees decreased from 1999 to 2007. This harmful practice was very widely practiced in 1999. Although still practiced by most residents in 2007, the intensity decreased significantly. This indicates that the value of argan fruit for sale or oil extraction has surpassed the value of argan fruit as goat fodder. On the other hand, residents have become more aggressive in argan fruit and wood harvesting. Hitting tree branches with sticks to knock out fruit was extremely rare in 1999, but occurred with some frequency in 2007. Harvesting with sticks is a pre-emptive tactic to avoid fruit theft,

⁹ Very few households produced argan products in 1999 but not 2007.

but can also damage trees (it is technically illegal for this reason) and dislodge the subsequent year's budding fruit, which are setting when this year's fruit are ripening.

We have already established that for most households argan fruit has become lucrative enough that keeping goats out of trees makes sense. We now turn to households' reliance on argan wood as a source of energy. Table 7c depicts a drastic and surprising trend away from butagaz (butane) and toward argan wood as a source of energy. Specifically, whereas under percent of our surveyed households relied primarily on argan wood for cooking in 1999, this had risen to 75 percent by 2007. This surprising trend is consistent with perceptions reported in Table 7b that illegal wood cutting may be becoming a problem in the forest. What explains this dramatic shift to argan wood for cooking that occurred at the same time argan markets were booming? In Morocco, butane is subsidized and its price has not changed since 1999, so increasing relative prices could not be the culprit. We asked several locals about this trend. They were not surprised at all by the finding – and the explanation was always the same: households in the forest region are having a tougher time making ends meet and are cutting costs where they can. With steadily increasing costs of living and stagnate household income, households are increasingly choosing to substitute 'free' argan wood for purchased butane. This finding and explanation suggest – yet again – that booming argan markets have done little to instill a long-run conservation ethic in the local population. High and rapidly appreciating fruit prices have clearly changed locals' short-run behavior and created compelling incentives to collect as much fruit as possible, but it is much less clear that these changes will translate into appreciable changes in local conservation.

V CONCLUSIONS

In the past decade, the market for argan products has boomed. This argan bonanza was sparked by credible evidence of the cosmetic and culinary virtues of argan oil. The oil has been successfully promoted using quaint win-win stories of rural poverty reduction, empowerment of women and forest conservation. Consumer demand for high quality and often "fair-trade" argan oil products has grown quickly and outpaced the supply of argan fruit – and argan prices have boomed as a result. Although this episode largely began with the formation of argan oil cooperatives, dozens of private firms saw a lucrative

opportunity and entered the developing market. In this frenzy of argan oil marketing and commercialization, there is often confusion between cooperatives and private firms – both of which recognize that many consumers are willing to pay a premium to help locals and protect the forest. In this paper, we provide the only rigorous evidence of any such impact on locals or the forest – and one of the few before-after empirical assessments of a bioprospecting-based boom.

At the market-level, most of the action in local argan markets has been in the market for whole argan fruit as expected (Lybbert, Barrett and Narjisse 2002). Fruit prices nearly doubled between 1999 and 2007. With this substantial increase in both the absolute value of argan fruit and its value in local markets relative to argan oil, households have started managing their fruit stocks like a quasi-liquid bank account. Many households now actively trade and speculate on the price of argan fruit. Skyrocketing fruit prices have also motivated locals to keep their goats out of argan trees during the fruit harvest since collecting by hand ensures a larger, more complete harvest. Less expected development in local argan markets has been the emergence of a significant argan kernel market. This market, which was previously stymied by asymmetric information about whether kernels had been ingested by goats, was facilitated by the collective shift towards manual fruit collection, which effectively remedied the asymmetric information problem.

At the household-level, the boom has had several impacts. Households are collecting more fruit – with most of this increase due to harvesting changes in the in the village commons (*azroug*). While most households did not bother manual collecting fruit from these common parcels in 1999 and chose to let goats eat the fruit instead, they have systematically shifted to manual collection and increased their total fruit harvest accordingly. While argan market participation was at best peripheral in 1999, it is now of primary importance to many households. Given the higher opportunity cost of oil and especially fruit, households are consuming significantly less argan oil themselves. Looking at differences between households, three key impacts emerge. Relative to other households, those that were well positioned in 1999 to benefit from higher argan prices (i) enjoyed higher market expenditures in 2007, (ii) added more goats to their herd, and

(iii) were more likely to transition their girls, and less likely to transition their boys, from primary to secondary school.

At the forest-level, the impact of booming argan markets appears mixed. While locals are now much less likely to let their goats browse in the tree canopy, this forest-friendly change is motivated more by immediate concerns about the fruit harvest than by any longer-term concern for tree or forest productivity. Goats still regularly climb and browse trees outside the fruit harvest season and so continue to tax the forest. The growing goat herds of local beneficiaries of high argan prices thus remain a relevant concern to the net effect of the boom. As further evidence of a short-term focus on mature fruit, locals are now resorting more frequently to aggressive harvesting techniques and often use sticks to knock fruit from trees instead of waiting for the fruit to dry and fall to the ground where they might easily be stolen. There is a growing preference for privatizing sections of the argan forest, but no appreciable change in households' conservation attitudes. Finally, locals have almost uniformly shifted to argan wood as their primary source of energy. Although this dramatic shift seems to be due to rising cost-of-living and locals' efforts to reduce their cash expenses by substituting collected wood for purchased butane, it provides additional evidence of a short-term focus on this year's fruit harvest. Locals have changed the way they use the forest to increase their personal fruit harvest, but rising argan prices have not turned them into champions of the forest's future. The polished win-win stories told on labels universally overlook this (understandable) focus on short-term gain.

While the 2007 harvest was one of the best in recent memory, the 2007-08 season was a severe drought and the 2008 harvest was one of the worst. Many households harvested nothing, but most did whatever they could to collect something. The fruit they collected were small. Argan fruit, kernel and oil prices nearly doubled in the first half of 2008. This led some cooperatives to close their doors, as they could no longer cover their input costs. Cooperatives with large fruit stocks fared better, but many of these reduced the piece rate paid to women extracting kernels from stones – work that had become even more tedious with the smaller 2008 fruit – and cut literacy training or other benefits to their members in order to cut costs. Unscrupulous firms – often posing as cooperatives – allegedly chose an easier route and diluted argan oil with a neutral cooking oil in order to

keep prices unchanged. While this may have happened in isolated cases, a more compelling reason producers could not simply pass higher input costs along to consumers has to do with very elastic demand in the high value argan oil market. Even rich consumers have a reservation price. In drought years like 2008, a focus on short-term fruit harvest without a counter-balancing longer term conservation ethic could prove especially destructive.

We end by looking forward and offering several projections and recommendations for improving both the flow of benefits to locals and the forest. First, the emergence of a growing argan kernel market, which could only happen after most locals stopped letting their goats eat argan fruit, is one of the most promising recent developments in argan markets. Cracking stones and removing the kernel is a laborious process that has yet to be effectively commercialized. This is best done locally, to increase the value to mass ratio the inputs that cooperatives and private firms use to make oil. This market could prove to be an effective means for locals to benefit by adding more value locally, especially if commercial oil extraction is no longer done in village households.

Second, the argan oil cooperative movement, which has played a central role in the development of argan markets, needs more effective certification, monitoring and enforcement. Diluted oil continues to be a concern, although the extent of the problem is difficult to assess. Similarly, there remains significant confusion about the differences between firms and cooperatives. Essentially every retailer makes cooperative-like claims about benefiting locals (and especially women). A credible and enforced certification for cooperatives might help them to more effectively differentiate themselves in high value markets. Any such certification program should hold cooperatives accountable for delivering the benefits they claim to deliver to their members, such as literacy programs, which they might be more eager to do if they were no longer in direct competition with private firms with pure profit motives.

Third, UNESCO recognized the argan forest as a Biosphere site in 1998, but there is currently no governing institutional structure in place. Based on the experiences of other Biosphere sites, much more could be done. Presently, there is no common Biosphere label or certification for argan oil. This is unfortunate since a strong, clear

Argan Forest Biosphere label could help producers to send a coordinated signal to consumers. Such a label could include a certification process to ensure purity. This would provide both firms and cooperatives more recognition and leverage with quality conscious consumers.

Finally, in order convert local benefits into conservation gains households in the argan forest region will ultimately have to broaden their focus beyond short-run fruit collection to include longer term considerations about forest productivity and preservation. While the tenure system that governs access to and use of the argan forest seems to have evolved in a way that strengthens private control over part of the forest (the *agdals*), the privatization pressure has increased and will continue to increase as long as fruit prices are high or continue to increase. Although privatizing sections of the forest may create a degree of certainty and control that will help locals see beyond fruit on the tree, such a shift toward stronger private rights raises unique equity concerns given the collective reliance on the forest outside of the fruit harvest season. Conservation education and training might also play an important role in lengthening locals' perspective. Many cooperatives have offered such programs to their members, but the efficacy of these programs is not yet clear. These programs should be extended to primary and secondary students in the argan forest region – perhaps with a proactive, hands-on component in which students can work as “Junior Argan Forest Rangers.”

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		Spatial Dimension			
		Village commons	Household usufruct	Private Land	
Temporal Dimension	Jan	Communal use (grazing, wood collection, etc.)		Household use	
	Feb				
	Mar				
	Apr				
	May	agdal season*	Intensive communal use including fruit collection from Azroug trees	Household fruit collection from Agdal trees	Houshold use, including fruit collection from private trees
	Jun				
	Jul				
	Aug				
	Sep				
	Oct	Communal use (grazing, wood collection, etc.)		Household use	
	Nov	Communal use (grazing, wood collection, etc.)		Household use	
	Dec	Communal use (grazing, wood collection, etc.)		Household use	

* Note that the precise start and end of *agdal* season varies annually.

Figure 1 The spatial and temporal structure of the right to collect argan fruit

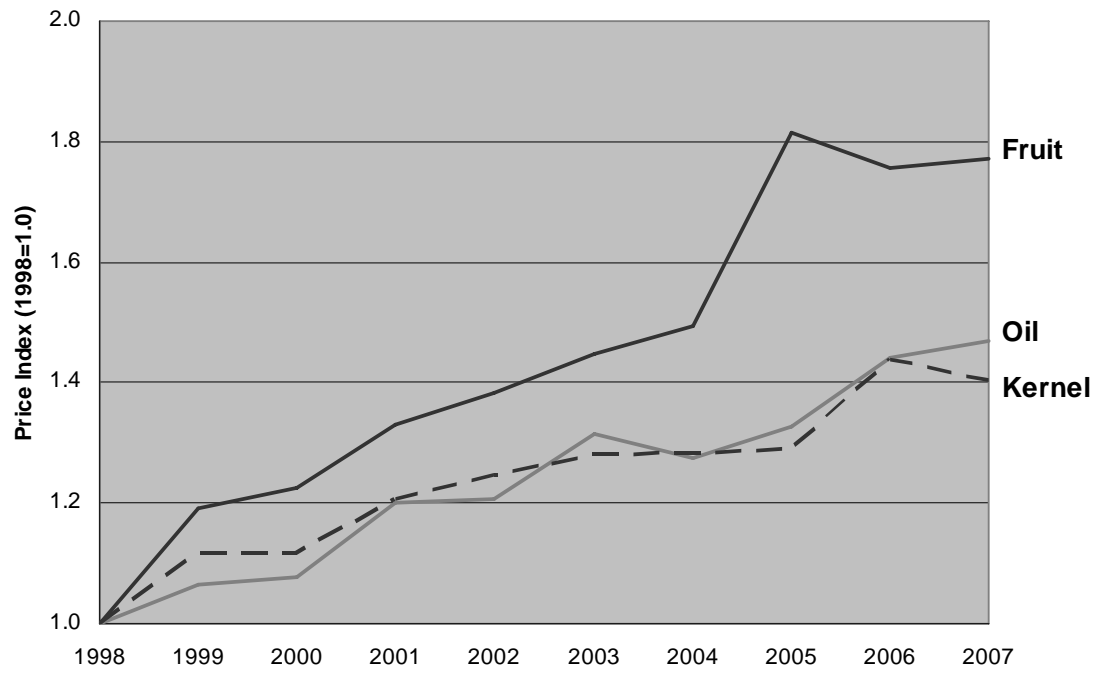


Figure 2 Evolution of real argan price indices in Essouira province (1998=1.0)

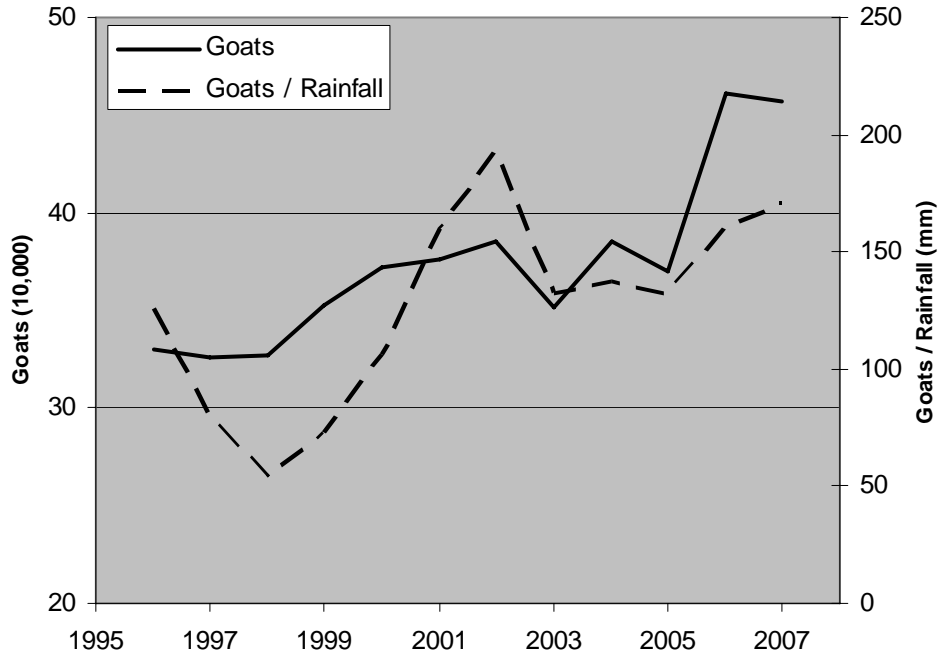


Figure 3 Evolution of goat herds in Essouira province and goats normalized by rainfall



Figure 4 Kernel density regressions of household wealth index for 1999 and 2007

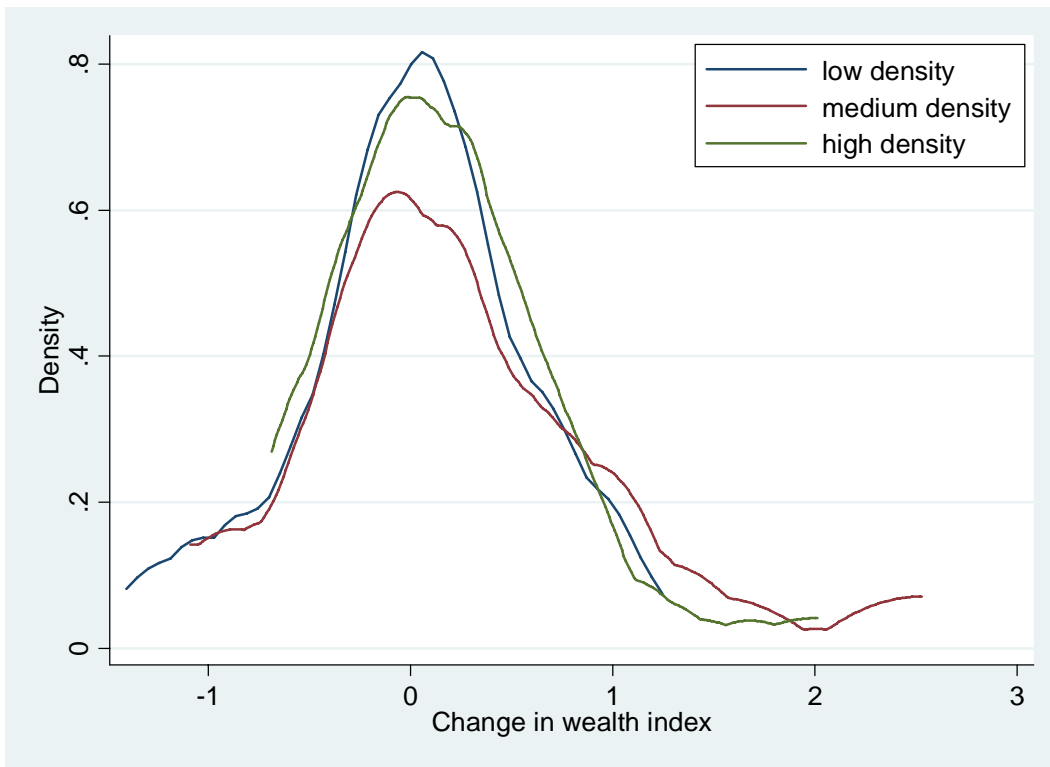


Figure 5 Kernel density regressions of change in household wealth index by density class

Table 1 Descriptive statistics (1999 values) for households that dropped out of the panel (i.e., were not surveyed in 2007) and those that were included in the panel

Variable (1999)	households that dropped out of panel	households included in panel
N	46	103
Age	57.98	47.63 (3.81)***
Years education (household head)	1.60	1.66 (0.51)
Years education (household members under 20)	2.88	2.70 (0.52)
Household size	7.11	6.97 (0.30)
Fruit collected		
Total argan trees	422.40	535.07 (0.73)
Private argan trees	82.18	59.97 (0.55)
Land (khadam)	27.14	19.07 (1.22)
Goats	10.68	12.15 (0.46)
Cows	1.05	0.95 (0.58)
Sheep	6.94	5.06 (1.32)
Weekly <i>souk</i> spending (Dh)	147.42	169.60 (1.31)
Is argan an important economic activity {0,1}?	0.85	0.88 (0.54)
If so, what rank (1=highest, 5=lowest)	2.72	2.71 (0.08)

Table 2 Changes in household argan production, storage, and consumption across density zones

	Full sample N=92		Low density N=30		Medium density N=22		High density N=44	
	1999	2007	1999	2007	1999	2007	1999	2007
Oil produced (l)	7.54	18.940 (4.68)***	6.74	21.5 (3.05)***	5.025	16.8 (3.18)***	9.28	18.19 (2.40)**
Oil stored (l)	0.19	0.758 (2.56)**	0.185	0.5 (1.37)	0	0.48 (3.25)***	0.275	1.05 (1.78)*
Oil consumed (times per week)	2.46	1.700 (4.14)***	2.129	1.548 (2.13)**	1.86	1.086 (2.89)***	3.00	2.258 (3.07)***
Collected fruit? (%)	92.05	96.59 (1.03)	85.7	96.4 (1.41)	83.3	88.9 (0.47)	100	100 N/A
Collected from <i>azroug</i> ? (%)	24.47	52.13 (4.05)***	19.4	48.4 (2.50)**	15.0	60.0 (3.24)***	32.56	51.16 (1.76)*
Fruit collected (kg)	364.39	585.78 (1.46)	126.75	705.718 (2.51)**	99.671	370.864 (2.70)**	636.22	598.00 (0.14)
...from <i>agdal</i> (kg)	334.62	376.80 (0.30)	115.83	583.141 (1.96)*	91.364	190.307 (1.19)	584.87	319.124 (1.11)
...from <i>azroug</i> (kg)	38.09	226.33 (3.83)***	12.22	137.28 (2.62)**	27.365	191.581 (2.61)**	59.839	300.3 (2.54)**
...from <i>azroug</i> (kg) if collected in 1999	13.00	25.90 (1.34)	-----n/a-----					
Fruit stored (kg)	206.7	580.879 (2.46)**	39.481	861.848 (2.46)**	9.178	292.123 (3.23)***	413.946	510.49 (0.37)

Table 2 Argan oil and fruit sales and the importance of oil and fruit revenue

	Full sample N=96		Low Density		Medium density		High density	
	1999	2007	1999	2007	1999	2007	1999	2007
Sell oil (%)	26.0	69.8 (6.71)***	16.7	63.3 (4.12)***	4.5	40.9 (3.12)***	43.2	88.6 (5.07)***
Sell fruit (%)	3.1	21.9 (4.07)***	10.0	36.7 (2.53)**	0.0	9.1 (1.445)	0.0	18.2 (3.09)***
Rank of argan oil revenue in total household income (%)								
Top1	26.0	24.0 (0.33)	23.2	20.0 (0.31)	27.3	13.6 (1.11)	27.3	31.8 (0.46)
Top 2	62.5	42.7 (2.79)*	46.7	43.3 (0.25)	45.5	22.7 (1.60)	81.8	52.3 (3.07)***
Top 3	66.7	54.2 (1.46)	53.3	50.0 (0.25)	46.7	43.4 (0.25)	27.2	31.8 (0.46)
Rank of argan fruit revenue in total household income (%)								
Top1	0.0	5.2 (2.28)**	0.0	0.0	0.0	9.1 (1.45)	0.0	6.8 (1.77)*
Top 2	2.1	14.6 (3.20)***	3.3	6.7 (0.58)	0.0	18.2 (2.16)**	2.3	18.2 (2.52)**
Top 3	3.1	26.0 (4.73)***	3.3	30.0 (2.92)***	0.0	18.2 (2.16)**	4.5	27.2 (3.03)***
Percent change in brackets, absolute value of t stats in parenthesis; significant at *10 %; **significant at 5%;* ** significant at 1%;								

Table 4 First stage regression results for 1999 argan fruit collection equation

	(1)	(2)	(3)	(4)
total argan holdings in 1999	0.453 (1.94)*	0.449 (1.98)*	0.474 (1.73)	0.491 (1.93)*
private argan holdings in 1999	-1.593 (1.81)	-1.593 (1.77)	-2.616 (1.89)*	-2.963 (2.06)*
<i>agdal</i> rights 1999	39.566 (0.34)	20.612 (0.16)	28.221 (0.47)	3.472 (0.03)
Land (khadam)	6.234 (1.12)	6.908 (1.32)	7.904 (1.59)	9.289 (1.63)
# household members	-6.276 (0.12)	20.285 (0.43)	8.472 (0.20)	36.901 (1.25)
age of household head	-9.570 (0.94)	-9.267 (0.87)	-13.289 (2.06)*	-10.917 (1.36)
Years of household head education	-17.382 (0.55)	-19.578 (0.60)	-4.733 (0.46)	-12.591 (0.92)
coop group		431.722 (1.66)		409.429 (0.77)
Distance from secondary school				-0.942 (0.04)
Constant	548.807 (1.67)	266.521 (0.62)	541.120 (1.09)	176.349 (0.28)
Observations	77	77	117	117

Robust t statistics in parentheses

* significant at 10%; ** significant at 5%; *** significant at 1%

(1) Household level data for *souk* spending and livestock holdings(2) Household level data for *souk* spending and livestock holdings (with control for coop village {0,1})

(3) Individual level data for educational advancement

(4) Individual level data for educational advancement (with control for coop village {0,1} and distance to secondary school)

Table 5 IV estimation results for change in weekly spending, total livestock, and goats

	<i>Souk</i> spending		Total livestock		Goats	
	(1)	(2)	(3)	(4)	(5)	(6)
Fruit collected (MT)	50.29 (2.15)*	42.41 (2.23)*	0.530 (1.20)	0.581 (1.43)	4.924 (1.94)*	4.990 (2.09)*
Land (khadam)	-0.784 (1.25)	-0.719 (1.13)	-0.0020 (0.27)	-0.0026 (0.33)	-0.1535 (2.36)**	-0.1541 (2.39)**
# household members	4.858 (0.85)	6.007 (0.94)	-0.0813 (0.92)	-0.1069 (1.35)	-0.4009 (1.21)	-0.4202 (1.08)
age of household head	4.858 (0.85)	6.007 (0.94)	-0.0813 (0.92)	-0.1069 (1.35)	-0.4009 (1.21)	-0.4202 (1.08)
Years of household head education	0.314 (0.31)	0.258 (0.25)	-0.0171 (0.75)	-0.0165 (0.71)	-0.0931 (1.14)	-0.0925 (1.15)
coop group		17.261 (0.29)	1.3458 (1.57)	-0.3950 (0.71)	3.5732 (1.03)	-0.2963 (0.09)
Constant	14.806 (0.14)	7.108 (0.06)		1.5879 (1.71)		3.7428 (0.75)
Observations	77	77	77	77	77	77

Robust t statistics in parentheses

* significant at 10%; ** significant at 5%; *** significant at 1%

Table 6 IV estimation results for children's' advancement to secondary school

	Girls				Boys			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Fruit collected (MT)	0.5200 (2.03)**	1.0200 (1.67)*	0.7659 (1.87)*	0.3972 (1.13)	-0.6790 (2.37)**	-0.5870 (1.88)*	-0.6664 (1.92)*	-0.5575 (2.01)**
Land (khadam)	-0.0024 (0.43)	-0.0074 (0.80)	-0.0062 (0.67)	0.0005 (0.08)	0.0080 (0.78)	0.0074 (0.62)	0.0036 (0.32)	0.0014 (0.13)
# household members	-0.1613 (1.81)*	-0.4522 (1.53)	-0.3345 (1.52)	-0.0945 (0.81)	-0.0292 (0.37)	0.0468 (0.51)	0.0445 (0.51)	0.0474 (0.53)
Age of household head	0.0199 (1.13)	0.1175 (1.77)*	0.1000 (1.79)*	0.0478 (1.69)*	-0.0041 (0.33)	-0.0096 (0.69)	-0.0074 (0.55)	0.0008 (0.06)
Years of household head education	0.0188 (0.25)	0.2824 (1.24)	0.1807 (1.41)	-0.0071 (0.06)	0.0353 (0.64)	0.0142 (0.22)	-0.0001 (0.00)	0.0052 (0.09)
Coop group		-1.3080 (0.50)		1.5846 (2.80)***		-0.4601 (0.61)		0.7887 (1.84)*
Distance to secondary school (minutes)		-0.2534 (1.39)	-0.1651 (2.53)**			-0.0770 (2.33)**	-0.0583 (2.89)***	
Constant	-0.3380 (0.37)	1.0668 (0.33)	-0.5220 (0.42)	-2.8155 (1.90)*	0.2535 (0.30)	1.3197 (1.08)	0.9555 (1.03)	-0.7326 (0.77)
Observations	57	57	57	57	60	60	60	60

Absolute value of z statistics in parentheses

* significant at 10%; ** significant at 5%; *** significant at 1%

Table 7a Attitudes towards strengthening property rights

[1=Strongly agree, 2=Agree, 3=Neutral, 4=Disagree, 5=Strongly disagree]	Full sample		Always produced argan goods		Started producing argan goods between 1999 and 2007		Did not produce argan goods in 1999 or 2007	
	1999	2007	1999	2007	1999	2007	1999	2007
Conflicts between villagers has increased	2.42	1.64 (4.80)***	2.58	1.64 (4.80)***	2.25	1.45 (2.51)**	2.5	1.77 (2.37)**
Number of permanent fences has increased over past ten years (1990-1999, 1998-2007)	2.19	1.86 (3.74)***	2.26	1.87 (2.27)***	2.21	1.74 (3.53)***	2.13	1.96 (0.93)
Permanent fences should be allowed.	4.39	1.69 (13.8)***	4.65	1.74 (8.21)***	4.38	1.64 (9.76)***	4.24	1.81 (5.40)***
Lower values indicate more pro-privatization attitudes. Absolute value of t stats in parenthesis; significant at *10 %; **significant at 5%;* ** significant at 1%;								

Table 7b Perceptions of forest abuse by others

[1=Strongly agree, 2=Agree, 3=Neutral, 4=Disagree, 5=Strongly disagree]	Full sample		Always produced argan goods		Started producing argan goods between 1999 and 2007		Did not produce argan goods in 1999 or 2007	
	1999	2007	1999	2007	1999	2007	1999	2007
Resident need to take better care of the forest.	1.02	1.41 (4.06)***	1.00	1.52 (2.41)**	1.05	1.43 (2.41)**	1.00	1.36 (2.35)**
Illegal cutting is a problem in the forest	4.11	2.80 (6.03)***	3.80	2.53 (2.76)***	4.33	3.10 (4.30)***	3.76	2.53 (2.35)**
Overgrazing is a problem in the forest	2.69	2.39 (1.19)	3.65	2.00 (3.85)***	2.83	2.76 (0.19)	3.00	3.05 (0.10)
Lower values indicate perceptions that the forest is deteriorating. Absolute value of t stats in parenthesis; significant at *10 %; **significant at 5%;* ** significant at 1%;								

Table 7c Individual stewardship towards the forest

[1=Very often, 2=Somewhat often, 3=Sometimes, 4=Rarely, 5=Never]	Full sample		Always produced argan goods		Started producing argan goods between 1999 and 2007		Did not produce argan goods in 1999 or 2007	
	1999	2007	1999	2007	1999	2007	1999	2007
I let my goats graze in trees	1.22	2.28 (4.59)***	1.00	1.88 (2.91)***	1.17	2.33 (3.59)***	1.67	2.50 (1.33)
I hit trees to harvest more fruit	4.54	3.45 (5.31)***	4.13	3.21 (2.00)*	4.70	3.77 (3.26)***	4.65	3.13 (3.88)***
Lower values indicate more frequent practice of activities considered harmful to argan trees.								
Argan wood is my household's primary fuel source (percent yes)	17.0	67.0 (8.01)***	30.4	78.3 (3.63)***	16.3	65.1 (5.25)***	8.3	66.7 (5.12)***
The alternative to argan wood is almost always butagaz, which does not effect the forest directly. Absolute value of t stats in parenthesis; significant at *10 %; **significant at 5%;* ** significant at 1%;								