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Gendered Access to Resources, Preferences, and Crop Choices in Arid Regions: A Focus on Oasis Agriculture in Southeastern Morocco

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ABSTRACT

This study investigates how production resource access and individual preferences shape gender-differentiated crop choices in arid regions with strong gender norms. We analyze date palm cultivation at the extensive and intensive margins using data from 109 female and 91 male farmers in southeastern Morocco. After confirming significant gender disparities, the results identify land access, land tenure, and agricultural assets as primary drivers of participation in date palm cultivation. We also find non-negligible gender gaps in its cultivation at approximately 28 percentage points, even after shutting down potential channels, presumably reflecting unobserved gender norms. In contrast, intensive margin analysis shows that risk-loving and, interestingly, impatient farmers plant more date palm trees. The remaining gender gaps in planting intensity after accounting for preferences and resource access are insignificant. Thus, entry into date palm cultivation, rather than investment after participation, is more challenging for female farmers because of the prevailing norms. We also confirm the robustness of these findings to potential sample selection bias. This study highlights the importance of relaxing women's constraints in farming as a policy implication to facilitate sustainable development in arid regions.

Keywords: Gender, Agricultural Investment, Property Rights, Risk and Time Preferences, Morocco.

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1. Introduction

Women's active engagement in agriculture in the Near East and North Africa (NENA) region, at 63% in 2020, mirrors that of men, highlighting the oversight of interventions that predominantly target male farmers (FAO Regional Office for the Near East and North Africa, 2020). More importantly, female farmers often make agricultural decisions independently and grow crops that are different from those of their male counterparts. This gendered pattern in crop choices often aligns with gendered expectations, with men typically associated with cash crops and women with subsistence crops.[1] A recent study by Baruah and Najjar (2022) in the Middle East and North Africa (MENA) region corroborated this finding, emphasizing the significant influence of gender norms on agricultural decisions. However, without understanding the deep factors behind the prevailing norms and different decision-making processes by gender, designing effective agricultural policies to boost overall farm productivity in the NENA region is impossible.

Women in the NENA region prioritize the cultivation of food crops that are essential for household consumption, such as barley and other drought-resistant varieties, whereas men are more inclined to grow cash crops for sale. This distinction reflects the different priorities for family food security and income generation. Such female farmers' "food security first" strategy, as Meinzen-Dick et al. (2014) documented, suggests that gender differences in preferences account for crop choice patterns. Mounting evidence on gender-differentiated risk attitudes reports that, on average, women tend to display greater risk aversion, with this difference diminishing in experienced and managerial contexts and sensitivity to potential losses compared to men (Croson & Gneezy (2009);

[1] For example, Doss (2002) stated that "Men are often viewed as being responsible for producing cash crops, while women are responsible for producing subsistence crops for home consumption. One frequent critique of agricultural development programs has been that they have focused on men's cash crops rather than women's subsistence crops."

Charness & Gneezy, 2012; Magnan et al., 2020). It also highlights that women's social preferences are context-dependent and that they are generally less inclined to participate in competitive environments, which can affect their career advancement. Furthermore, Holden and Tilahun (2022) found that women in rural Ethiopia generally display higher risk aversion levels than men, contributing to their significantly lower investment levels in both real and hypothetical scenarios. While risk preferences account for a notable portion of the gender gap in investment behavior, the study emphasizes that socioeconomic factors and cultural norms play critical roles in shaping these differences. Building on this literature on different tastes by gender, it is natural to assume that risk-averse women, rather than risk-taking men, may opt for low-risk crops because farming is inherently uncertain. Similarly, patient women may prefer perennial crops that require waiting a few years to generate returns. Such innate factors may shape gender-differentiated crop choices.

Production resource access is another leading candidate among potential drivers of gender-differentiated crop choices. For example, land ownership in the NENA region is distinctively shaped by socio-cultural norms and environmental conditions, among other factors. Consequently, less than 7% of women have land ownership as of 2023, underscoring significant gender disparities in resource access (FAO Regional Office for the Near East and North Africa, 2024). These gender disparities are likely to extend to differences in water resource agencies, with women having less decision-making power over water management. Such inequalities may also apply to other resources like access to agricultural inputs, subsidies, and extension services. These statistics suggest that gender differences in access to productive resources are another critical dimension that can lead to different cropping patterns by gender, highlighting the need to explore deeper gender dynamics within agricultural decision-making frameworks.

Overall, understanding the nuanced interplay between gender preferences, plurality of land governance regimes and related land arrangements, and access to other productive resources is crucial for elucidating how these factors collectively influence crop choice decisions. This perspective sheds light on the economic efficiency within agricultural systems and unveils the underlying mechanisms that shape resource allocation and productivity outcomes. However, studies that rigorously address this issue are scarce. Few studies have extended gendered analyses to investigate the influence of land ownership on crop selection decisions, particularly in arid and semi-arid regions.

This study addresses this gap in the literature by undertaking a comprehensive gendered analysis of crop choice decisions through a multi-dimensional framework focusing on oasis agriculture in Morocco. Our conceptual framework encompasses two primary dimensions: Resources and Preferences. The first resource dimension includes four key components that substantially influence farmers' crop selection decisions: 1) Land, focusing on tenure (including formal legal arrangements and customary practices) and the degree of control over resources within farmers' plots. 2) Agricultural assets, particularly irrigation infrastructure that plays a critical role in water management in arid agricultural systems. 3) Financial resources (e.g., livestock, remittances, and informal savings mechanisms) that can be liquidated as capital for agricultural investment. 4) Social capital is measured by farmers' cooperative membership to test how cooperative involvement influences crop selection decisions, thereby exploring potential (dis)connections between cooperative activities and farming practices.

The second preference dimension delves into farmers' attitudes toward risk aversion and patience: 1) Risk preferences that are particularly relevant in the context of agriculture, where outcomes are often uncertain due to factors such as weather variability and market fluctuations; 2) Time

preferences that are crucial for understanding decisions related to long-term investments in crops, such as tree fruits, or decisions between annual and perennial crops by considering how farmers value present versus future outcomes. By incorporating resources as structural factors and preferences as individual traits, we aim to provide a nuanced understanding of the complex factors that influence gendered crop choices in this unique agricultural context.

Our empirical analysis uses data from 200 farmers (109 female and 91 male) engaged in oasis agriculture in the Tata region of southeastern Morocco. The Tata region provides an excellent laboratory for examining crop choices from the gender perspective for several reasons. First, female farmers play a significant role in agriculture and often make agricultural decisions independently. Second, female farmers have limited access to resources, reflecting socio-cultural norms. Finally, several crops, ranging from annual to perennial, are available in farmers' choice sets. Among them, date palm crop requires a longer growth cycle, but promise higher profitability than other crops. Thus, time and risk preferences should significantly influence farmers' decision-making regarding crop choices. Given this setting, we select date plantations over the past five cropping seasons as the primary outcome in the empirical analysis, assessed both at the extensive margin (whether the farmer engaged in date cultivation) and intensive margin (the number of date trees planted).

The descriptive results reveal that female farmers generally manage less secure land, such as inherited untitled plots. By contrast, male farmers are more likely to manage more secure land, predominantly communal plots. This disparity highlights the land tenure insecurity faced by women in arid regions where customary and informal land arrangements are predominant. Additionally, female farmers frequently experience restricted access to and limited control over

resources, particularly date palm trees, in their allocated plots. By contrast, their male counterparts generally do not face such constraints.

Our subsequent regression analysis indicates that at the extensive margin, access to resources—particularly land and tenure type—emerges as the primary factor that negatively influences the decision to cultivate date palms. This negative association remains robust across various specifications with different controls, such as individual characteristics (e.g., age and education) and regions. Conversely, communal land, perceived as the second most secure type of tenure after titled land, is negatively associated with date palm cultivation. This suggests a trend toward diversifying away from date palms as the primary cash crop in the region. The gender coefficient in magnitude diminishes once agricultural assets, notably irrigation infrastructure, are controlled for. This empirical pattern underscores the critical role of irrigation infrastructure in determining crop choices. In contrast, financial resources, social capital, and individual preferences related to risk and time have a comparatively minor correlation with date palm cultivation at the extensive margin, relative to the fundamental role of land tenure. The robustness of the findings regarding land tenure persists even after accounting for these additional factors, highlighting the predominant influence of land tenure on agricultural decision-making and its pivotal role in shaping crop choices in the region. Gender gaps in date palm cultivation in magnitude are non-negligible and stable at approximately 28 percentage points (ppt) even after shutting down potential channels, presumably reflecting unobserved gender norms.

The regression results at the intensive margin reveal that personal preferences significantly influence the number of date palm trees planted over the past five cropping seasons. Specifically, farmers with higher risk-taking attitudes tend to plant more trees. Conversely, we find an inverse relationship with time preferences: Impatient farmers plant more trees than their patient

counterparts. This counterintuitive result suggests a complex relationship between time preferences and long-term agricultural investments. Notably, time and risk preferences show minimal correlation, indicating that they operate as separate factors in farmers' decision-making. We propose that date palm cultivation functions as a commitment device as a plausible explanation for this unexpected pattern (Bryan et al., 2010; Thaler & Shefrin, 1981). Impatient farmers may strategically use the illiquid nature of date palm investments to constrain future decisions, thereby overcoming short-term temptations and ensuring long-term savings. This interpretation challenges traditional economic assumptions and underscores the need for a nuanced understanding of farmers' investment behavior in contexts with significant time lags between planting and profit realization. Finally, the gender coefficient demonstrates null correlations with the number of date palm trees planted after shutting down the resource and preference channels. Thus, our results suggest that prevailing gender norms influence participation in date palm cultivation more than investments after participation.

To further validate the robustness of our findings, we employ a Heckman two-step estimation approach to address potential sample selection bias and verify the consistency of our results. Specifically, we use titled and communal land, which represent more secure land tenure arrangements, as instruments in the selection equation to determine the likelihood of participation in date palm cultivation. The estimated inverse Mills ratio is statistically insignificant, suggesting that the selection bias is not severe, at least in our sample. This finding confirms that the observed relationships between individual preferences and investments in date palm trees are not contaminated by sample selection bias, thus reinforcing the robustness and reliability of our estimates.

This study contributes to the literature in two ways. First, we advance the technology adoption literature by taking a comprehensive approach, integrating resources and preferences and considering their gender differentials. While previous studies have examined these elements in isolation when explaining crop selection decisions (e.g., Doss & Morris, 2000; Quisumbing & Pandolfelli, 2010), our integrated approach allows for a more direct comparison of the relative importance of resource access versus preferences in shaping crop choices, providing novel insights into the mechanisms underlying gender differences in agricultural decision-making. Additionally, our focus on gender differences across two primary mechanisms—resource access and preferences—offers a more comprehensive view of how male and female farmers may differ in their crop choices and agricultural strategies. This multifaceted approach provides a more nuanced understanding of crop choice decision-making in the NENA region, where such studies are limited, by helping disentangle the effects of structural barriers from personal choices in shaping gendered cropping patterns.

Magnan et al. (2020), the study closest to our approach, investigated the impact of heterogeneous risk preferences within households on technology adoption in Tanzania, focusing on improved maize varieties. Their household-level analysis examines how spousal differences in risk preferences influence agricultural investment decisions. They found that women's risk and men's loss aversion were negatively correlated with the adoption of improved maize varieties, suggesting that gender-specific risk attitudes could act as barriers to agricultural innovation. Our study builds upon this foundation but diverges methodologically by emphasizing individual-level decision-making across genders. We account for the possibility of incomplete resource pooling within households, an approach particularly relevant in Morocco's arid regions, where women's land access can occur through not only marriage but also inheritance from natal families, often with

more restricted management rights. By accounting for these institutional and cultural nuances, we aim to provide a more comprehensive understanding of gender dynamics in agricultural decision-making within rural Morocco's specific economic and social context. Our study also expands on Magnan et al.'s work by investigating barriers to agricultural investments at the extensive and intensive margins, examining how their influence differs at these levels.

Our second contribution is broadening the geographical scope of such technology adoption analyses from the gender perspective by providing empirical evidence tailored to the NENA region, where household surveys are scarce. Previous studies have vividly reported gendered resource access patterns and their relationship with crop choices in other contexts. For instance, in northern Mozambique, women may avoid investing in cash crops on land outside their matrilineal holdings because of tenure insecurity concerns (Pitcher, 1996). In that research context, gender shapes crop decisions through plot control, crop variety, and women's involvement in agricultural decision-making (De Brauw, 2015). However, significant gaps remain in understanding how gendered resource access affects crop choices in the NENA region. The scarcity of studies and household surveys in this region, especially in arid regions, is particularly concerning given these areas' unique challenges (e.g., water scarcity) and constraints for agriculture. Climate change exacerbates these challenges, making it crucial to understand how gender intersects with resource management and agricultural practices in these vulnerable ecosystems. Furthermore, the unique interplay between traditional cultural norms, religious practices, and modernizing economies in the NENA region may make resources and preferences work in ways that are not observed in other contexts.[2]

[2] For example, Islamic finance principles, which prohibit interest-based lending (*riba*), significantly shape the financial landscape (Abedifar et al., 2016). This restriction on conventional credit systems creates unique challenges and opportunities for agricultural financing. As another example, social norms in many NENA countries lead to gender-segregated networks. These separate networks may influence crop choices differently for men and women, offering valuable insights into gender-specific agricultural practices and decision-making processes. Interestingly,

Understanding these region-specific dynamics is crucial for addressing the unique challenges faced by the NENA farmers and for developing more effective, gender-sensitive, and climate-adaptive agricultural support systems under water-scarce conditions, with climate change as a pressing concern.

This paper is structured as follows: Section 2 outlines the study context, data collection methods, and theoretical framework for key variables, and then provides a descriptive analysis. Section 3 presents the results from three sets of regressions: the first explores the relationship between key variables and gender, while the second and third analyze date palm cultivation at the extensive and intensive margins, respectively. Finally, Section 4 concludes by discussing the main findings and their broader implications.

2. Study context and data

2.1. Background

Morocco's arid regions provide a compelling context for studying gendered crop choice decisions because of the unique and complex mosaic of land tenure systems, including private property, collective lands, state-owned lands, and religious endowments (*habous*). Private property is divided into two significant categories: titled land, which offers the highest degree of tenure security; and inherited untitled land, which, despite being privately held, often lacks formal documentation and may be subject to customary practices. This diversity in tenure arrangements creates a nuanced environment for agricultural decision-making, with varying levels of land

research has shown that there can be a disconnect between the crops grown by farmers and the activities of their cooperatives. A study by Francesconi & Heerink (2011) found that only a few cooperatives actively process and sell members' agricultural output. This disconnect could have substantial consequences in regions with more constrained crop choice options, such as arid and semi-arid environments.

security influencing farmers' crop choices and long-term investment. Communal lands, known as "*Soulali*" lands in Morocco, present a fascinating case, as their security is often perceived as intermediate between private property and open access resources. This scenario shed the light on the flexibility offered by legal pluralism, allowing users to navigate various legal frameworks to negotiate their rights and responsibilities (Meinzen-Dick & Pradhan, 2002). Doss et al. (2014) argued that sometimes the titling of communal lands can reduce tenure security for marginalized groups by simplifying complex use rights into exclusive ownership. This simplification can lead to the loss of secondary rights that are often held by women or poorer community members. Gender disparities are prominent across all tenure types, with women often having limited rights, particularly to communal and inherited lands, and needing to negotiate access through male relatives or community leaders (Berriane, 2017).

Additionally, access to resources, particularly water, continues to be a significant challenge in the study region, as traditional management systems face increasing pressure from climate change and population growth. Recent initiatives, such as the Plan Maroc Vert, aim to modernize agriculture in these regions, adding another layer of complexity to farming decisions and potentially impacting land tenure arrangements. This unique combination of factors—diverse land tenure systems with varying degrees of security, resource constraints, gender disparities, and evolving agricultural policies—makes Morocco's arid regions an ideal setting for examining the interplay between gender, land security, resources, and preferences in shaping crop choices.

Furthermore, date palm cultivation is salient in Morocco's arid regions, making it an excellent focus for our study. As a drought-tolerant crop well adapted to the oasis environment, date palms are crucial for sustaining local agriculture and livelihoods (Sedra, 2015). The multilayered oasis system, in which date palms form the upper story, maximizes water use efficiency and supports

biodiversity. Date palms require significant long-term investment and care, making them an ideal crop for examining how gender, resource access, and individual preferences influence agricultural decisions. The long maturation period of date palms (typically 5–7 years before full production) allows us to explore how farmers balance immediate needs with long-term planning, providing insights into the role of attitudes toward risk and time in their cultivation. Furthermore, the gendered division of labor often associated with date palm cultivation offers a unique lens through which to study how access to resources and decision-making power shape crop choices along gender lines. By focusing on date palms, we can gain deep insights into the complex interplay of factors influencing crop choices in arid gender-differentiated agricultural systems.

2.2. Sample and data collection

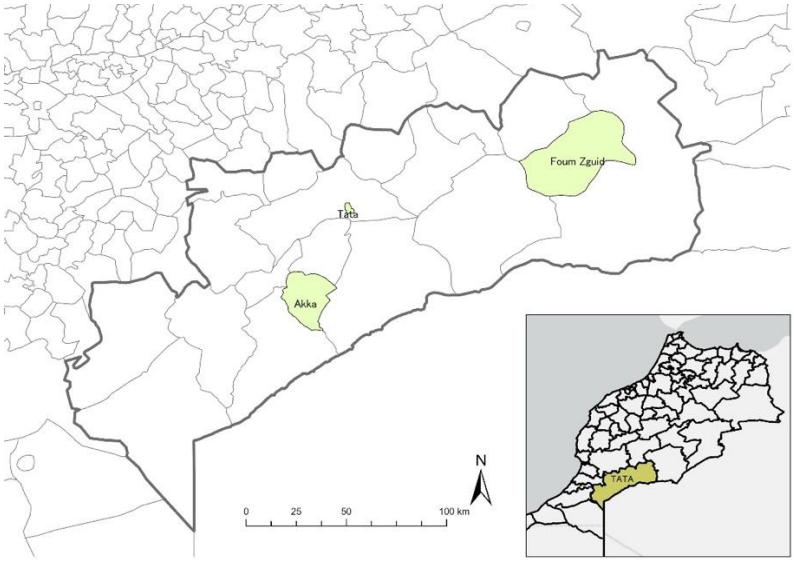

Figure 1: Survey areas in Tata province, Morocco

Tata province was selected as the study area because of its representativeness of Morocco's arid regions and its rich diversity in agricultural practices. Located in southeastern Morocco, this region exemplifies the complex land tenure systems of Morocco's rural areas, including private (titled and

untitled), communal, and other customary land arrangements (Figure 1). Tata's dominant agriculture system is oasis agriculture, which is mainly characterized by date palm cultivation alongside other crops, with over 150 date palm varieties (Association Marocaine des Présidents des Conseils des Préfectures et des Provinces, 2014). Notably, the region's date production capacity has never been fully realized, with actual production significantly lower than its potential. This underutilization is intriguing when studying the interplay between gender, resources, preferences, and crop choices. Additionally, the region's ongoing transition, influenced by climate change and modernization efforts such as the Plan Maroc Vert, offers a unique opportunity to examine how these factors shape agricultural decision-making in a changing environment.

Data were collected from 200 farmers (109 females and 91 males) in Tata province, specifically from three administrative districts: Tata, Foum Zguid, and Akka (Figure 1). We imposed two eligibility conditions on the sample selection: (1) Farmers engage in oasis agriculture, excluding monoculture practices, as crop diversification inherently characterizes oasis agriculture. (2) Farmers exclusively make decisions regarding crop choices and marketing, excluding joint management scenarios, to better isolate individual preferences regarding time and risk in decision-making processes. We employed a random sampling method to ensure a representative cross-section of the agricultural community in Tata province and capture the diversity of farming practices, land tenure arrangements, and socio-economic conditions present in the region. To implement random sampling, we first obtained a comprehensive list of farmers in the three districts from local agricultural offices. From this list, we randomly selected survey participants. If the selected farmers did not meet the eligibility criteria or were unavailable, we moved on to the next randomly selected farmer on the list. This process was continued until the target sample size of 200 eligible participants was reached.

We conducted household interviews from November 2022 to May 2023. The survey questionnaire gathered rich information on various factors influencing agricultural decision-making. Specifically, we collected data on land tenure, access to critical resources (particularly water and date trees), preferences (via hypothetical questions to elicit risk and time preferences and explored self-reported crop preferences and risk perceptions), dynamics of cooperative membership, cropping patterns and cultivated varieties, agricultural assets, agricultural and non-agricultural income, labor, off-farm activities, and individual characteristics (e.g., age, education, and farming experience). This multifaceted approach to data collection allows us to capture the complex interplay of factors shaping crop choices and agricultural practices in the Tata region, thus providing a rich dataset for our analysis of gender dynamics in oasis agriculture.

2.3. Measurement of key variables

Information collected for this study is grounded in an integrated framework that combines theories of property rights, gender in agriculture, and experimental economics. We draw on the property rights theory (Besley, 1995; Goldstein & Udry, 2008) to understand how land tenure and resource access influence agricultural decisions. This theoretical view is complemented by gender theories in agriculture (Doss, 2018; Quisumbing & Pandolfelli, 2010) to examine how gender intersects resource access and decision-making. Moreover, we incorporate experimental approaches to understand how risk and time preferences influence crop choices (Binswanger, 1980; Laibson, 1997). Additionally, this study adopts an individual-level approach to data collection, allowing us to capture intra-household dynamics that are often missed in household-level analyses (Deere et al., 2012). The authors demonstrated that focusing solely on household headship can significantly underestimate women's land ownership because women in male-headed households may still own

or co-own assets. By collecting data at the individual level, we can better understand how gender influences asset ownership, resource access, and agricultural decision-making within households. Such an integrated approach allows us to examine the complex interplay between institutional structures, gender dynamics, and individual preferences in shaping agricultural decisions in Morocco's oasis agriculture context. This subsection explains key variables used in this study.

2.3.1. Property rights, gender, and resources access

First, our approach to understanding land tenure and resource access is grounded in the property rights theory (Besley, 1995; Goldstein & Udry, 2008). This framework posits that secure property rights incentivize long-term agricultural investments and influence productivity by affecting farmers' willingness to improve land, adopt new technologies, or engage in long-term crops. It also recognizes that informal rights and social positions can significantly affect land tenure security and subsequent agricultural decisions.[3] We operationalize this theory by distinguishing between de jure and de facto property rights (Schlager & Ostrom, 1992), capturing both formal legal structures and on-the-ground practices. Our measurement includes the following:

a. Land tenure: Four dummy variables representing titled land, inherited land without titling, communal land, and sharecropping, reflecting the complex, often overlapping nature of land rights in developing contexts (Meinzen-Dick & Mwangi, 2009).
b. Plot size: A continuous variable as a proxy for land access.

[3] Building on this idea, secure land tenure for women can be essential for their empowerment and have far-reaching societal benefits. For example, Quisumbing et al. (2014) discussed that when women have legal land rights, they are more likely to invest in better farming practices, leading to increased productivity, improved food security, enhanced intra-household bargaining power, and more access to credit and other financial resources.

c. Resource access: Two dummy variables capturing water purchase and restricted control over date trees, embodying the "bundle of rights" concept associated with natural resources (Schlager & Ostrom, 1992).

Second, to examine gender disparities in asset ownership, we measure several types of assets by drawing on the sustainable livelihoods framework (Scoones, 1998) and asset-based approaches to poverty (Carter & Barrett, 2006): a) Agricultural assets related to land preparation and planting equipment, fertilization and pest control, irrigation and water management, harvesting and post-harvest handling, transportation and machinery, and energy and power sources. b) Financial resources such as livestock, remittances, and Rotating Savings and Credit Association (ROSCA) savings. We log-transformed these variables to account for their right-skewed distribution. Additionally, we investigate gendered patterns in social capital. Following Woolcock & Narayan (2000) and Krishna (2001), we focus on a) cooperative membership and b) marketing of crops or other food products through cooperatives.[4] By examining cooperative membership and active participation through marketing, we can assess how gender influences the access to and utilization of social capital in agricultural decision-making.

[4] These measures are informed by the work of Woolcock and Narayan (2000), who conceptualized social capital as networks and norms that enable collective action. Krishna (2001) further distinguished between "active" and "passive" social capital, emphasizing the importance of not just membership but active engagement in social networks.

a. Land access and land tenure

Table 1: Descriptive statistics

	Variable	Female	Male	Difference (Female – Male)
Date Palm Plantation	Number of planted date trees in the last 5 cropping seasons	**5.73**	**53.48**	**-47.75*** **
		(16.42)	(152.87)	(16.1)
Land Tenure	Private ownership (Titled land) (dummy)	**0.12**	**0.21**	**-0.09***
		(0.33)	(0.41)	(0.05)
	Inherited land (non-titled land) (dummy)	**0.85**	**0.53**	**0.33*** **
		(0.36)	(0.5)	(0.06)
	Communal land (dummy)	**0.00**	**0.47**	**-0.47*** **
		(0.0)	(0.5)	(0.05)
	Sharecropping (dummy)	**0.03**	**0.04**	**-0.02**
		(0.16)	(0.21)	(0.03)
Resource Tenure	Plot size (ha)	**0.80**	**4.22**	**-3.41*** **
		(1.3)	(3.92)	(0.43)
	Water purchase expenses in the last cropping season (2022/2023) in MAD[5]	**927.99**	**418.31**	**509.68***
		(2301.43)	(1016.78)	(244.85)
Physical Assets	Agricultural assets (in MAD)	**5932.01**	**31399.13**	**-25467.12*** **
		(18408.35)	(33431.14)	(3923.09)
Financial Resources	Livestock values (in MAD)	**11260.64**	**14938.41**	**-3677.76**
		(10507.48)	(21327.73)	(2451.84)
	Remittances & ROSCA saving (in MAD)	**3138.53**	**4451.55**	**-1313.02**
		(5711.27)	(8958.25)	(1086.8)
Social Capital	Cooperative membership (dummy)	**0.76**	**0.44**	**0.32*** **
		(0.43)	(0.5)	(0.07)
	Crop marketing via cooperative (dummy)	**0.17**	**0.1**	**0.08**
		(0.38)	(0.3)	(0.05)
Preferences	Estimated CRRA coefficient	**1.21**	**0.95**	**0.26*** **
		(0.61)	(0.69)	(0.09)
	Scaled time discount rate	2.28	1.79	0.5
		(3.16)	(3.44)	(0.47)
Farmers' Characteristics	Age	**50.97**	**52.29**	**-1.31**
		(11.95)	(12.87)	(1.77)
	Years of education	**2.71**	**6.18**	**-3.47*** **
		(3.46)	(3.22)	(0.47)
	Years of farming experience	**29.85**	**26.95**	**2.91**
		(14.25)	(13.41)	(1.96)
	Household size	**5.80**	**7.13**	**-1.33** **
		(4.17)	(2.92)	(0.5)
	Total Observations	**109**	**91**	

Note: Significance levels: * p<0.1, ** p<0.05, *** p<0.01
Standard deviations in parentheses, Difference column shows (Female - Male).
The exchange rate at the time of the survey in December 2023 was 1 USD = 10.081 MAD.

[5] Moroccan Dirham.

Table 1 reports summary statistics for each key variable by gender. As shown in Table 1, the average female farmer manages only 0.8 hectares of land compared to 4.2 hectares for their male counterparts. This substantial gap in land access aligns with broader patterns observed globally (e.g., Doss et al., 2015; Slavchevska et al., 2021; Kieran et al., 2015). Additionally, Figure 2 shows that women commonly acquire land for farming through inheritance, while men are more likely to manage communal land. This contrast indicates that women are likely to own and manage plots with less secure land rights. Ownership over inherited land is restricted to management rights and not extended to alienation rights, where women can pass it on to their children, for instance. The observed gender disparity in land tenure derives from the fact that women have no access to communal land, attributed to historical and cultural factors, making women more vulnerable to land rights insecurity.

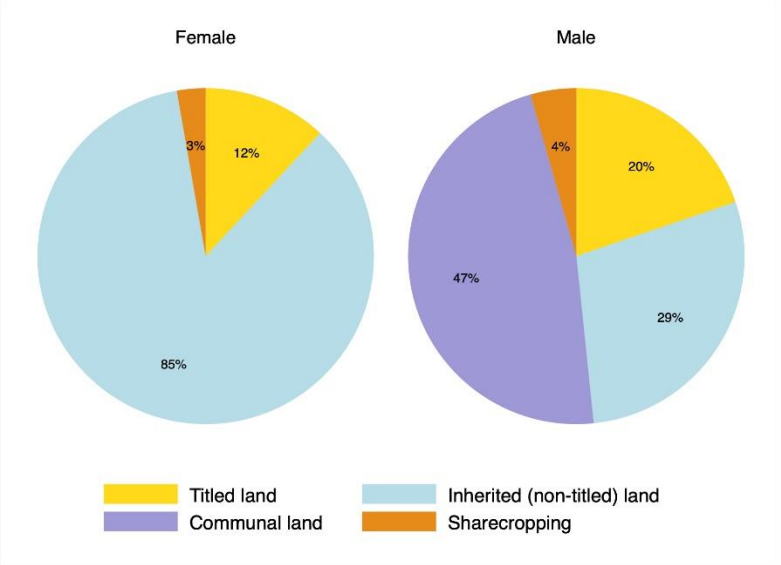

Figure 2: Land tenure by gender

Table 2: Tenure types among farmers with inherited land

Inherited land (Many owners)	LAND TENURE				Total
	Titled land (One owner)	Inherited Land (Many owners)	Communal land	Sharecropping	
Yes	0	119	20	2	**141**
	0%	**84.4%**	**14.2%**	**1.4%**	**100%**
No	31	0	23	5	**59**
	52.5%	**0%**	**39.0%**	**8.5%**	**100%**
Total	31	119	43	7	**200**
	15.5%	**59.5%**	**21.5%**	**3.5%**	**100%**

Table 2 presents the tenure structure within our sample, showing that 16% of farmers own inherited land collectively with family members, while simultaneously cultivating plots under different tenure systems, predominantly communal land. This pattern suggests unresolved conflicts or legal challenges in formalizing the ownership of inherited land, prompting farmers to seek alternative tenure arrangements. Overall, the land tenure structure in our study area reveals significant complexities, reflecting broader patterns observed in many developing countries, particularly in arid regions with overlapping traditional and modern land rights systems.[6]

Additionally, 4% of the farmers in our sample engage in sharecropping, a practice typically associated with landless men cultivating land in exchange for a portion of the harvest. Within this sample, three female farmers manage land under unique conditions, describing their tenure as "freely rented," with no compensation required. Such an arrangement, observed among some female farmers, may represent a locally specific manifestation of flexible land access mechanisms,

[6] Such complexities are not unique to our study area; Benjaminsen et al. (2009) observed similar patterns in Mali, Niger, and South Africa, where attempts to formalize land rights often intersect with existing customary systems, creating a web of overlapping claims and rights. Moreover, Meinzen-Dick & Mwangi (2009) cautioned that attempts to formalize property rights in such complex systems can sometimes exacerbate existing inequalities or create new conflicts. They argued that focusing on individual titling often neglects the diverse claims of various stakeholders. Our findings add additional evidence to the literature by illustrating how these global patterns of tenure complexity manifest in the specific context of the Tata region, with implications for gender disparities in land access and control.

similar to the diverse informal institutions Lavigne Delville (2010) documented in other parts of Africa. These informal arrangements underscore the complexity of land tenure systems in the region and the potential vulnerabilities that rely on such informal arrangements.

a. Non-land production resources

The implications of land tenure extend to other resources within farmers' plots. Female farmers are often disadvantaged in terms of accessing date palm harvests from their managed plots. For instance, 13% of surveyed female farmers have date palm trees in their plots but lack the rights to harvest, consume, or sell fruits. However, no male farmers reported this issue. This gender-based disparity in resource access aligns with broader patterns observed in agricultural contexts worldwide (Doss & Meinzen-Dick, 2020; Meinzen-Dick et al., 2019; Rocheleau & Edmunds, 1997).[7]

Furthermore, purchasing water resources is considered a primary necessity rather than a supplementary measure to meet farmers' needs. Field observations and farmers' experiences suggest two contributing factors: the scarcity of water resources within shared sources and the denial of access to water resources due to management rights over plots. Additionally, results reveal a significant difference in average water expenses related to the last crop season across genders (928 vs. 418 MAD in Table 1), with 67% of water purchasers being female farmers. These findings highlight the distinct separation between land tenure and resource tenure under informal land arrangements, showing that this separation becomes more pronounced when gender disparities are considered. These empirical findings imply that land and water rights are

[7] For example, Doss & Meinzen-Dick (2020) discussed "tolerated use," where women may access land and resources without recognized rights. They also highlighted that women's restricted rights limit their ability to fully benefit from agricultural resources.

intertwined but not necessarily interchangeable within Moroccan arid regions, challenging the findings of Rignall et al. (2018). Our observations underscore the complex, gendered nature of resource access in agriculture, where formal ownership or management rights may not translate into complete control over valuable resources, such as tree crops and water.

While mechanization remains limited within our sample—only 24% of farmers have implemented drip irrigation systems—male farmers possess more agricultural assets than female farmers (Table 1). The reported assets consist primarily of irrigation infrastructure, including drip irrigation systems, solar panels, and well pumps. These irrigation assets are largely confined to farmers who manage communal or tilted land. This pattern likely reflects the advantages conferred by land titling, which enhances access to subsidies targeted at irrigation systems, underscoring the pivotal role of land tenure in driving mechanization.[8]

Livestock holdings and remittances, combined with ROSCA savings, represent crucial financial resources for rural households that function as productive assets and risk management tools (Fletschner & Kenney, 2014). Results reveal gender differences in both resources, with male farmers having higher mean values. Table 1 shows that the average gender gap in livestock value is -3678 MAD, while for remittances and ROSCA savings combined, it is -1313 MAD. However, these differences are not statistically significant because of their high variations.

[8] This observation aligns with findings from various contexts. For instance, Zheng et al. (2021) found that land transfer status significantly influences machinery ownership in China, with renting-in cropland leading to increased use of self-owned machinery. Theis et al. (2018) observed that women farmers in Ghana, Ethiopia, and Tanzania face more severe constraints in adopting and benefiting from agricultural mechanization technologies, partly due to differences in land tenure security and resource access. These findings highlight the crucial role of land tenure security in promoting long-term agricultural investments.

Table 1 indicates notable gender differences in cooperative membership within Tata province, with female farmers exhibiting a 32 ppt higher likelihood of participation than their male counterparts. However, our data reveal a significant discontinuity between cooperative membership and sales activities. Only 10% of male and 17% of female farmers report selling their produce through cooperatives, despite higher membership rates, with most female cooperatives focusing on processing food products, mainly couscous, from raw materials purchased from the local market or other farmers. This disconnection between production and cooperative activities aligns with the findings of Fischer and Qaim (2012). While cooperatives provide essential economic participation and empowerment opportunities for female farmers by offering alternative avenues to navigate resource constraints, their effectiveness is hindered when they fail to process and market members' agricultural produce.

2.3.2. Risk and time preferences elicitation

To capture farmers' risk attitudes and time preferences, we employed non-incentivized hypothetical questions, an approach validated by recent literature on experimental and behavioral economics. While the necessity of monetary incentives in preference elicitation has been debated, studies by Dohmen et al. (2011) and Falk et al. (2018) have demonstrated that carefully designed hypothetical measures can reliably predict real-world behaviors and outcomes. These measures are particularly suitable for field studies, such as ours, where practical constraints may limit the use of incentivized experiments. Moreover, hypothetical scenarios allow respondents to consider choices that are more closely aligned with their actual decision-making contexts when making decisions involving significant long-term investments such as date palm cultivation. This approach enables us to gather meaningful data on risk and time preferences efficiently, which are crucial factors in understanding agricultural investment decisions in our study area.

Following Binswanger (1980) and Holt & Laury (2002), we presented respondents with hypothetical scenarios involving choices between uncertain outcomes, a method validated by Dohmen et al. (2011) as predictive of real-world risk-taking behavior (Table 3). Specifically, respondents were asked to choose between a series of lotteries with varying levels of risk and expected returns (see Appendix 2.1 for more details.**)**. From these choices, we calculated the coefficient of partial risk aversion, which reflects the curvature of the utility function and indicates the degree of risk aversion. Based on the selected choice, we categorized farmers into risk preference groups within the risk aversion spectrum.

Table 3: Binswanger-style lottery game and its results

Option	1st choice	2nd choice	Risk aversion class	Coefficient of partial risk aversion	Farmers by risk level (%)	
	Low	High			Female farmers	Male farmers
1	250 MAD	250 MAD	Extreme risk-averse	$1.37 \leq r \leq \infty$	42%	30%
2	200 MAD	400 MAD	High Risk-averse	$0.81 \leq r \leq 1.37$	21%	12%
3	150 MAD	550 MAD	Moderately risk-averse	$0.57 \leq r \leq 0.81$	8%	29%
4	100 MAD	700 MAD	Neutral risk-averse	$0.37 \leq r \leq 0.57$	8%	11%
5	0 MAD	1000 MAD	Risk-seeker	$\infty \leq r \leq 0.37$	21%	18%

Note: The exchange rate at the time of the survey in December 2023 was 1 USD = 10.081 MAD.

Table 3 shows a substantial gender disparity in risk attitudes among farmers. Most female farmers (63%) exhibit extreme to high levels of risk aversion, in contrast to 42% of their male counterparts. This indicates that women are generally more risk-averse in decision-making, opting for safer, lower-payoff choices. Male farmers dominate the moderately risk-averse category in the middle range (29%), compared to only 8% of female farmers. This result suggests that while still cautious, men are more willing to take moderate risks than women. Conversely, when combining the neutral

and risk-seeking classes, male and female farmers chose these categories equally, with 29% of each group exhibiting either neutral or risk-seeking behavior. Thus, while women generally display higher risk aversion, a notable proportion are still willing to take risks, particularly in higher-risk categories. Furthermore, the average coefficient of partial risk aversion under the assumption of CRRA utility form corresponds to the "extreme risk aversion" and "high risk aversion" categories for women and men, respectively.

For time preferences, we employed a staircase method closely aligned with the Global Preference Survey approach developed by Falk et al. (2018). This method has been validated across diverse cultural contexts (Falk et al., 2023). Our elicitation procedure involved a series of binary choices between immediate and delayed monetary rewards. The initial choice was 300 MAD today or 500 MAD in one month. Subsequent questions adjusted the timing and amounts based on the participant's previous choice (see Appendix 2.2). Based on this game, we calculate the measured discount rates in Table 4.

Table 4: Classification of time preferences based on calculated time discount rate

Scenarios	Choices	Discount rates	Scaled discount rates	Interpretation
1	500 MAD in 1 month, 500 MAD in 2 months	0%	0%	Highly patient
2	500 MAD in 1 month, 500 MAD in 1 month, 700 MAD in 2 months	325.43% (Midpoint)	3.25	Moderate impatience
3	500 MAD in 1 month, 300 MAD in 1 month, 300 MAD in 1 month	558.90% (Estimated)	5.59	Higher impatience
4	300 MAD today, 700 MAD in 1 month	792.36%	7.92	High impatience
5	300 MAD today, 300 MAD today	1000% (Assigned)	10	Extreme impatience

As presented in Table 1, summary statistics reveal no statistically significant gender disparity in time preferences among farmers, with average female farmers exhibiting a marginally higher level of impatience (M = 2.28) than their male counterparts (M = 1.79), although this difference lacks statistical significance. As shown in Table 4, the average time discount rates for both genders fall between high patience and moderate impatience.

2.3.3. Gender, cropping systems, and date palm plantation

Our primary outcome is date palm plantation in the last five cropping seasons, measured as an extensive margin (whether a farmer planted date palms) and an intensive margin (the number of date palms planted). Our focus on the date palm as the primary outcome is ideal for several reasons. First, the date palm is a profitable and climate-resilient crop in arid regions, essential for local livelihoods, and a key indicator of sustainable agriculture (Chao & Krueger, 2007). Second, date palm cultivation requires high upfront investments in labor and water resources, with a significant delay before fruiting begins (typically 5–7 years). The long-term nature of investment makes it particularly suitable for examining the influence of risk and time preferences on agricultural decision-making. The five-year timeframe allows us to capture recent decision-making while accounting for the fact that date palm cultivation is a long-term investment. By focusing on this crop, we can analyze how farmers balance immediate costs with future benefits, providing insights into their risk attitudes and time preferences in a real-world context.

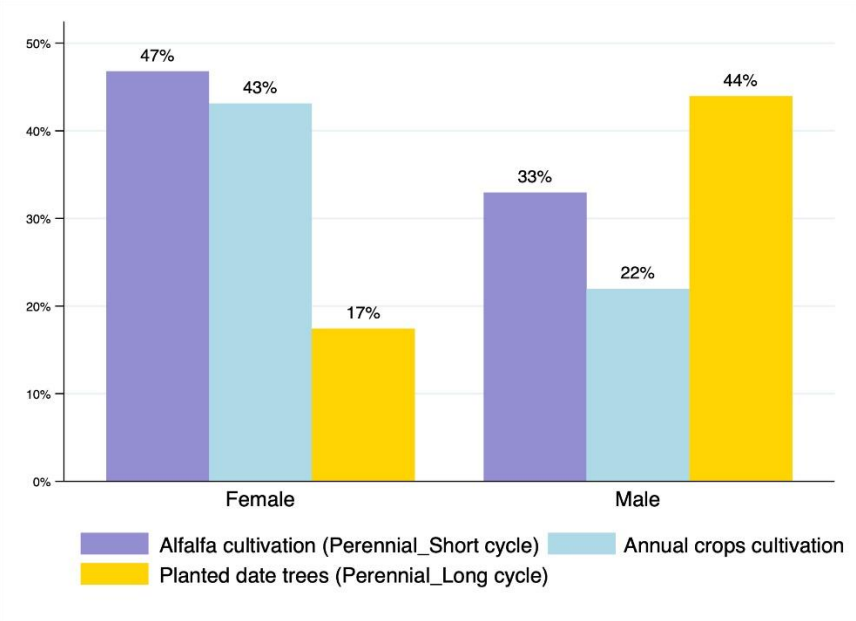

Figure 3: Cropping systems across gender

Figure 3 illustrates the cropping patterns by gender for three main categories in Tata province: (1) perennial crops with a short cycle, primarily alfalfa; (2) annual crops (cereals and vegetables); and (3) date palm plantations within the last five years. Results reveal significant gender disparities in crop choices, particularly in recent date palm plantations and vegetable cultivation; 44% of male farmers have planted date palms in the last five years compared to only 17% of female farmers. Cumulatively, women account for only 32% of the total planting, with an average of 6 trees planted per female farmer compared to 53 per male farmer (Table 1). Conversely, 43% of female farmers cultivate annual crops (cereals and vegetables), whereas only 22% of male farmers do so. Thus, female farmers demonstrate a pronounced preference for crops that directly contribute to household food security and animal husbandry, primarily vegetables and alfalfa. The high prevalence of alfalfa cultivation predominantly mirrors livestock care, an activity engaged in by both genders, albeit with a higher participation rate among women (82%) than men (55%). This

heightened involvement of women in livestock-related activities aligns with patterns observed across various developing countries (Kristjanson et al., 2014).

Overall, descriptive results reveal significant gender disparities across multiple dimensions of agricultural decision-making in the Tata province. Female farmers manage smaller land parcels, have no access to communal land, face more restricted access to date palm harvests, and exhibit higher risk aversion than male farmers. Although women are more likely to join cooperatives, they lag in date palm cultivation. The next section presents regression analyses to rigorously confirm these observed gender disparities while controlling for potential confounders.

3. Regression analysis

3.1. Empirical specification

We design our empirical strategy to investigate the interplay between gender, property rights, resource access, and individual preferences in shaping agricultural decisions, particularly regarding date palm cultivation. To this end, we conduct our analysis in two steps.

First, we establish the gendered nature of asset ownership and resource access. We regress asset-related outcomes (e.g., land, agricultural assets, financial resources, and social capital) on a female dummy variable and relevant controls, such as farmers' age, level of education, farming experience, ethnicity, household size, and regional fixed effects. This first step allows us to confirm the empirical patterns reported by descriptive statistics and quantify gender disparities in resource access and ownership after accounting for controls, providing a foundation for understanding differential constraints faced by male and female farmers.

Second, we examine how these gender differentials in property rights, resource access, and individual preferences collectively influence date palm plantation decisions. Following the recent literature on gender asset gaps and agricultural decision-making (Deere & Doss, 2006; Peterman et al., 2014; Lambrecht, 2016), we analyze this at two levels:

1. Extensive margin: We use a dummy indicating whether a farmer has engaged in date palm plantations in the last five cropping seasons as the outcome. This analysis allows us to identify factors influencing the decision to cultivate date palms.
2. Intensive margin: We use the number of date palms planted in the last five cropping seasons as the outcome. This analysis enables us to understand factors affecting the scale of investments in date palm cultivation.

We run regressions for both margins, progressively incorporating our key variables of interest: gender, land tenure, resource access, agricultural assets, financial resources, social capital, and risk and time preferences. This stepwise approach allows us to observe how gradually shutting down potential mechanisms alters the relationship between gender and date palm cultivation decisions. We regard the remaining gender influence, measured by the coefficient of the gender dummy after accounting for observed channels, as an unobserved influence of gender norms on date palm cultivation. Particularly, we specify our empirical model as follows:

$$Y_i = \beta_0 + \beta_1 G_i + \beta_2 L_i + \beta_3 R_i + \beta_4 P_i + \beta_5 A_i + \beta_6 F_i + \beta_7 S_i + \beta_8 X_i + \varepsilon_i$$

where Y_i is the outcome of interest, either a dummy for date palm cultivation to gauge the extensive margin, or the number of date palms planted to gauge the intensive margin of respondent *i* in the last five cropping seasons. The main explanatory variable is G_i representing a female dummy and

β_1 is the coefficient of interest. We hypothesize that β_1 measures the influence of prevailing gender norms on date palm cultivation. As mediating variables, L_i is a vector of land tenure variables, including dummies for private ownership with legal titles, inherited land, communal land, and sharecropping. R_i is a vector of resource access variables, including whether the farmer purchased water and whether they have restricted control over date palms on their plot. P_i is a vector of elicited preference measures, including the farmer's risk aversion coefficient and time discount rate. While A_i is the agricultural asset value, F_i is a vector of financial resource variables, including livestock value, remittances, and ROSCA savings, all of which are log-transformed. As the last channel variable, we included a vector of social capital variables, denoted by S_i, including dummies for cooperative membership and marketing through cooperatives. Finally, X_i is a vector of controls including individual characteristics (e.g., education, age, ethnicity, and years of farming experience) and household characteristics (family size, income, and regional dummies) and ε_i is an error term.

We estimate this model using OLS for the intensive margin (decision to plant) and Tobit regression for the extensive margin (number of trees planted).[9] This empirical strategy allows us to systematically examine how gender interacts with property rights, resource access, and individual preferences to influence the decision to cultivate date palm trees and the intensity of cultivation. By analyzing the extensive and intensive margins, we can capture nuanced gender differentials in agricultural decision-making, providing insights into the complex factors shaping crop choices in our study area.

[9] As elaborated later; to address potential sample selection bias embedded in participation in date palm cultivation, we also employ a Heckman two-step estimation approach with land tenure variables (specifically, titled land and communal land) as instruments in the selection equation to check the robustness of our Tobit regression results.

3.2. Regression result 1: Gender-differences in resource access

Table 5: OLS regression of natural/physical resources and land tenure on gender

	Natural and Physical Resources				Land Tenure			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Plot Size	Water Purchase	Collective Date Trees	Log Agricultural Assets	Private Ownership (Titled Land)	Inherited land (non-titled)	Communal Land	Sharecropping
Female	-2.667***	0.0427	0.152***	-5.169***	-0.0333	0.250***	-0.522***	-0.0367
	(0.461)	(0.0719)	(0.0375)	(0.774)	(0.0557)	(0.0692)	(0.0559)	(0.0296)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
No Observations	200	200	200	200	200	200	200	200
R-squared	0.346	0.158	0.152	0.443	0.160	0.210	0.412	0.0786

Note: Robust standard errors are shown in parentheses. The following controls are included, but not reported: age, level of education, farming experience, ethnicity, household size, and regional fixed effects. * p<0.1, ** p<0.05, *** p<0.01

Table 5 presents regression results examining gender-differences in land and resource access. Our previous findings from the descriptive analysis remain robust after accounting for various factors. Notably, being a female farmer is significantly associated with managing smaller plots by approximately 2.7 hectares after controlling for other variables, such as age, level of education, farming experience, ethnicity, household size, and regions. Additionally, female farmers are more likely to manage land with less secure tenure, such as inherited land, whereas male farmers predominantly cultivate communal land. Furthermore, there is a significant disparity in agricultural asset ownership, with female farmers owning approximately 517% fewer assets in value than their male counterparts.

Table 6: OLS regression of financial resources and social capital on gender

	(1) Log Remittances & ROSCA	(2) Log Livestock	(3) Coop. Membership	(4) Marketed Crops via Coop.
Female	1.322*	1.976***	0.356***	0.134**
	(0.726)	(0.729)	(0.0765)	(0.0533)
Controls	Yes	Yes	Yes	Yes
No. Observations	200	200	200	200
R-Squared	0.134	0.136	0.159	0.0698

Note: Robust standard errors are shown in parentheses. The following controls are included, but not reported: age, level of education, farming experience, ethnicity, household size, and regional fixed effects. * p<0.1, ** p<0.05, *** p<0.01

In our analysis of financial resources, we examine three key components: livestock value, received remittances, and ROSCA savings. Table 6 shows that female farmers are associated with significantly more financial resources across these categories. Specifically, female farmers exhibit an approximately 132.2% higher combined value of remittances and ROSCA savings. This gender difference is statistically significant at the 10% level. Moreover, female farmers possess livestock values approximately 197.6% higher than those of their male counterparts. The gender disparity is significant at the 1% significance level. However, the coefficient requires careful interpretation. Although we categorized livestock as a source of cash income, this perception may differ across genders. Our data reveal that male farmers engage in more frequent livestock sale transactions than female farmers, suggesting that male farmers are more likely to perceive livestock as a cash source. By contrast, women may view it as an asset or an activity. This gender difference in livestock perception aligns with the findings of Bebbington (1999), who argued that assets not only serve as resources for making a living but also provide meaning and purpose in individuals' lives, reflecting their broader livelihood strategies and cultural values.

For social capital, we analyze membership in cooperatives and whether any crops/products are marketed via such cooperatives. Columns (3) and (4) in Table 6 report the significant engagement of female farmers in cooperatives. Although shrunk in magnitude, the empirical regularity observed in descriptive results remains robust even after controlling for primary individual and household characteristics. This finding reflects their drive to engage in more profitable activities and compensate for their limited resource access. Thus, the discontinuity between women's farming activities and cooperative engagement remains significant. This inefficiency limits the potential benefits of cooperative membership, as it prevents the leveraging of agricultural output to add value and improve market access, thereby undermining their overall economic impact.

Table 7: OLS regression of risk aversion measures and time discount rates on gender

	(1)	(2)
	Coefficient of partial risk aversion	Scaled time discount rate
Female	0.115*	0.741
	(0.0685)	(0.518)
Controls	Yes	Yes
No. Observations	200	200
R-Squared	0.124	0.114

Notes: Robust standard errors are shown in parentheses. The following controls are included, but not reported: age, level of education, farming experience, ethnicity, household size, and regional fixed effects. * p<0.1, ** p<0.05, *** p<0.01

After controlling for confounding variables, our analysis reveals notable gender-based differences in risk preferences among farmers. Table 7 shows that female farmers have a higher coefficient of partial risk aversion by 0.115 points than their male counterparts, suggesting a tendency towards higher risk aversion. This difference, while modest, is statistically significant at the 10% level. This finding aligns with the meta-analysis conducted by Charness and Gneezy (2012), who consistently demonstrated greater financial risk aversion among women across various countries and contexts. Conversely, our results show no significant gender disparity in time preferences.

Table 8: OLS regression of cropping patterns on gender

	(1)	(2)	(3)	(4)	(5)
	Date Plantation (5 Years)	Alfalfa (Perennial SC)	Cereals (Annual)	Vegetables (Annual)	Newly cultivated Annual Crops
Female	-0.181**	0.0447	0.0991	0.239***	0.137*
	(0.0812)	(0.0817)	(0.0643)	(0.0593)	(0.0737)
Controls	Yes	Yes	Yes	Yes	Yes
No. Observations	200	200	200	200	200
R-Squared	0.131	0.0957	0.0631	0.0939	0.161

Notes: Robust standard errors are shown in parentheses. The following controls are included, but not reported: age, level of education, farming experience, ethnicity, household size, and regional fixed effects. * p<0.1, ** p<0.05, *** p<0.01

Table 8 reports significant gender differences in cropping patterns even after accounting for other variables. The coefficient for the female dummy in Column (1) is negative and statistically significant at the 5% level, suggesting that women are 18.1 ppt less likely to plant date palms in the last five crop seasons than men. Additionally, regression results indicate that women are 23.9 ppt more likely to cultivate vegetables than men.

Our findings on gender disparities in agricultural practices in Morocco's Tata region show similarities and differences with those of studies from other regions. The observed gender gap in land access and control is consistent with global patterns documented by Slavchevska et al. (2021) in Sub-Saharan Africa and Kieran et al. (2015) in South Asia. Our results reveal high female engagement in cooperatives yet simultaneously highlight a disconnect between cooperative activities and agricultural production. A similar paradox was discussed by Meier zu Selhausen (2016), who posits that producer groups frequently fail to realize their anticipated benefits, leading to passive participation or even dissolution of the groups. Finally, we observe gender-based differences in crop choice, with women focusing more on food security crops, mirroring patterns documented by Doss (2002) and Carr (2008) in Ghana and Djurfeldt et al. (2018) in

Malawi.[10] These comparisons suggest that, while some aspects of gender disparities in agriculture may be universal, others are shaped by local contexts, highlighting the importance of region-specific studies in informing effective policy interventions.

[10] The preference for annual crops among female farmers can be attributed to several factors: their direct contribution to household food security, which is often a higher priority for women responsible for household nutrition (Doss, 2002); the lower long-term investment and resource requirements of annual crops, aligning with women's typically more limited access to land, labor, and capital (Bhaumik et al., 2016); and the potential of diverse crops as a risk management strategy, allowing for more flexible responses to market and climate variabilities (Farnworth et al., 2016).

Table 9: OLS and Tobit regression of date palm plantation

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
			OLS Regression				**TOBIT Regression**
			Dependent variable: Dummy variable for date palm plantation in the last five years				Dependent variable: Number of the planted date trees
Gender							
Female	-0.181**	-0.307***	-0.221*	-0.230*	-0.278**	-0.277**	-79.46
	(0.0812)	(0.1154)	(0.1206)	(0.1222)	(0.1264)	(0.1267)	(54.2759)
Land Resources							
Plot Size		0.0318**	0.0269*	0.0258*	0.0223	0.0210	18.07**
		(0.0151)	(0.0151)	(0.0152)	(0.0151)	(0.0150)	(8.9743)
Land Tenure							
Private Ownership (Titled Land)		-0.0828	-0.0527	-0.0883	-0.115	-0.108	-21.02
		(0.1620)	(0.1617)	(0.1648)	(0.1635)	(0.1639)	(101.3336)
Inherited Land (Non-Titled)		-0.117	-0.0930	-0.109	-0.146	-0.132	6.548
		(0.1273)	(0.1287)	(0.1328)	(0.1343)	(0.1330)	(87.7056)
Communal Land		-0.427***	-0.410***	-0.380***	-0.387***	-0.391***	-92.52
		(0.1237)	(0.1222)	(0.1243)	(0.1198)	(0.1189)	(65.2039)
Sharecropping		-0.248	-0.167	-0.188	-0.167	-0.184	-53.96
		(0.1834)	(0.1895)	(0.2062)	(0.2053)	(0.2114)	(118.1579)
Resource Tenure							
Water Purchase		0.00866	0.0845	0.0679	0.0720	0.0597	30.53
		(0.0715)	(0.0776)	(0.0789)	(0.0786)	(0.0808)	(46.4290)
Collective Date Trees		0.0338	0.0625	0.0520	0.0624	0.0632	82.41
		(0.1137)	(0.1130)	(0.1128)	(0.1115)	(0.1149)	(64.5387)
Non-Land Resources							
Physical Assets							
Log Agricultural Assets			0.0192**	0.0187**	0.0171*	0.0165*	6.707
			(0.0094)	(0.0094)	(0.0096)	(0.0097)	(4.2964)
Financial Resources							
Log Livestock				0.0110	0.00738	0.00583	4.042
				(0.0080)	(0.0084)	(0.0084)	(4.1202)
Log Remittances & ROSCA Saving				0.000693	0.00192	0.00340	-5.019
				(0.0075)	(0.0077)	(0.0078)	(4.4823)
Social Capital							
Coop. Membership					0.0770	0.0689	19.85
					(0.0766)	(0.0781)	(36.0170)
Marketed Crops via Coop.					0.0917	0.0978	17.41
					(0.0912)	(0.0926)	(48.4277)
Preferences							
Risk Aversion (CRRA)						-0.106	-88.96*
						(0.0860)	(45.5589)
Time Discount Rate						0.00338	8.258*
						(0.0097)	(4.4236)
No. Observations	200	200	200	200	200	200	200
R-Squared	0.131	0.258	0.277	0.286	0.296	0.303	-

Notes: Robust standard errors are shown in parentheses. The following controls are included, but not reported: age, level of education, farming experience, ethnicity, household size, and regional fixed effects. * p<0.1, ** p<0.05, *** p<0.01

3.3.Regression result 2: Date palm plantation at the extensive margin

Table 9 presents the OLS regression results for the extensive margin of date palm cultivation. For reference, Column (1) replicates the regression results of Column (1) in Table 8. The specification in Column (2) shuts down land resources, including plot size and land tenure channels. After controlling for land-related variables, the estimated gender disparity is wider at 30.7 ppt. Additionally, plot size positively influences date plantation, with each additional hectare associated with a 3.2 ppt increase in planting probability. The significant relationship between plot size and plantations partially explains the reversed association between gender (being a female farmer) and date plantations, where female farmers very often own smaller plots than male farmers. Combined with the previous estimation results in Column (1), this change in the magnitude of the gender coefficient implies that female farmers have less access to land resources, negatively influencing their engagement in date palm plantations, consistent with previous findings in Table 5.

Furthermore, results in Column (2) report a negative influence of communal land on date palm cultivation: Managing communal land, perceived as the second most secure type of tenure after titled land, is associated with a 42.7 ppt decrease in the likelihood of planting date trees. This unexpected finding must be contextualized within a broader historical framework to understand evolving cropping patterns in the region and their relationship with date palm as the primary cash crop in Moroccan arid areas. This echoes the findings of Lawry et al. (2017) on the complex relationship between various forms of land tenure, including communal land, and agricultural investment in Africa. Communal land tenure can influence agricultural investments by providing security. However, reforms that shift to individual rights may create uncertainty and lead to elite capture, disadvantaging vulnerable groups such as women. Thus, while communal systems can

support collective security, careful management of reforms is needed to ensure gender equity and promote investment in agriculture. Determining why a relatively secured land tenure negatively influences date palm plantation decisions at the extensive margin is a promising avenue for future research. By contrast, resource tenure, represented by water purchases and collectively owned date trees, has no pronounced effect on such decisions.

Column (3) in Table 9 shows that additionally controlling for agricultural assets makes the gender coefficient smaller in magnitude but still significant at the 10% level. This change suggests that the initial negative impact of being a female farmer on date palm plantations can be explained mainly by disparities in agricultural asset ownership between male and female farmers. The positive and significant coefficient of agricultural assets indicates that a one percent increase in asset value increases the likelihood of planting date palms by 1.9%. The mitigating effect of agricultural assets on gender disparities in date palm plantation decisions highlights the critical role of productive resources in shaping farmers' choices and capabilities, which is consistent with the findings of Deere and Doss (2006). The diminishing gender disparity, when controlling for assets, underscores the importance of addressing structural inequalities in resource access. Our findings suggest the importance of closing the gender asset gap to promote more equitable participation in high-value perennial crop cultivation, such as date palm plantations (Johnson et al., 2016).[11]

The specification in Column (4) additionally controls for financial resources, that is, livestock, ROSCA savings, and remittances. These financial resource variables exhibit a positive yet statistically insignificant relationship with date palm plantations. The coefficients for gender, land

[11] Johnson et al. (2016) found that increasing women's ownership and control over assets is crucial for promoting equitable participation in agricultural projects and for improving outcomes in agricultural productivity and livelihoods.

access, land tenure, and agricultural assets remain robust after controlling for these financial variables. This finding indicates that greater access to financial resources may be required to overcome other structural barriers (e.g., insecure property rights and market inefficiencies).

We then added cooperative membership and crop marketing participation through these cooperatives as social network proxies to the previous specification. Regression results in Column (5) reveal a positive but insignificant association with date plantations. The insignificance of social network effects may stem from the misalignment between farming activities and cooperative functions, which often prioritize alternative income generation over the direct marketing of members' agricultural produce.[12] The effectiveness of cooperatives depends on aligning their activities with members' farming practices because a disconnect can limit the potential advantages of membership.

Finally, Column (6) specification incorporates elicited risk and time preference measures into the model. Results show that these innate factors play no significant role in date palm plantation decisions at the extensive margin. This null result suggests that structural factors, such as land tenure, outweigh the perceived risks associated with the extended growth cycle and delayed profit generation of date palms. Furthermore, the coefficient of the gender dummy remains significant at the 5% level, suggesting that unobserved gender norms prevent female farmers from engaging in date palm cultivation.

In conclusion, these findings suggest that participation in date palm plantations is more heavily influenced by access to resources, particularly land tenure, than by personal preferences or

[12] This result echoes the findings of Fischer and Qaim (2012) on the complex relationship between cooperative membership and agricultural decision-making. They demonstrate that while cooperative organizations can enhance market access and facilitate innovation, the benefits of collective action are context-specific.

financial constraints. Gendered disparities in resource access are critical factors explaining why female farmers are less likely to plant new date trees, highlighting the need for gender-sensitive policies in agricultural development programs. Another important finding is that our results suggest the restricting role of unobserved gender norms in female entry into date palm cultivation.

3.4. Regression result 3: Date palm plantation at the intensive margin

To analyze factors influencing the intensity of date palm plantations, we employ a Tobit regression model that accounts for the censored nature of our dependent variable (i.e., the number of trees planted). We maintain the same mediating variables and controls as those used in the extensive margin analysis.

Column (7) in Table 9 reports the Tobit regression results for the number of date palm trees planted during the last five cropping seasons. Results at the intensive margin reveal a contrasting pattern compared with the extensive margin analysis. First, the results show no gender differences at the intensive margin. Thus, participation in date palm cultivation per se is more challenging for female farmers than investments after participation because of prevailing gender norms.

Plot size emerges as a crucial determinant, with each additional hectare associated with planting 18 more date trees. Plot size's significance partially explains the lower contribution of female farmers to new date palm plantations, as they often manage smaller plots than their male counterparts. Interestingly, while salient at the extensive margin, land tenure and resource access variables become insignificant at the intensive margin, suggesting a two-stage decision-making process.

Risk preferences significantly influence planting intensity, with more risk-averse farmers planting 89 fewer trees. This result indicates that more risk-tolerant farmers are more willing to invest in long-term, high-value crops. Our analysis reveals a positive relationship between farmers' discount rates and date palm planting intensity. Given the wide range of discount rates in our study (from 0% to 1000%), this effect is substantial: farmers in the most impatient category (1000% discount rate) planted approximately 83 more trees than those in the most patient category (0% discount rate). This finding is particularly intriguing given that date palm cultivation represents the investment with the most delayed returns in the region, challenging the conventional economic theory's prediction that patience fosters greater long-term investment.[13]

This counterintuitive finding may be explained by impatient farmers' perceptions of date palms as illiquid savings or commitment devices (Bryan et al., 2010; Thaler & Shefrin, 1981). The illiquidity of the investment may prevent impulsive spending as capital is tied up in the palms, encouraging farmers to focus on future financial stability. Farmers can resist immediate consumption and enhance savings by committing to date palm cultivation, effectively managing self-control challenges. This behavior may reflect a sophisticated form of time-inconsistent decision-making in which more impatient farmers leverage the long-term nature of date palm investment as a self-control mechanism against their short-term impatience.

Our findings indicate that structural factors, such as land tenure, influence the initial decision to plant date palms. Once a participation decision is made, individual preferences play a more significant role in determining the scale of investment. This empirical regularity underscores the

[13] Our measured coefficient of partial risk aversion and discount rates has no significant correlations (not reported), suggesting distinct factors in decision-making. The independence of both preference measures supports treating time and risk preferences separately rather than as components of a unified theory of choice under uncertainty (Andersen et al., 2008). Thus, risk attitudes do not confound the observed relationship between impatience and investment.

complexity of agricultural investment decisions and the importance of considering crop-specific attributes and local economic contexts in models of farmer behavior, particularly in settings with significant delays between investment and returns. Our results suggest that the relationship between time preferences and agricultural investments is more nuanced than previously understood, necessitating a reevaluation of how we model and interpret farmers' long-term economic decisions. These findings have important implications for agricultural policy and development interventions. They suggest that efforts to increase date palm cultivation should consider structural barriers to entry and individual farmer characteristics. Policies to close gender disparities in land access could help equalize opportunities for intensive date palm cultivation. Additionally, interventions that help farmers manage risk, such as improved irrigation systems or crop insurance, could encourage more significant investments in date palms among risk-averse farmers. Finally, addressing prevailing gender norms is necessary for female farmers to grow long-term, high-value crops such as date palm trees.

3.5. Robustness check

One may be concerned about our previous approach of treating participation and investment decisions independently. These decisions may depend on one another. In our context, unobserved factors that determine the decision to plant date palms (selection) may also influence the number of trees planted (outcome). To test the robustness of our findings to potential sample selection bias, we employ a Heckman two-step estimation approach as a complementary approach to our main analysis (Heckman, 1979). By comparing the results of this model with our primary specifications, we can assess whether our main findings regarding gender differences in date palm cultivation decisions are contaminated by sample selection bias. In particular, we use land tenure variables as instruments in the selection equation, specifically focusing on titled land and communal land

ownership. This choice is based on the theoretical argument that land tenure significantly influences the decision to invest in long-term crops such as date palms (Besley, 1995; Goldstein & Udry, 2008) but may not directly affect the intensity of planting once the decision is made.

Appendix Table A1 reports estimation results of the Heckman correction model. The results reveal a statistically insignificant inverse Mills ratio in the second-stage outcome equation. This lack of significance suggests that sample selection bias is not a significant concern, at least in our estimation sample. The unobserved factors affecting the decision to plant date palms are not significantly correlated with the unobserved factors influencing the number of trees planted. Consequently, we can be confident in the validity of our main regression results, as they are unlikely to be substantially biased owing to the potential sample selection in date palm cultivation.

4. Discussion and conclusions

This study introduces a novel multilevel approach for analyzing crop choices, addressing a significant gap in the literature. We develop a comprehensive framework that quantifies the relative influence of structural factors (natural, physical, and financial resources, and social capital) and preferences (risk and time preferences) on crop choices. This framework considers two critical components: the decision to plant (extensive margin) and intensity of cultivation (intensive margin). We apply this approach in a context characterized by complex land and resource landscapes, allowing us to observe the influence of land rights security on agricultural decisions through an inclusive analysis of various land tenure types. This complexity stems from overlapping governance regimes and rights over land and other resources, heavily influenced by gender norms and historical factors.

Our findings reveal significant gender gaps in resource access, particularly in terms of land tenure and agricultural assets. Female farmers are more likely to manage smaller, inherited, or untitled lands, whereas male farmers predominantly manage more extensive communal land. This disparity underscores female farmers' disadvantage regarding land access and vulnerability to land rights insecurity. Moreover, female farmers have restricted access to agricultural resources within the plots they manage, especially date palm trees, over which they often lack harvest control.

Interestingly, our results indicate that female farmers tend to have higher livestock assets in value despite animal husbandry being an essential activity within the oasis regardless of gender. Further research is needed to investigate whether livestock is perceived as a source of cash income or as an asset from a gendered perspective, considering that male farmers have engaged in livestock sale transactions more frequently than women in the previous year. Female farmers' engagement in cooperatives is significantly more pronounced than that of their male peers, suggesting that women seek to secure stronger bargaining power and smoother market access, potentially to compensate for their limited resource access. These findings align with broader global patterns of gendered resource access and control.

Regarding personal preferences, female farmers exhibit higher risk aversion than their male counterparts, whereas time preferences have a less pronounced gendered effect. This gender-differentiated preference aligns with the broader analysis of cropping patterns, showing that female farmers are less likely to cultivate perennial crops with longer cycles that require intensive capital and are more likely to grow annual crops, especially vegetables. This observation is consistent with previous literature, indicating that women are more inclined to grow crops that contribute to food security rather than income generation.

Our analysis of crop choice decisions, focusing on date palm plantations during the last five cropping seasons, yields several key insights. At the extensive margin, the decision to cultivate date palm trees is driven primarily by structural factors, particularly land tenure and agricultural assets. These structural barriers create a gender gap in date palm cultivation, as evidenced by lower participation rates of female farmers. Additionally, communal land management has been associated with fewer plantations in recent years, suggesting a shift in cropping patterns away from traditional crops. Conversely, our analysis at the intensive margin reveals that personal preferences regarding time and risk influence the intensity and scale of investment in date palm plantations. Importantly, once female farmers overcome the initial barriers and engage in date palm cultivation, their investment intensity does not differ significantly from that of male farmers. This stark contrast generated by the extensive and intensive margins suggests that participation, rather than investment intensity, poses the main challenge for women, driven primarily by resource constraints, rather than preferences or willingness to invest.

The gender disparities identified in this study suggest several policy recommendations for promoting equity and enhancing agricultural productivity. Addressing the structural barriers to land tenure for female farmers is crucial. Land reform policies that provide women with more secure access to land would empower them to make long-term investments in high-value crops. Additionally, policies that facilitate access to agricultural assets are essential for leveling the playing field for female farmers. Interventions should be designed to leverage women's preferences and strengths, while addressing regional needs. Since female farmers prioritize food security and are more active in social networks, such as cooperatives, policies should aim to align their farming practices with local food and dietary needs. Such policies could involve supporting women-led cooperatives that produce diverse nutritious crops contributing to both household food security

and regional dietary requirements. Moreover, providing training and resources for these crops' value addition and processing could create additional income streams, bridging the gap between subsistence and commercial farming.

Despite our efforts to account for various factors influencing farmers' decisions to plant date trees, gender still exerts a significant influence. This empirical result implies that other factors likely related to the cultural context may undermine such decisions. This observation opens several critical paths for future research to better understand the dynamics of agricultural decision-making in NENA regions and rural arid regions globally. Another limitation of our study is the need for an intra-household analysis to account for the integrality of decision-making dynamics within farming households. Future research should incorporate this dimension to provide a more comprehensive understanding of how crop choices are negotiated and decided within family units. Additional areas for future research include expanding the scope to include a broader range of traditional and nontraditional crops, conducting longitudinal studies to track changes in crop choices and farming practices over time, and performing comparative studies across different arid regions to identify commonalities and differences in factors influencing crop choices.

In conclusion, this study demonstrates the profound influence of gender on agricultural decision-making processes in the context of arid regions. While acknowledging that factors beyond the scope of this research may offer complementary explanations for gender-based disparities, the findings underscore the critical role of land tenure and asset ownership in promoting sustainable agricultural investments. Achieving sustainable development goals appears to be intrinsically linked to addressing the gender gap in resource access and land rights security. This study highlights the complexity of these issues, revealing that structural barriers significantly impact

women's participation in high-value crop cultivation. Addressing these barriers is crucial for enhancing women's effective participation in agriculture. Future research directions should include a deeper examination of the cultural norms that shape gender roles and crop choices, as a thorough understanding of these factors is vital to fully grasp the dynamics of agricultural decision-making. Building on these findings, researchers can contribute to a more nuanced understanding of gender dynamics in agriculture, potentially providing more effective, equitable, and gender-sensitive policy recommendations.

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APPENDIX 1

Table A1: Heckman two-step model results

	Number of planted date trees in the last five cropping seasons
Outcome Equation	
Gender	
Female	8.659
	(186.4867)
Resources	
Plot Size	30.72*
	(18.3314)
Water Purchase	70.78
	(112.3934)
Collective Date Trees	78.77
	(226.2326)
Land Tenure	
Private Ownership (Titled Land)	-79.74
	(156.3089)
Inherited Land (Non-Titled)	30.58
	(152.9816)
Communal Land	115.3
	(138.4663)
Sharecropping	-8.873
	(214.8126)
Physical Assets	
Log Agricultural Assets	9.659
	(26.1524)
Financial Resources	
Log Livestock	8.311
	(21.2044)
Log Remittances & ROSCA Saving	-15.38
	(12.2025)
Social Network	
Cooperative Membership	39.86
	(114.6120)
Crop Marketing via Cooperative	12.10
	(127.5485)
Preferences	
CRRA Coefficient (Constant Relative Risk Aversion)	-133.3
	(115.0742)
Scaled Time Discount Rate	15.01
	(13.8663)
Farmers' Characteristics	Yes
Regional Fixed Effects	Yes

Selection Equation	
Gender	
Female	-0.389
	(0.3261)
Resources	
Plot Size	0.0511
	(0.0406)
Water Purchase	0.251
	(0.3214)
Collective Date Trees	0.297
	(0.4725)
Land tenure	
Inherited Land (Non-Titled)	0.220
	(0.2732)
Sharecropping	0.00230
	(0.6544)
Physical Assets	
Log Agricultural Assets	0.0624**
	(0.0317)
Financial Resources	
Log Livestock	0.0572**
	(0.0281)
Log Remittances & ROSCA Saving	-0.0279
	(0.0290)
Social Network	
Coop Membership	0.267
	(0.2695)
Crop Marketing via Cooperative	0.287
	(0.3405)
Preferences	
CRRA Coefficient (Constant Relative Risk Aversion)	-0.266
	(0.2801)
Scaled Time Discount Rate	0.0300
	(0.0337)
Farmers' Characteristics	Yes
Regional Fixed Effects	Yes
Mills λ (Inverse Mills Ratio)	261.5
	(546.9)
No. Observations	200
Wald $\chi 2$	16.75
Prob > $\chi 2$	0.777

Note: Standard errors are in parentheses. * p<0.1, ** p<0.05, *** p<0.01

APPENDIX 2

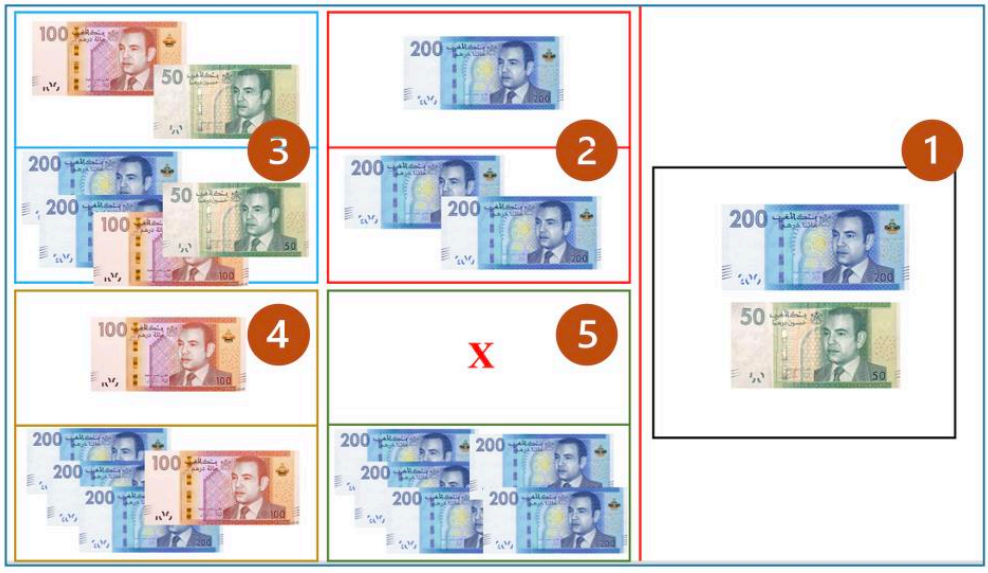
Appendix 2.1: Elicitation of Risk Preferences

Farmers were presented with a hypothetical scenario in which they had to choose between receiving a guaranteed payment and selecting one of four lotteries, each with varying levels of risk. Figure A1 outlines the different payoffs offered to the farmers.

- **Payoff 1:** A guaranteed payment of 250 MAD.
- **Payoff 2:** A choice between 200 MAD and 400 MAD.
- **Payoff 3:** A choice between 150 MAD and 550 MAD.
- **Payoff 4:** A choice between 100 MAD and 700 MAD.
- **Payoff 5:** A choice between 0 MAD and 1000 MAD.

Note: The exchange rate during the survey period in December 2023 was 1 USD = 10.081 MAD.

Figure A1: Hypothetical scenarios for risk preferences elicitation



Appendix 2.2: Elicitation of Time Preferences

Figure A2 illustrates the hypothetical scenarios designed to elicit farmers' time preferences. The following five scenarios were presented:

- **Scenario 1:** 500 MAD in one month, followed by 500 MAD in 2 months.
- **Scenario 2:** 500 MAD in one month, followed by 300 MAD in one month, and then 700 MAD in two months.
- **Scenario 3:** 500 MAD in one month, followed by 300 MAD in one month, then 300 MAD in one month, and finally, an amount (X MAD) chosen by the farmer to wait for two months.
- **Scenario 4:** 300 MAD today, followed by 700 MAD in one month.
- **Scenario 5:** 300 MAD today, followed by another 300 MAD today, and then an amount (X MAD) chosen by the farmer to wait for one month.

Note: The exchange rate during the survey period in December 2023 was 1 USD = 10.081 MAD.

Figure A2: Hypothetical scenarios for time preferences elicitation