Political Economy of the Wheat Sector in Morocco: Seed Systems, Varietal Adoption, and Impacts

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Institut National de la Recherche Agronomique

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Science for resilient livelihoods in dry areas

Political Economy of the Wheat Sector in Morocco: Seed Systems, Varietal Adoption, and Impacts

Editors: Zewdie Bishaw, Yigezu A. Yigezu, Abdoul Aziz Niane, Roberto Ariel Telleria Juárez, and Dina Najjar

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Established in 1977, the International Center for Agricultural Research in the Dry Areas (ICARDA) is a non-profit, CGIAR Research Center that focusses on delivering innovative solutions for sustainable agricultural development in the non-tropical dry areas of the developing world.

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Preface

In Morocco, wheat is an important cereal crop that significantly contributes to the livelihoods of farming communities and the national economy. On average for the period 2010–2016, the country produced 5.7 million tonnes of wheat grain on about 3.2 million ha of land. In 2013, total cereal production accounted for 47% of the agricultural value added. Wheat production alone was worth about USD 850 million, making it the second most important crop after olives.

In the 1960s, Morocco was largely self-sufficient, producing more than 80% of the wheat for domestic consumption. This declined over the years and by the turn of the century, on average, only 60% of the total domestic demand for wheat was met. Despite the doubling of its population during the same period, the per capita supply of wheat increased impressively from 138 kg/person in the 1960s to an average of 255 kg/person in the period 2001–2016. Considering the population increase and changing food habits, wheat, and particularly bread, consumption became an even bigger component of food security.

With the introduction of improved wheat varieties in the 1980s, significant increases in yields were observed, though the yield levels were far below both the global average of over 3 t/ha and the African average of 2.3 t/ha. Consequently, Morocco continued to import large volumes, making wheat the most important (in both volume and value terms) of all agricultural imports. Despite the high dependency on imports, wheat remains one of the most important food staples in the Moroccan diet. The Green Morocco Plan (GMP) (the official government strategy to achieve food security), for the sustainable management of natural resources and agricultural competitiveness, considers the cereal seed system as a fundamental component to enhance the agricultural sector and to achieve wider economic development.

The use of high-yielding varieties and the associated crop management practices have been the major drivers for the significant changes in wheat production and productivity. One of the most important results from public investment in agricultural research is the development of new crop varieties and their associated technologies. The Government of Morocco and its

international research and development partners have made substantial investments in agricultural innovation. However, developing new crop varieties is not enough. To have a real impact, crop development should be coupled with an efficient and effective seed-delivery system that will push technologies out to farmers' fields. Within this context, there are several actors in the Moroccan seed sector. These include the national agricultural research system, public and private seed companies with networks of seed dealers, associations of seed growers and seed traders, and regulatory agencies whose individual or collective strengths and weaknesses influence the country's ability to achieve meaningful impacts.

This book, *Political Economy of the Wheat Sector in Morocco: Seed Systems, Varietal Adoption, and Impacts,* documents the studies conducted on the wheat sector in general. It also documents the wheat seed system, its adoption and impacts in Morocco, through support provided by the CGIAR Research Program (CRP) on Wheat and the European Union-International Fund for Agricultural Development (EU-IFAD) Project. Chapter 1 highlights the cereal seed sector, including the policy and regulatory frameworks. Chapter 2 presents the development of improved wheat varieties, their registration and release, including variety protection and licensing for commercialization. Chapter 3 summarizes the early generation seed (breeder, pre-basic, and basic) multiplication by the National Agricultural Research System (NARS), and large-scale certified seed production by the public and private sectors. Chapter 4 elaborates on seed quality assurance and certification. Chapter 5 describes the adoption and impacts of improved varieties and seed demand analysis. Chapter 6 presents perspectives on the wheat seed sector. Chapter 7 synthesizes the overall findings on the wheat seed sector, focusing on delivery systems, variety adoption, and impacts in Morocco.

The experiences documented in this book are expected to inform stakeholders – including policy makers, researchers, farmers, private and public commercial farms, and development partners – about the status, challenges, and opportunities in the wheat sector in Morocco. Additionally, it paves the way for the development of more efficient intervention options for the future.

Editors
February 2019

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The views and opinions expressed in this book are purely those of the authors and do not necessarily reflect the views of their employers.

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Abbreviations

AMMS	Association Marocaine des Multiplicateurs de Semences (Moroccan Seed Growers' Association)
AMSP	Association Marocaine des Semences et Plants (Moroccan Seed Trade Association)
CAP	Common Agricultural Policy
CCPOV	Commission Consultative de la Protection des Obtention Végétale
CIHEAM	Centre International de Hautes Etudes Agronomiques Méditerranéennes
CIMMYT	International Maize and Wheat Improvement Center
CNSSP	Comité National de la Sélection des Semences et des Plants
COMADER	Confédération Marocaine de l'Agriculture et du Développement Rural
CRP	CGIAR Research Program
DCSP	Division de Contrôle des Semences et Plants
DDFP	Direction de Développement des Filières de Production
DPA	Direction Provinciale d'Agriculture
DPVCTRF	Direction de la Protection des Végétaux, des Contrôles Techniques et de la Répression des Fraudes
DRA	Direction Régionale d'Agriculture
DSS	Directorate of Strategies and Statistics
DUS	Distinctness, uniformity and stability
EU	European Union
FDA	Fonds de Développement Agricole (Agricultural Development Fund)

FMCA	Fédération Marocaine des Chambres de Agriculture
FNIS	Fédération Nationale Interprofessionnelle des Semences et Plants
GDP	Gross domestic product
GIS	Geographic Information System
GMP (LMV)	Green Morocco Plan (Le Maroc Vert)
GPS	Global positioning system
GTAP	Global Trade Analysis Project
IARC	International Agricultural Research Center
ICARDA	International Center for Agricultural Research in the Dry Areas
IFAD	International Fund for Agricultural Development
INRA	Institut National de la Recherche Agronomique (National Agricultural Research Institute)
ISTA	International Seed Testing Association
MAAR	Ministry of Agriculture and Agrarian Reform
MAD	Moroccan Dirham (USD 1 = MAD 8.62 in 2012 and 8.5 in 2014)
MAPM	Ministère de l'Agriculture et de la Pêche Maritime (Ministry of Agriculture and Maritime Fisheries)
MENA	Middle East and North Africa
MHH	Men heads of households
MoA	Ministry of Agriculture
MoAF	Ministry of Agricuture and Fisheries
MoF	Ministry of Finance
NARS	National Agricultural Research System
OECD	Organisation for Economic Co-operation and Development
ONCA	Office National du Conseil Agricole
ONSSA	Office National de Sécurité Sanitaire des Produits Alimentaires (National Office for the Safety of Agricultural Products)

ORMVA	Office Régional de Mise en Valeur Agricole
PSM	Propensity score matching
PVP	Plant Varieties Protection
SODEA	Société de Développement Agricole (Farm Development Corporation)
SOGETA	Société de Gestion des Terres Agricoles (Agricultural Land Management Corporation)
SONACOS	Société Nationale de Commercialisation des Semences (National Seed Commercialization Company)
UNESCO	United Nations Educational, Scientific and Cultural Organization
UPOV	International Union for the Protection of New Varieties of Plants
USDA	United States Department of Agriculture
VCU	Value for cultivation and use
WHH	Women heads of households
WTO	World Trade Organization

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Chapter 1: The cereal seed sector in Morocco – policies and regulations

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1 The cereal seed sector in Morocco – policies and regulations

1.1 Executive summary

The Green Morocco Plan (GMP) is the official government strategy to achieve food security, sustainable management of natural resources, and agricultural competitiveness. It considers the cereal seed system as a fundamental component to enhancing the agricultural sector and to achieving broader economic development. As such, the Moroccan government has introduced legislation that regulates the seed sector and protects the rights of breeders in line with international norms and standards. The Fonds de Développement Agricole (FDA) is an operational arm in charge of implementing mechanisms to promote the expansion of investments in the agricultural sector. This mechanism consists of agricultural subsidies that are granted according to pre-established investment commitments between farmer organizations and government offices. These commitments are collective rather than individual, showing the government's intention to promote farmer cooperatives or associations.

The government provides direct price subsidies to farmers that represent about 35% of the cereal seed cost. Since the production cost for bread wheat is between Moroccan Dirhams (MAD) 4,000 (USD 470.6) and MAD 6,000 (USD 705.9) per ha, the subsidy represents 4–6% of the total production cost. This subsidy has directly contributed to improving the marketing of certified cereal seeds. The use of certified cereal seed has increased about 88% in five years (from 0.68 million quintals[1] before 2008 to 1.28 million quintals in 2013). The Government of Morocco subsidizes about 1.2 million quintals of certified seeds and about 220,000 quintals of carry-over certified seed (for all seed companies) per year.

[1] One quintal is equivalent to 100 kg.

1.2 Introduction

The GMP (Le Maroc Vert) is the official strategy of the Government of Morocco to meet challenges related to food security, competitiveness, and the sustainable management of natural resources. The GMP has two core functions:

- It accelerates the development of modern and competitive agriculture, by realizing thousands of new projects with high added value in both production and agricultural processing
- It supports smallholder agriculture by implementing aggregation projects for small farms in marginalized rural areas, which promote greater productivity and, hence, the production and sustainability of farm incomes.

The cereal seed sector plays an important economic role in producing and supplying certified seeds of advanced genetics that improve productivity and quality. It also produces seeds of improved varieties that are resistant to diseases. The cereal seed sector is an important component of the wider agricultural system that creates employment and economic growth in the cereal seed sector and other agricultural sectors. According to the Ministry of Agriculture (MoA), in 2009 the cereal seed sector produced an income of around MAD 600 million (USD 70 million) (Royaume du Maroc 2009). Currently it is estimated that the turnover is more than MAD 1.2 billion (around USD 140 million). Thus, the cereal seed sector is important to the GMP as it improves agricultural productivity and boosts the performance of other agricultural (such as legumes, vegetables, and fruits) and livestock sectors.

In the early 1970s, the Moroccan government managed to set up a few state institutions that built the structure of the cereal seed sector in Morocco. These institutions were INRA for research, and the Agricultural Land Management Corporation (SOGETA), and the Farm Development Corporation (SODEA) for seed production (they actually reclaimed lands from French occupation). The Société Nationale de Commercialisation des Semences (SONACOS) is responsible for seed multiplication and marketing and the Direction de la Protection des Végétaux, des Contrôles Techniques et de la Répression des Fraudes (DPVCTRF) (now named Office National de Sécurité Sanitaire des Produits Alimentaires [ONSSA]) for seed quality control and certification. This set-up was mainly oriented to cereal crops, or low-margin crops, such as wheat.

Later, plant breeders' rights were introduced into the country. The private sector started to become involved in developing improved varieties

and marketing of the seeds. Certified seeds have been produced by farmers who operate under contracts with the private seed companies, which are also involved in marketing certified seeds.

The government has established a regulatory framework for the seed sector with laws, regulations, and strategies designed to provide equal treatment to private and public seed companies. This chapter seeks to provide an overview of the legal framework governing this sector in the country. This overview is complemented with an analysis of policy and regulatory incentives (i.e. subsidies) that affect the cereal seed sector in the country, including aspects of seed policy and international trade.

1.3 Overview of the cereal seed sector

The cereal seed value chain in Morocco is a set of integrated activities ranging from developing improved varieties to the marketing of certified seeds. The chain consists of the following main components:

- *Variety development and release programs*: INRA is mainly responsible for breeding programs to develop improved varieties, while the introduction of foreign varieties included in the Official Catalogue is performed by both public and private seed companies. ONSSA is responsible for release of varieties
- *Production of cereal seeds*: This involves production of pre-basic, basic, and certified seeds. Pre-basic (G1 and G2) seed production is undertaken by INRA, while the production of basic seed (G3 and G4) and certified seed (R1 and R2) is undertaken by seed companies contracting the seed multipliers. Currently there are about 1,200 seed-growing farmers who are members of AMSP. Altogether, they use about 70,000 ha for seed multiplication
- *Processing, storage, and packaging of cereal seeds*: SONACOS and three private companies perform most of the processing, packaging, and storage of cereal seeds. They have the capacity to process nearly 1.5 million quintals per year. The private sector accounts for less than 10% of the total
- *Marketing and distribution of cereal seeds*: SONACOS is the main actor in the marketing of seeds (cereals, potatoes, sugar beet, vegetables, and others). Four other seed companies (Agrin Maroc, Deltasem, Maroc-Semences [Marosem], and Agriculture, Phytosanitaires, Semences d'Elite

du Maroc [Aphysem]) operate in the cereal seed sector. In addition, more than 140 private companies are licensed to market imported seeds. Private companies mainly specialize in the seeds of vegetables, oilseed, and maize

- *Monitoring, control, and certification*: Apart from variety releases (national catalogue), ONSSA oversees seed quality control through field inspection and laboratory seed testing. Seed quality control activities cover multiplication, processing, storage, and marketing. ONSSA is also responsible for controlling and monitoring imported seeds.

Some of these institutions are public and yet they have autonomy to establish their own strategies, internal guidelines, and procedures for better performance (quality products, social services, fair competition, and sustainability).

1.4 Policy and regulatory framework for the cereal seed sector

The Government of Morocco is conscious of the important role of the quality of agricultural inputs in the improvement of agricultural productivity and hence food security. It has tried to install instruments to encourage the use of improved inputs (such as seeds and fertilizers) through its new strategy, GMP. The GMP consists of two pillars:

- Pillar I: Accelerated development of a modern and competitive agricultural sector characterized by market responsive value addition
- Pillar II: Empowerment of vulnerable households and continuing the fight against rural poverty through improved farm incomes.

The GMP focuses on both the crop (cereals, sugar beet, sugar cane, olives, citrus fruits, apricots, argan trees, cactus, and carob) and livestock (milk and red meat) sectors. The overall objectives of the GMP are to:

- Increase levels of production
- Improve product quality for commercialization
- Improve the efficiency and equity of irrigation water
- Generate employment
- Improve the incomes of the rural population
- Enhance the sustainable use of natural resources.

Since its launch in 2008, the GMP has been guiding government strategy to revitalize the agricultural sector and spur economic development. The GMP

considers the cereal seed system as a fundamental component in enhancing the agricultural sector and achieving wider economic development. Under the GMP, improving the performance of the seed sector is one of the priorities in the agricultural transformation agenda of the country.

Morocco has introduced legislation that regulates the seed sector and protects the rights of breeders in line with international norms and standards as established by the Organisation for Economic Co-operation and Development (OECD), the European Union (EU), and the International Union for the Protection of New Varieties of Plants (UPOV). Morocco also adopted the rules, procedures, and methods developed by the International Seed Testing Association (ISTA) for seed quality testing. In particular:

- Law (Dahir) No. 1-69-169 of 25 July 1969, as amended and supplemented by Law (Dahir) No. 1-76-472 of 19 September 1977, is the main seed law. This law regulates the production and marketing of seeds and planting materials. It comprises a set of 15 technical regulations, decrees or orders defining the production, control, packaging, and certification of seeds and planting materials. These technical regulations apply to most plant species produced in Morocco and to imported seeds. The implementation of this law has been achieved through the following set of regulations or decrees (Tourkmani 1994; ONSSA, 2018):
    - Ministerial Decree No. 864-75 of 22 September 1977, as amended by Decree No. 3538-13 of 4 December 2013, decides the composition and responsibilities of the National Commission for the Improvement of Seeds and Propagating Materials
    - Ministerial Decree No. 863-75 of 22 September 1977 regulates the inscription of species and varieties in the Official Catalogue
    - An inter-ministerial decree levies fees for inscription in the Official Catalogue
    - A joint ministerial decree No. 865-75 of 22 September 1977 of the Ministry of Agriculture and Agrarian Reform (MAAR) and the Ministry of Finance (MoF) levies fees for seed quality control
    - A ministerial decree sanctions regulations related to processing, control, and certification
    - A ministerial decree licenses enterprises to market seed and planting materials

- Ministerial Decree No. 966-93 of 20 April 1993, as amended by Order No. 3828-94 of 9 November 1994, covers importing seed and planting materials.

- Law No. 9-94 on Plant Varieties Protection (PVP) is an intellectual property statute in Morocco. This law grants plant breeders legal rights over new plant varieties implemented through the establishment of legal instruments that:
  - Allow breeders to protect their property rights related to variety development. The instruments are meant to encourage breeders to develop new protected varieties
  - Allow Moroccan farmers to benefit from access to new plant varieties adapted to domestic conditions developed from breeding programs abroad.

Some of the decrees for implementing the PVP law include (http://www.onssa.gov.ma/fr/reglementation/reglementation-sectorielle/vegetaux-et-produits-dorigine-vegetale/semences-et-plants):

- Decree No. 2-01-2324 of 12 March 2002 adopted for the application of Law No. 9-94 on the Protection of New Varieties of Plants
- Decree No. 2-01-2325 of 12 March 2002 institutes remuneration for services rendered by the MoA for the protection of plant varieties.

- Harmonization of seed testing is conducted in line with the international procedures and methods defined by the International Rules for Seed Testing of ISTA. Also, harmonization of varietal certification procedures is in line with the international procedures and methods as defined by the OECD seed schemes for crops where the country is a member.

1.5 Policy and regulatory incentives for the cereal seed sector

The GMP provides the policy and strategy for sustainable agricultural development, while the FDA oversees the implementing mechanisms to promote the expansion of investment in all agricultural sectors of the economy. Since its inception in 1986, the FDA has been promoting private sector investment in agriculture. The investment is encouraged through targeted subsidies and technical assistance granted to activities that permit better

exploitation of agricultural potential. The FDA has been a key instrument in implementing government policy in the agricultural sector through investment, leveraging funding, and improvement of the overall growth of the economy.

These agricultural subsidies are granted according to pre-established investment commitments agreed between farmers' organizations and government offices (regional or national). These commitments are formalized through production contracts between both parties. The contracts are collective rather than individual, which clearly shows the intention of the government to promote farmer aggregation into cooperatives or farmers' associations. The FDA provides subsidies to promote investment in land improvement, irrigation, farm equipment, certified seed and planting material, export promotion, genetic improvement, agro-processing units, and farmer aggregation.

The government, through the MoA, has provided incentives for the development of the cereal seed sector by providing seed control and certification services, undertaken by ONSSA. At national level, extension services are coordinated by the MoA. At regional level, extension is delivered through the Direction Régionale d'Agriculture (DRA). This organization comprises two regional institutions, the Office Régional de Mise en Valeur Agricole (ORMVA) for large irrigated areas[2], and the Direction Provinciale d'Agriculture (DPA) for rainfed areas. The newly created Office National du Conseil Agricole (ONCA) is responsible for defining strategies for technology transfer and extension services, promoting plans, undertaking open field demonstrations, and media campaigns.

ORMVA and DPA have technical arms, called nodes of extension, which are used for seed and fertilizer distribution. Seed companies, in coordination with regional offices, estimate the amounts of seed required to meet demands at the regional level. This information is communicated to SONACOS. Agreements between seed companies and ONCA, and between seed companies and ORMVA help identify the areas and responsibilities for the marketing of seeds. ORMVA and DPA provide storage facilities (warehouses) to assist seed companies to market seed through distribution networks. There are almost 400 local distribution centers used by seed companies for the marketing of their seeds. In 2013 the price of one quintal of R2 certified bread wheat seed was MAD 325 (USD 38.2). The selling period typically starts in early September and extends to December each year.

[2] Large irrigation dams were built primarily to promote production of high market value crops like fruit trees (olives, citrus, and fruits), and vegetables, but few irrigation schemes benefit cereal grain and seed production.

1.6 Subsidies to farmers

The government, through the MoA, provides direct price subsidies to both seed and producer farmers. This seed subsidy is MAD 170/quintal (USD 20/quintal) for bread wheat, MAD 180/quintal (USD 21.2/quintal) for durum wheat, and MAD 160/quintal (USD 18.8/quintal) for barley and is based on the grain price. For example, a typical subsidy structure for bread wheat is a grain price of MAD 325/quintal (USD 38.2/quintal) and a subsidy of MAD 170/quintal (USD 20/quintal). This results in a total price of MAD 495/quintal (USD 58.2/quintal), where about 35% of the cereal seed cost is subsidized by the government. The production cost for bread wheat is between MAD 4,000 and 6,000 (USD 470.6–705.9) per ha depending on the production system. Thus, the subsidy represents 4–6% of the total production cost per ha[3].

This subsidy has directly contributed to improving the marketing of certified cereal seeds. Production has increased from 0.68 million quintals before 2008 to 1.28 million quintals in 2013 – an increase of almost 88% in just five years[4]. The use rate for certified bread wheat seed has increased from 18% before 2009 to almost to 35% in 2013. The Government of Morocco subsidizes about 1.2 million quintals of certified seed and about 220,000 quintals of carry-over certified seed per year. The distribution of these subsidized quantities among seed companies is proportional to the level of sales reached by each company in the previous year.

The government, through the MoA, provides subsidies to both seed-producer and grain-producer farmers:

- The cereal seed producers are supported through a government subsidy on basic seeds (G3 and G4) and certified seeds (R1 and R2) for wheat, which are domestically produced and marketed through national authorized seed companies. Yet, imported basic seeds are also subsidized so that they can be sold at the same price as domestically produced ones. The wheat seed subsidy per quintal was MAD 50 (USD 5.9) in 2010/11, MAD 45 (USD 5.3) in 2011/12, MAD 40 (USD 4.7) in 2012/13, MAD 35 (USD 4.1) in 2013/14, and MAD 30 (USD 3.5) in 2014/15 (MAPM 2014). Producers of pre-basic seeds (G1 and G2) do not benefit from subsidies

[3] Note that other subsidies available to farmers are for irrigation, mechanization, soil analysis, and storage facilities.

[4] In 2009, production of one million quintals of certified seed was reached, and since then, the average level is more or less 1.2 million quintals.

- Farmers producing wheat grain have been receiving a subsidy on certified seed. The MoA provides funding to seed companies and they, in turn, pass the subsidy on to farmers. This subsidy reaches farmers in the form of lower prices than they would pay for certified cereal seeds.

The documentation needed for the seed companies to handle the subsidies consists of:

- A summary of certified seeds harvested during the year and a summary of current seed stocks according to standards as set by ONSSA
- A summary of seed stocks at the end of the sales period according to safety norms as set by ONSSA
- A summary of cereal seed stocks at the end of the seed sales period, issued by ONSSA, based on the declarations of the seed stocks handled by the seed companies
- Reports on detailed seed sales by crop, variety, and class, signed by the directors of the respective seed companies
- Statements signed by the directors of the corresponding seed companies in the event of loss of or damage to seeds during the sales period.

According to Joint Law No. 1060.90 (29 August 1990), the government subsidizes part of the total cost of laboratory analysis, such as purity, germination, and health tests. This subsidy is directly paid to the certified laboratories which, in turn, allow farmers a deduction from the analysis costs at the time of payment. The operationalization of the subsidy involves the MoA, which collects information on the laboratories participating in the scheme, the rates being charged to farmers, and the invoices submitted by farmers. This information highlights the cost of analysis and the amounts deducted, generating annual and monthly summary reports. These reports include a complete list of farmers (with their addresses) who benefited from the subsidy, the types and numbers of analyses, and the total amount covered by the subsidy. In addition to these incentives, the government provides other incentives (i.e. subsidies) to the agricultural sector for equipment, farmer aggregation (associations), irrigation, mechanization, credit, etc[5].

[5] Information about these other incentives can be seen in the following report: http://www.agriculture.gov.ma/pages/regime-des-aides-aux-projets-d%E2%80%99agregation.

1.7 Cereal seed policy and international trade

Over time, the Government of Morocco has provided significant subsidies to the agricultural sector, and particularly to wheat production. Because of these subsidies, ordinary people in Morocco pay as little as USD 0.2 per loaf of bread (of about 500 g). This wheat subsidy has driven patterns of consumption to be based intensively on cereal consumption to the point that Morocco has become one of the highest wheat-consuming countries in the world (about 255 kg/year per capita[6]). Decades of subsidies and investment to improve wheat productivity, together with high import tariffs to protect domestic wheat production from more competitive imports, have not stemmed the decline in total domestic wheat production in comparison with wheat imports.

World Trade Organization (WTO) countries have been encouraged to eliminate import tariffs to experience economic benefits from international trade. Morocco did so by liberalizing the cereal seed sector, which brought diversification through the import and use of seed of foreign varieties. In fact, the Moroccan catalogue of varieties currently shows that there is an ever-increasing presence of foreign improved varieties (> 90%), which are imported through seed companies and protected under domestic plant protection laws. In terms of tariffs, pre-basic and basic seeds have always been tariff-free. This has been extended to certified seeds. Certified seeds (R1 and R2) used to pay a customs tariff of 49% of the "free on board" (FOB) price. Lately, these tariffs have been reduced for all generations (including certified seed) to as low as 2.5% of the FOB price.

The government subsidizes imported basic (G3 and G4) cereal seed costs. The subsidies per quintal are MAD 500 (USD 58.8) for G3 seed and MAD 400 (USD 47) for G4 seed. This subsidy considers the cost of seeds produced abroad.

The government has encouraged foreign private seed companies to establish partnerships with Moroccan counterparts (including producers) through special concessions. The concessions include providing government land to foreign seed companies on condition they partner with local entrepreneurs (so far 11 partnerships have been established).

[6] In Morocco, wheat is used to make a wide range of foods like bread, crumpets, muffins, noodles, pasta, cakes, pastries, cereal bars, sweet and savory snack foods, crisp-breads, sauces, and confectionery.

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Chapter 2: Varietal development, evaluation, and release

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2 Variety development, evaluation, and release

2.1 Executive summary

This chapter summarizes the findings on regulatory frameworks and technical procedures in variety development, registration, PVP, and licensing. Public agricultural research was established in the 1920s and reorganized, in its current structure, under INRA, in 1981. Since the 1990s, both public and private sectors have been engaged in plant breeding and variety development. The close collaboration with international organizations, like the International Maize and Wheat Improvement Center (CIMMYT) and ICARDA, and other bilateral collaborations with foreign seed companies, allowed INRA and the private sector to access improved foreign germplasm to broaden the genetic basis for crop improvement programs in the country. Moreover, a genebank was established in the early 2000s, to support the national breeding programs. It currently holds 44,000 accessions of 87 genera and 256 species, including wheat (7,651 accessions) and *Aegilops* (106 accessions). INRA's breeding strategy combines the national crossing programs with introductions from International Agricultural Research Centers (IARCs) or bilateral collaborations. It includes subsequent evaluations carried out in a network of its agricultural research stations located in irrigated, high rainfall, mountainous, semi-arid, and arid areas. These represent the different agro-ecological zones for wheat production. The private sector primarily introduces varieties from overseas through partnership agreements with foreign seed companies for direct registration or evaluation for adaptation prior to submitting them for registration.

The variety release and registration system started with the implementation of regulations related to creating a national variety catalogue in 1977. After 1980, the DPVCTF (Service de Contrôle des Semences et des Plants) was established as an independent and official organization within the MoA and became responsible for variety release. From 2010, variety release has been

a responsibility of ONSSA. Variety release includes conducting registration testing for distinctness, uniformity and stability (DUS) and performance testing for value for cultivation and use (VCU). It also includes preparing ministerial decrees for variety release, publishing the variety catalogue and granting rights to plant breeders. The official variety catalogue consists of two lists:

- List A for varieties (tested for both DUS and VCU) that can be produced and marketed in Morocco, imported to Morocco, or exported from Morocco
- List B for varieties (tested for DUS only) that can be produced and certified in Morocco for export purpose only.

The partnership of INRA with IARCs (e.g. CIMMYT and ICARDA) and, particularly, the private sector that deals with the foreign seed companies, provided opportunities to have access to a wide range of germplasm from international sources. It has helped with the release of a diverse set of wheat varieties in the country. Since 1982, about 88 bread wheat (69% foreign) and 83 durum wheat (58% foreign) varieties were registered in the national catalogue – about six varieties per year. A significant increase in the number of foreign varieties has been observed over the years, particularly during the last two decades. Among 60 bread and durum wheat varieties released from 2001 to 2012, only nine (15%) – seven bread wheat and two durum wheat varieties – are from INRA. The rest are foreign varieties introduced by the private sector. Two key trends were observed over the years. The number of varieties from public breeding programs is decreasing and there is a continuous trend of varietal releases from the private sector for both domestic and export markets. The registration of a variety in the national catalogue means that its seed or planting material is authorized to be imported or produced locally for commercial purposes in Morocco.

The PVP system was introduced in Morocco in 2002. It provides the public and private sectors equal opportunities for protecting and exploiting plant variety rights. ONSSA received PVP applications for 23 durum (14 from INRA) and 18 bread (6 from INRA) wheat varieties from 2006–2013. About 19 durum (14 from INRA) and 15 bread (6 from INRA) wheat varieties were granted protection by the Commission Consultative de la Protection des Obtention Végétale (CCPOV). Breeders have the full right to enforce protection of their varieties using a licensing mechanism and have sought an effective mechanism to oversee PVP enforcement and royalty collection.

Initially, SONACOS was established in 1975 as the sole national parastatal body to produce and market seeds of INRA varieties on a concessional basis with a 2.5% royalty on the sale of certified seed. In 1992, one significant innovation in the seed sector was the decision to offer all new INRA varieties through an open tender system for both the public and the private sectors. The license is granted based on the highest combined offer of royalty paid on certified seed sales to farmers and the concessional fees paid at the time of signing the contract. A flaw in the licensing contracts is that it provides absolute exclusivity to the recipient seed company for the exploitation of the licensed varieties but does not stipulate any obligation for commercialization of these varieties. This privilege allowed the seed companies not to multiply some of these varieties. This resulted in not only a monetary loss to INRA, but also the waste of several years of research and technological progress.

Current multi-locational trials favor varieties that have wide adaptation, even though they may not be the best varieties in specific locations. In countries like Morocco, which have a very diverse agro-ecology, it might be beneficial to exploit the potential of niche varieties with extraordinary performance in targeted agro-ecologies. Moreover, INRA's variety licensing contract with the public and private sectors appears dysfunctional and is undermining the investments made in agricultural research and the development of new varieties in Morocco. It is expected that the new licensing system will address these challenges.

2.2 Variety development

2.2.1 Introduction with historical context

In Morocco, the wheat breeding program was started in the early 1920s within the Agriculture Research and Development Services (Direction de la Recherche Agronomique) of the Ministry of Agriculture. The main objectives of the breeding program were to improve and stabilize grain yields and quality, primarily using local germplasm for durum wheat and introduced bread wheat varieties from other countries, including Algeria, Tunisia, France, Italy, Spain, India, Australia, and the USA (Jlibene 2005; Nsarellah et al. 2006). The breeding program gradually shifted to hybridization to improve grain yield and quality. Many varieties were released and cultivated widely in the country (Jlibene 2005; Nsarellah et al. 2006). Some of these early durum wheat varieties are still cultivated on a smaller scale in the mountain areas of Morocco. In the 1960s,

in addition to national releases, high-yielding, early, and semi-dwarf Mexican wheat varieties were directly introduced and grown in Morocco. Some of those varieties were developed using germplasm from the Mediterranean region, which was well adapted to conditions in Morocco.

In the 1950s and 1960s, the main objectives of the durum wheat program were to increase productivity and incorporate disease and pest resistance (rust and Hessian fly) using interspecific hybridization with bread wheat and other relatives. However, no tangible results were obtained (Nsarellah et al. 2006). The establishment of CIMMYT (1966) and ICARDA (1977) and their subsequent collaboration with INRA allowed the introduction of improved germplasm with earliness and semi-dwarf characteristics. These collaborations consolidated the breeding program and permitted the release of several high-yielding and disease- (rust and Septoria) and pest- (Hessian fly) resistant durum and bread wheat varieties (Jlibene 2005; Nsarellah et al. 2006). Since the 1980s the durum wheat program has been oriented to developing varieties with high yield, good grain quality, early maturity, drought and heat tolerance, and resistance to major diseases and pests in Morocco.

The close collaboration with CIMMYT, ICARDA, and other international organizations allowed INRA and other Moroccan institutions to access improved international germplasm to broaden the genetic basis of the crop improvement programs. The National Gene Bank was established in the early 2000s at the Settat Regional Agricultural Research Center to support the breeding programs. The gene bank has a capacity to handle 65,000 accessions. Currently, it holds 44,000 accessions distributed among 87 genera and 256 species. These include wheat (7,651 accessions), barley (3,743), *Lupinus* (3,675), *Avena* (2,133), *Helianthus* (1,223), *Zea* (1,105), *Vicia* (782), *Oryza* (750), *Cucumis* (609), *Trifolium* (513), *Lens* (365), *Cicer* (332), and *Gossypium* (259). The remaining 1,227 accessions include *Aegilops* (106 accessions), *Dactylis* (120), *Astragalus* (139), *Lathyrus* (140), *Sorghum* (161), *Carthamus* (186), and *Scorpiurus* (250).

Morocco became a member of CGIAR in 2005. According to INRA, better opportunities were then created for collaboration with and support to the national crop breeding program. To date, molecular tools and doubled haploid techniques are being used in breeding programs with the purpose of shortening the breeding cycles. Despite the departure of several breeders in the early 2000s, new young scientists were recruited recently to reinforce the cereals and food legumes breeding programs. Great efforts and investments

have been made to develop research capacities in new breeding technologies within the national program during the last decade, which will affect variety release in the coming years. The public sector dominated plant breeding and variety development before the 1990s. Since then, however, the private sector has started playing an important role in variety development.

2.2.2 Regulatory frameworks

INRA is mandated by law to conduct agricultural research and development in field crops, horticultural crops, and livestock. The mission and organization of INRA is regulated by Law 40-80 of 8 April 1981, Decree 2-81-348 of 22 March 1982, and Ministerial Decree 1/INRA/85 of 4 February 1985.

2.2.3 Institutional arrangements

In Morocco, both the public and private sectors are involved in plant breeding of wheat. INRA is a public organization in charge of the crop improvement of major field and horticultural crops. The Breeding and Genetic Resources Conservation Department of INRA is responsible for coordination of plant breeding and variety development. Breeding programs are conducted in three Regional Agriculture Research Centers (CRRAs). The CRRA at Settat is handling the breeding programs for durum wheat, bread wheat, chickpea, and lentil. The CRRA at Meknes is conducting breeding of bread wheat and the CRRA at Rabat oversees the breeding of barley. The genetic materials developed by national breeding programs or introduced from abroad are evaluated in several environments located in different agro-climatic zones of the country. A multidisciplinary team is involved in variety development. The team includes plant breeders, biotechnologists, pathologists, entomologists, physiologists, and technologists. The private sector depends on introducing foreign varieties through partnerships with foreign seed companies.

2.2.4 Technical arrangements

The variety development strategy at INRA has two approaches. First, is the national crossing program, where the selection of the parents and the crossing is done by the respective breeding programs. The subsequent selection of the segregation population and the evaluation of promising lines are conducted by the national breeding program at INRA. Different selection methods are used to develop new varieties, including pedigree, modified pedigree, and bulk

and back-cross methods. The segregating materials from the national crossing program are tested in different INRA experimental stations located in different regions of the country. The selections are made according to the set objectives for each crop, such as grain yield and grain quality, biotic and abiotic stress tolerance, etc.

Second, is the introduction of elite germplasm through international nurseries from IARCs (ICARDA, CIMMYT, etc.), or bilateral collaboration where the subsequent evaluation of the promising lines is conducted by INRA. The INRA breeding program aims to develop varieties adapted for use across the country at a national level. Therefore, the advanced promising lines are evaluated in a network of INRA stations and farmers' fields under different environments, such as irrigated, mountains, high rainfall, and semi-arid and arid regions.

These selected and advanced genetic materials pass through a series of evaluations. These include preliminary (adaptation) yield trials and intermediate (advanced) yield trials before the most promising lines are submitted for registration and release tests (Figure 2.1). At least three years of multi-location trials are conducted in research stations prior to submission. The superior lines are submitted by INRA or by private sector actors for registration in the national catalogue and/or PVP, managed by ONSSA. Once registered, INRA starts early generation seed multiplication (breeder and pre-basic seed) in different research stations and conducts demonstrations to popularize the varieties.

To date, molecular tools and doubled haploid techniques are used in breeding programs to shorten the breeding cycle. Kharouba was the first bread wheat variety released through this technique in 2010.

In Morocco, the private sector also introduces new varieties from abroad and directly submits them for registration or evaluates them for adaptation before submission for registration in the official catalogue. The private sector could also introduce advanced lines through partnership agreements with foreign seed companies and conduct variety evaluations. The introduced lines/varieties are tested in multi-location trials, including on the stations of the companies and/or on-farm with farmers. Field days are organized to get feedback from the farmers and these will provide an opportunity for the companies to make the final decision on the submission of the variety for registration. INRA used to provide the registered varieties to SONACOS for nominal royalty payments. Since 1989, however, private seed companies also use INRA varieties. In the 1990s, INRA introduced licensing of its varieties through open tenders. To date, new guidelines for licensing the rights of

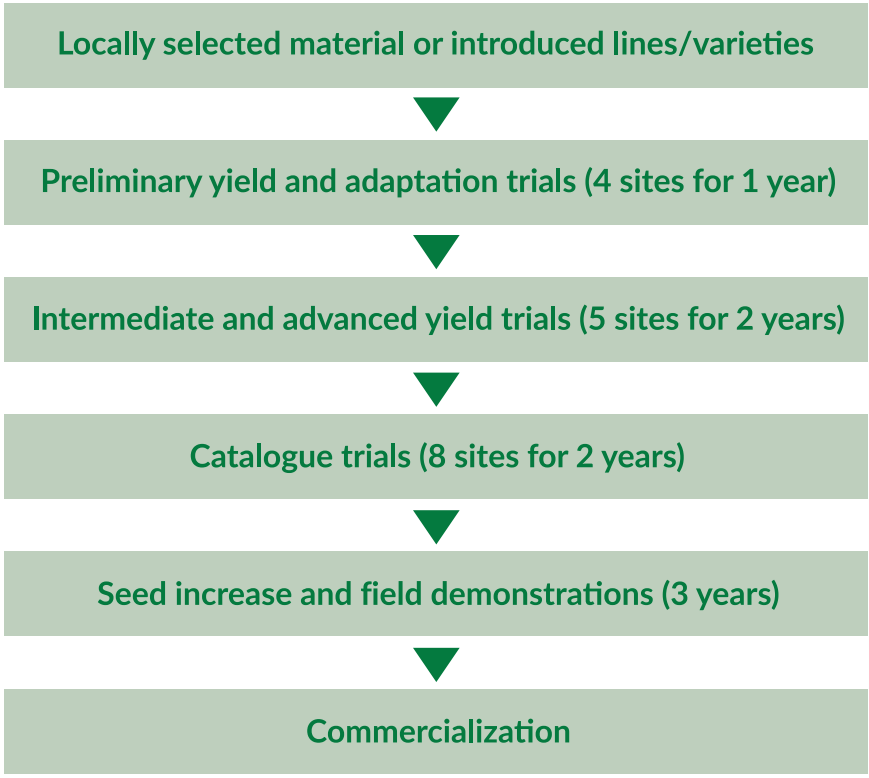

Figure 2.1: Scheme for variety evaluation of cereals and food legumes

commercialization of recently released varieties of INRA are being finalized. These guidelines are expected to allow better commercialization of new INRA varieties.

2.2.5 Major achievements

INRA has a long tradition in varietal development of strategic and important crops for the country, such as cereals and legumes. INRA's breeding programs mainly target high yield potential and grain quality as well as tolerance to biotic and abiotic stresses. The main traits for bread and durum wheat include high yield potential and tolerance to drought, rusts, and pests, as well as grain color for durum wheat. The national breeding program has released many varieties of bread and durum wheat since the beginning of agricultural research in the

country. In the 1960s, five bread wheat improved varieties were cultivated in Morocco (Grillot 1960; cited by Jlibene 2005). In the 1970s, the semi-dwarf bread wheat variety Nessma was released and largely adopted because of its high yield potential, grain quality, earliness, and resistance to lodging and leaf rust (Jlibene 2005).

Since 1982, several INRA varieties of bread wheat (25) and durum wheat (34) have been registered in the national catalogue along with other crops (Figure 2.2). Prior to 1990, INRA was the only source of new varieties for cereals and legumes although its contribution was very low or absent for crops such as oil and industrial crops, potato, and vegetables (Tourkmani 1994). The Moroccan national catalogue of varieties currently has about 2,000 registered varieties. More than 90% of them are foreign varieties, including the most important crops, such as cereals, legumes, fodders, vegetables, and sugar beet.

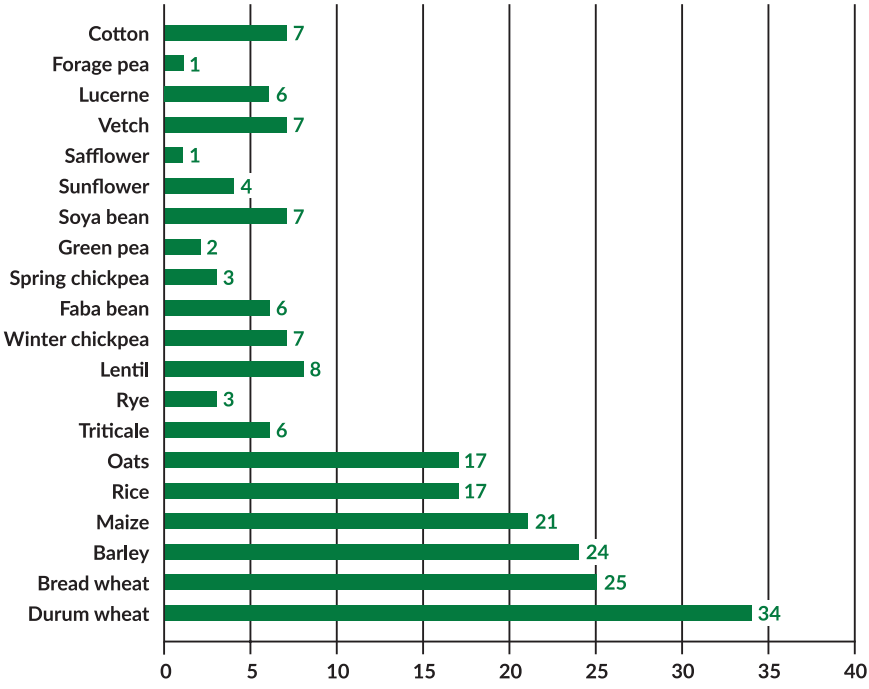

Figure 2.2: Number of INRA varieties registered, 1982–2012

Source: Badraoui and Dahan 2010; ONSSA.

Historically, INRA has been responsible for variety maintenance and the production of pre-basic and basic seed. Also, it provided seed to SONACOS until the private sector entered commercial seed production in the early 1990s. INRA had a seed unit in charge of variety maintenance, early generation seed production (G0-G4), and provision of basic seed (G4) to seed companies until 2005. Thereafter, INRA limited its role to production of G1 and G2 and anticipated that the public and private seed companies would take over responsibility for basic seed production.

2.2.6 Key challenges

- In recent years, climate change (frequent drought, extreme temperatures, etc.) has affected Morocco, as it has other countries. It has influenced crop production as well as pathogen patterns and epidemiology. Consequently, breeding objectives should be revised accordingly to meet the challenges presented by climate change
- INRA faces the challenge of adequate human resources, particularly following the departure of its experienced scientists and technicians, which seriously affected its breeding programs. Currently, although young scientific staff are being recruited, there is still a shortage of trained technical staff
- The dissolution of the seed unit at INRA in 2005 consequently led to the disruption of variety maintenance and early generation seed multiplication programs
- Lacking a marketing strategy for INRA varieties to promote their wider-scale use, several varieties have not been licensed for more than 10 years.

2.2.7 Lessons learned

INRA has a long tradition in varietal development of strategic and important crops, such as cereals and legumes, for the country. Since the 1920s, several wheat varieties have been released and cultivated on a large scale and have contributed to the development of the agricultural sector in Morocco. However, during the last decade, new bread and durum wheat varieties have faced marketing problems that have given better opportunities to foreign wheat varieties. Therefore, concrete measures should be taken to develop and release new varieties coupled with an effective marketing strategy by INRA.

2.2.8 Recommendations

- Strengthen the breeding programs to respond to climate change and market demands
- Reinforce the breeding programs by recruiting human resources (breeders and support staff)
- Upgrade research facilities and equipment (greenhouses, laboratories, and experimental domains)
- Encourage and provide funding to multidisciplinary networks seeking to develop new varieties
- Strengthen collaboration between INRA and the IARCs for variety development
- Develop partnerships with seed companies (domestic and foreign) for joint variety development
- Re-establish the INRA seed unit to implement the following tasks
    - Variety maintenance and early generation seed multiplication (breeder, pre-basic, and basic seed) of INRA varieties considering the demands of the seed companies
    - Provide support to the breeders in the registration and protection of new wheat varieties
        - Develop capacity building programs for variety maintenance, seed production, seed processing, and legal protection
        - Develop marketing strategies to ensure promotion and diffusion of INRA varieties and follow-up and recover royalties
        - Develop appropriate agreements with seed companies for licensing new varieties to ensure their rapid diffusion
        - Explore opportunities to register and protect INRA varieties in other countries
        - Have INRA represented in all consultations related to seed activities.

2.3 Variety evaluation and release

2.3.1 Introduction with historical context

The objective of the variety release and registration system is to protect the farmers (users) by making available new varieties with high yield potentials,

which are adapted to Moroccan conditions. This will ensure the new varieties meet the minimum requirements for technological quality, and pest and disease resistance. Registration is the final stage of a series of variety testing mechanisms undertaken in the field and in laboratories under controlled conditions. The variety release system started with implementation of regulations related to the creation of the national variety catalogue in 1977. Prior to 1980, the variety evaluation and release activities were conducted by the agricultural research and development services (Direction de la Recherche Agronomique). After 1980, the Service de Contrôle des Semences et des Plants (DPVCTF) was established as an independent and official organization within the MoA and became responsible for variety release. From 2010, the variety release activity has been under the responsibility of ONSSA.

2.3.2 Regulatory frameworks

The production and marketing of seed and planting materials is governed by Seed Law No. 1.69.169 of 25 July 1969, as amended by Seed Law No. 1.76.472 of 19 September 1977. To implement the law, several regulations related to the official catalogue, production, control and certification, and import and trade of seeds and planting materials were promulgated. These included several ministerial decrees (Tourkmani 1994; http://www.onssa.gov.ma/fr/controle-des-semences-et-plants/homologation-des-varietes):

- Ministerial Decree No. 864-75 of 22 September 1977, as amended by Decree No 3538-13 of 4 December 2013, fixes the composition and responsibilities of the National Commission for the Improvement of Seeds and Propagating Materials
- Ministerial Decree No. 863-75 of 22 September 1977 regulates the inscription of species and varieties in the Official Catalogue
- An inter-ministerial decree levies the fees for inscription in the Official Catalogue
- A joint ministerial decree No. 865-75 of 22 September 1977 of the Ministry of Agriculture and Agrarian Reform (MAAR) and the Ministry of Finance (MoF) levies the fees for seed quality control
- A ministerial decree sanctions the regulations related to processing, control, and certification
- A ministerial decree allows enterprises to market seed and planting materials

- Ministerial Decree No. 966-93 of 20 April 1993, as amended by Order No. 3828-94 of 9 November 1994, regulates the import of seed and planting materials.

2.3.3 Institutional arrangements

ONSSA is a public organization, created in 2010, that brings together all the sanitary and phytosanitary services of the MoA, which were formerly under DPVCTRF and the Direction de Livestock. Within ONSSA, the former Seed and Plant Control Service was upgraded to the Division de Contrôle des Semences et Plants (DCSP), with three main services: (i) the variety registration service, (ii) the seed certification service, and (iii) the plant certification service (http://www.onssa.gov.ma/fr/images/onssa/organigramme/Arrt_Organigramme_ONSSA_2017.PDF).

The variety registration service consists of 13 services, among which the autumn cereals service is responsible for wheat. Each section is responsible for all the processes of the variety registration (DUS) and performance (VCU) trials. These processes start with receiving the applications to preparing seed samples, designing the experiments and planting the trials, to data recording, harvesting, preparing samples for technological analysis, and statistical analysis. It also includes preparing and presenting the final report to the technical and the national committees. This section is also responsible for post-control experiments and for updating and distributing the lists of registered varieties as well as plant breeders' rights. Each section is fully responsible for all aspects of the respective crop species, including representing the DCSP in the technical meetings of ONSSA, MoA, etc. This organizational structure has enabled the building of crop-based expertise and given each section an autonomy and responsibility in decision making, organizing, and conducting different tasks.

ONSSA is responsible for implementing the variety release system, in conducting DUS and VCU trials, preparing ministerial decrees for variety release, publishing the variety catalogues, and issuing plant breeders' rights. The DUS and VCU trials are conducted based on the experimental protocols adopted by the Comité National de la Sélection des Semences et des Plants (CNSSP). The trials are conducted in locations defined by the CNSSP's various technical committees. The technical section is composed of experts covering different disciplines, such as breeding, plant pathology, seed production, seed certification, extension, and grain marketing. To date, CNSSP has been

chaired by the Director General of INRA and comprises representatives from Fédération Nationale Interprofessionnelle des Semences et Plants (FNIS), Fédération Marocaine des Chambres de Agriculture (FMCA), ONSSA, ONCA, Direction de Développement des Filières de Production (DDFP), Office National Interprofessionnel des Céréales et des Légumineuses, and Etablissement Autonome de Contrôle et de Coordination des Exportations. ONSSA serves as a secretariat of the committee. FNIS was created in 2009, in the framework of the Green Morocco Plan (GMP) representing the seed growers, nurseries, and seed and planting material traders. FMCA represents the farmers. CNSSP has several technical committees including the technical committee for cereals, which deals with cereal crops including wheat.

Prior to 2002 most of the VCU trials were conducted at INRA experimental stations. After 2002, a new arrangement was made to conduct VCU trials in partnership with the Association Marocaine des Semences et Plants (AMSP), Offices Régionaux de Mise en Valeur Agricole (ORMVA) (MoA's regional organizations in charge of extension), private seed companies, and private farmers. In this arrangement, the AMSP mainly funds the labor and ORMVA funds the private seed companies. The farmers contribute the land, irrigation, and labor costs. The remaining costs and inputs are funded by the annual operational budget of ONSSA obtained from the state. To assist AMSP in supporting labor charges, the applicants are contributing MAD 500 for field crops and MAD 1,000 for other crops. This contribution was decided by the Association in 2002 given INRA's decision to withdraw from conducting VCU trials on its experimental stations. It should be noted, however, that since 2012, INRA has allowed use of its two locations at Jemaat Shaim (rainfed areas) and Annoaceur (mountain areas) for VCU trials of cereals.

2.3.4 Technical procedures

The official variety catalogue (Catalogue Officiel) of cereals and food legumes consists of two lists. List A includes cereal and food legume varieties that can be produced, certified, and marketed in Morocco, imported into Morocco or exported from Morocco. List B includes cereal and food legume varieties that can be produced and certified in Morocco for export only. For List A, all varieties from national breeding programs or imported (introduced) must go through official DUS and VCU trials, conducted by ONSSA, before being included in the catalogue. For registration in List B, varieties are only tested by ONSSA for DUS. None of the varieties in List B are eligible to be marketed in

Morocco. However, these varieties are eligible for seed production in Morocco and marketing outside the country.

Application procedures

All varieties from the national breeding programs or introduced from abroad can be submitted for registration in a national catalogue for release in Morocco. The foreign varieties are treated and tested under similar conditions as varieties from the national breeding programs. The application is made by the breeder directly or through his/her representative in Morocco. The application requires declarations about the breeder and variety (Forms 1 and 2), the amount of seed, spikes, or plants submitted, a non-genetically modified (transgenic) certificate, and information about the variety (publications, prospectus, descriptors, commercial announcements, pictures, statistics, etc.) by specified dates.

The application is completed with the payment of fees specific for each crop. For cereals, food legumes or forage crops the fee is MAD 500 for the first variety, MAD 1,000 for the second, and MAD 2,000 for the third. These fees have been applied since the establishment of the variety release system in 1977. The low fees were part of the government's strategy to encourage more foreign breeders to submit their varieties for the benefit of Moroccan farmers. However, the number of varieties submitted per year, per species, and per breeder is restricted to just three. It is anticipated that this will encourage the breeder to submit their best varieties, already tested in Morocco, and to avoid the variety release system being used as a screening mechanism for foreign varieties. However, all the fees related to the variety release system (application, DUS and VCU testing, and registration on the list) were revised and new rates became applicable starting from April 2014. The new flat rate is MAD 4,000 per variety with no restriction on the number of varieties that can be submitted for testing.

Testing for registration and performance

Two comprehensive variety tests are required for official release in Morocco: DUS testing for registration and VCU testing for performance.

Performance testing

VCU trials are conducted according to an experimental protocol specified for each species. The protocol defines the design (generally block design), the number of replicates (generally 4), and the plot size (between 12 and 18 m^2). The protocol also defines the period of planting; quantity of fertilizers; herbicide and pesticide treatments; diseases and pests to be recorded; plot

size to be harvested; quantity of seeds or plant parts sampled for technological and quality analysis; and, plot yield, dates of emergence, heading, flowering, maturity, and harvesting.

VCU trials are conducted for two consecutive cycles in the areas of the country where the crop is cultivated. Eight VCU trials are conducted for cereals in different agro-ecological zones. For bread and durum wheat, VCU trials are mostly conducted in different zones, such as irrigated areas (Tedla and Doukala), rainfed areas (Jimmat Shaim and Doukala), mountainous areas (Annoaceur), and favorable rainfed areas (Merchouch, Meknes, Lukous, and Bouznika).

All varieties submitted for VCU trials are compared to checks – generally two – chosen by the technical committee from among registered varieties in the national catalogue. One check is selected from the best performing varieties recently registered and the other from the most cultivated varieties. After field testing and quality analysis, the results are statistically analyzed per location for each testing cycle for all locations for each cycle and finally for both cycles. The new varieties are compared to the checks, using the Dunnett test. Experiments with a coefficient of variation of higher than 25% are considered not valid and are discarded from the data used for the final decision. To ensure maximum transparency and neutrality of the registration system, all new varieties coming from the national breeding program (INRA), from the private sector (foreign varieties), and the check varieties are coded during the VCU testing. The trial results are also reported under coded varieties. The decoding of the varieties is done after the final decision is made by the National Committee for Variety Release.

Registration testing

For most crops (cereals and food legumes) DUS tests are conducted at the Station de Contrôle Variétal et de Quarantaine, located in Bouznika, which belongs to ONSSA. The DUS tests are performed according to an experimental protocol specific for each species, based on UPOV technical guidelines. DUS tests are conducted mainly for variety registration in the official catalogue, but also to grant the plant breeder rights. The DUS tests are compulsory both for registration and protection of a variety. DUS tests, particularly variety descriptors, are fundamental for seed certification (field inspection, seed analysis, and post-control tests). The results of the DUS tests are very important to protect breeders' rights in cases of infringement and to the extension services for promotion to a variety to users.

According to the DUS results, a variety could be rejected during the first year if there is a lack of clear evidence of it not being distinct, uniform, or stable. A variety could be re-tested for a second crop cycle to complete and confirm the results of the first cycle. It could also be re-tested for a third crop cycle when there is doubt and no clear decision can be made. The decision for conducting the test for a third cycle is based on agreement with the breeder and the approval of the national variety release committee. If the variety is rejected in the DUS tests for uniformity and/or stability problems, the breeder can re-submit the variety after removing the impurities. The re-submission is considered as a new application and new material must be provided by the breeder both for DUS and VCU trials following the payment of fees. However, if the variety is rejected in the VCU trials, the decision is final, and the breeder cannot re-submit it for testing.

Requirements for registration and release

The DUS tests are conducted for two consecutive cycles in parallel with the VCU tests. This allows for the results of both the DUS and VCU tests to become available at the same time. For VCU, grain yield is the main criteria for release. However, other criteria can also be taken into consideration, such as grain quality, maturity, and tolerance to diseases and pests. In general, the new variety is proposed for registration only when it is significantly higher in yield than the mean of the checks. When the new variety is statistically at par with the mean of the checks, it could be proposed for release if it has certain key traits (tolerance, quality, etc.), or at least it has no disadvantage.

ONSSA will prepare the technical reports for both the DUS and VCU trials and present them to the technical committee for examination. The technical committee will review the reports based on the criteria adopted by CNSSP and then submit them for a decision by CNSSP to reject, suggest a re-examination or make a recommendation to the MoA for registration and release. Based on the decision of the CNSSP, ONSSA will prepare a ministerial decree for approval and publication in the Bulletin Officiel. The lists of registered varieties are distributed to professional associations, to seed inspectors, and to the services in charge of the control of seed imports. Those lists are also published on the ONSSA website (www.onssa.gov.ma). The variety registration is valid for 10 years. This can be extended, at the request of the breeder, for another five years and no new trials are conducted. The committee can withdraw registered varieties from the catalogue if any variety exhibits varietal purity problems (mainly genetic deterioration).

Authorization for production, certification, or import

Moroccan regulations stipulate that the registration of a new variety is compulsory prior to seed certification and the import of seed or planting material into the country. The regulations also stipulate that imported seed or planting material should be certified according to OECD seed schemes. Thus, all imported seeds belong to varieties registered in Morocco, their country of origin, or on the OECD lists. The registration of a variety in the national catalogue means that its seed or planting material is authorized to be imported or produced and certified for commercial use in Morocco, provided that other technical and phytosanitary requirements are fulfilled (http://www.onssa.gov.ma/fr/controle-des-semences-et-plants/controle-des-semences). The registration, however, gives no guarantee of the commercial success of the variety. Hence, from a long list of registered varieties, only a limited number of varieties are produced and commercialized in Morocco.

The variety registration system is well established and has permitted the registration of many varieties from the national breeding program and from around the globe. This provides an opportunity for Moroccan farmers to benefit from new technologies obtained elsewhere. The system is also permitted to discard many varieties, protecting Moroccan agriculture. The variety registration system allows official public institutions (research centers, extension, control, production, and commercialization units), the private sector, through its professional organizations, and farmers' unions to participate in making the decisions. Indeed, both the public sector and the private sector are participating in the monitoring and evaluation of the trials and have representatives on the technical committees and the release committee that makes the final decision.

2.3.5 Major achievements

Since the establishment of the variety catalogue, several crop varieties have been registered and released in Morocco. The number of crop varieties released in the national catalogue is presented in Table 2.1. Of the 4,112 registered varieties, vegetables are the most numerous with 2,774 varieties (55%). Cereals and food legumes together constitute 831 varieties (almost 20%). Maize, with 430 varieties, accounts for over half of these crop varieties (52% of field crops and 11% of the total). Wheat (bread and durum) with 171 varieties accounts for 4.2% of the total number of released varieties. Among the cereals, wheat varieties constitute almost 21%.

Table 2.1: Number of crop varieties released in Morocco, 1982–2012

Crops	Number of varietal releases			Share of public sector releases (%)	Share of crop type in total releases (%)
	Public sector	Private sector	Total		
Winter cereals	**94**	**153**	**247**	**38**	**6.0**
Durum wheat	35	48	83	42	**2.0**
Bread wheat	27	61	88	31	**2.1**
Barley	24	36	60	40	**1.5**
Triticale	8	8	16	50	**0.4**
Spring cereals	**31**	**504**	**535**	**6**	**13.0**
Maize	14	416	430	3	**10.5**
Sorghum	0	60	60	0	**1.5**
Rice	17	28	45	38	**1.1**
Food legumes	**26**	**23**	**49**	**53**	**1.2**
Faba bean (*V. faba* Major)	3	14	17	18	**0.4**
Faba bean (*V. faba* Minor)	3	4	7	43	**0.2**
Chickpea	11	5	16	69	**0.4**
Lentil	9	0	9	100	**0.2**
Forage crops	**50**	**241**	**291**	**17**	**7.1**
Oilseed crops	**28**	**162**	**190**	**15**	**4.6**
Sugar beet	**0**	**284**	**284**	**0**	**6.9**
Fruit trees	**0**	**242**	**242**	**0**	**5.9**
Vegetables	**0**	**2,274**	**2,274**	**0**	**55.3**
Total	**229**	**3,883**	**4,112**	**6**	**100**

Source: ONSSA.

From data presented on varietal release, the private sector released 3,883 varieties (about 94%) because of its strong involvement in the vegetable seed sector. Among cereals and legumes, the private sector released 680 varieties (nearly 82%) because it accounts for the lion's share of maize varieties. In the case of wheat, the private sector released 109 (13% of the total) varieties – 61 (69%) bread wheat and 48 (58%) durum wheat varieties. The data illustrates the important role played by the private sector across all crops, even in field crops, where the public sector used to be dominant from the 1960s to the 1990s.

2.3.6 Key challenges

ONSSA is implementing variety evaluation and release in coordination with representatives of FNIS, ORMVAs, etc. Technically there are no challenges in implementing the variety release system. The major challenge remains the procedure of the release system when new varieties need to perform across locations and have wider adaptations to be considered for release over varieties with specific adaptations. Moreover, it is necessary to strengthen the capacity of ONSSA in terms of human resources and physical facilities to cope with the increasing demand for variety release of many crops.

2.3.7 Lessons learned

The distribution of varieties released by the public and private sectors for bread and durum wheat during the last three decades is presented in Table 2.2. The data show a significant change in the origin (INRA versus private) of the released varieties of cereals between the 1980s and the 2000s. In total, 181 bread and durum wheat varieties were released during the three decades 1982 to 2012, which is equivalent to about 6 varieties per year. However, public varietal releases decreased from 37 to 9 varieties over the three decades while those from the private sector increased from 5 to 58. Two emerging trends can be observed in variety registration and release in Morocco:

- A continuous decrease in the registrations and releases of INRA varieties in the catalogue. Most of the INRA varieties (70% of bread wheat and 53% of durum wheat) were registered in the 1980s. For bread wheat there were no registrations between 1997 and 2010
- A net increase in the numbers of variety registrations and releases in the catalogue from the private sector. For bread wheat, 48% of the registrations were made in the 1990s and 44% in the 2000s. For durum wheat, almost 50% of the registrations and releases were made in the 1990s and the same proportion was achieved in the following decade.

There is a clear decline in the number of new INRA varieties of wheat. Several varieties submitted for release were discarded in the official trials for registration, either because of DUS problems or because the new varieties performed significantly worse than the checks in the VCU trials (Table 2.3). For the period 2009–2012, of the eight INRA durum wheat varieties submitted for registration, three were discarded in the DUS trials and four were discarded in the VCU trials; only one variety was registered in 2011.

Table 2.2: Wheat varieties registered and released, 1982–2012

Species		Period			Total
		1982–90	1991–2000	2001–12	
Bread wheat	INRA	19	6	2	**27**
	Private	5	30	27	**62**
Sub-total		**24**	**36**	**29**	**89**
Durum wheat	INRA	18	9	7	**34**
	Private	0	25	24	**49**
Sub-total		**18**	**34**	**31**	**83**
Total	**INRA**	**37**	**15**	**9**	**61**
	Private	**5**	**57**	**58**	**120**
Grand total		**42**	**72**	**67**	**181**
Private sector share (%)		**12**	**79**	**87**	**66**

Source: ONSSA.

Table 2.3: Number of varieties submitted and approved for release, 2007–2013

Crop	Number of varieties tested		Number of varieties approved		Number of varieties rejected		Reasons for rejection			
							Public		Private	
	Public	Private	Public	Private	Public	Private	DUS	VCU	DUS	VCU
Durum wheat	15	29	3	18	12	11	4, stability 2, distinctness 2, uniformity	4	2, stability 2, uniformity	7
Bread wheat	15	34	2	22	13	12	3, stability 2, distinctness 1, uniformity	7	1, stability 2, distinctness 1, uniformity	8
Total	**30**	**63**	**5**	**40**	**25**	**23**				

Source: ONSSA.

For bread wheat, of the six varieties submitted, two were discarded in the DUS trials, two were discarded in the VCU trials, and two were registered (one in 2010 and the other in 2012).

The variety release system has made considerable progress over the last 35 years. More recently, the system has entered a new phase to ensure its sustainability by revising, with effect from January 2014, the fee schedule for

application and VCU and DUS testing. It also envisages the progressive transfer of VCU trials to the private sector through FNIS, under the supervision of ONSSA. The contributions and responsibilities of each party will be specified in the contractual agreement to be signed.

2.3.8 Recommendations

During the last decade, varieties from foreign and private sources have accounted for a greater share of the varieties that have become available on the seed market. To keep domestic breeding competitive, the recommendations for variety development are equally relevant where public investments are needed. These recommendations are to:

- Strengthen the breeding programs to respond to climate change and market demands
- Reinforce the breeding programs by enhanced human resources and facilities
- Strengthen collaboration between INRA and IARCs for variety development.

Moreover, in Morocco, the structure of the current multi-locational variety trials naturally favors varieties with wide adaptation, where the best performing varieties across the environments are eventually released for commercial use, even though they may not be the best varieties in specific locations. Cognizant of the agro-ecological diversity of the country, it might be beneficial to exploit the potential of niche varieties with extraordinary performance in targeted agro-ecologies. Considering these circumstances, there needs to be a debate about whether the current variety release system should be reviewed to accommodate regional releases (with specific adaptation).

2.4 Plant variety protection

2.4.1 Introduction with historical context

The plant variety protection (PVP) system was introduced in Morocco in 2002 with the objectives of:

- Encouraging foreign breeders to introduce their new varieties into Morocco
- Giving plant breeders the legal rights to protect their varieties

- Promoting the development of the seed industry in the country with all its components (research and breeding, multiplication, certification, trade, etc.)
- Fulfilling the requirements for Morocco to join international organizations (WTO, UPOV, etc.).

2.4.2 Regulatory frameworks

The PVP system was established following publication in the official bulletin of the implementing regulations (Decree No. 1-196-255 of 21 January 1997) and of the Law 9-94 on plant breeders' rights in Morocco. The law is based on the 1991 UPOV Convention; Morocco became a member of UPOV in October 2006. The law entered into force on 28 October 2002 when the implementing regulations of the law were published in the official gazette. To implement Law 9-94, two decrees and seven ministerial orders were promulgated. These were:

- A decree on the procedures for submitting applications, examining the applications, and granting of the PVP certificate
- A decree for all the fees related to the issuance of PVP
    - A ministerial order specifying the list of genera and species to be protected, duration of protection, and the scope of breeders' rights
    - A ministerial order regarding the deadline for depositing propagating material, and the required quantities for the examination of varieties, to be granted plant breeders' rights
    - A ministerial order on the composition, tasks, and functions of the consultative committee for the protection of new varieties of plants
    - A ministerial order about information contained in the bulletin for the protection of new varieties of plants
    - A ministerial order about information contained in the national register of applications for the protection of new varieties of plants
    - A ministerial order fixing the information contained in the national register of certificates for the protection of new varieties of plants
    - A joint ministerial order of the Minister of Agriculture and the Minister of Finance detailing the fees for the services concerning the protection of new varieties of plants.

2.4.3 Institutional arrangements

ONSSA is responsible for implementing the examinations for PVP based on the application from the breeder or his/her representative. The same staff and organization responsible for variety registration are also in charge of PVP. ONSSA prepares the DUS and novelty report and presents it to the CCPOV. The Commission holds meetings twice each year, in April and September. The Commission comprises representatives of INRA, Hassan II Institute of Agronomy and Veterinary Medicine, DDFP, Directorate of Strategies and Statistics (DSS), ONCA, FNIS and FMCA. It is chaired by the Director General of ONSSA. According to UPOV guidelines, DUS test results could also be purchased from UPOV member countries where the variety has already been examined or tested.

2.4.4 Technical procedures

Application for PVP

Applications for granting PVP can be made by breeders from UPOV member countries for species determined or considered eligible by the MoA based on the 1991 UPOV Convention. The applicant should include general information related to the breeder and the variety (Form A), an exhaustive description of the variety (Form B), and a statement related to the novelty of the variety (Form C). The applicant should also include information about seed and vegetative material for each variety, payment of the fee, the non-genetically modified organism certificate, and proof of authorization of the breeder. When the application is completed, it is registered in the "Plant Variety Protection Bulletin", which is published by ONSSA twice a year (in April and September). The bulletin is widely distributed among different administrations at national and regional levels and to different professional organizations. It is also published on the ONSSA website. The objective of this publication is to permit any person to lodge an objection to an application or to a PVP grant.

Testing of a new variety

After publication of the application, the variety is examined for DUS, novelty, and denomination. There are two possibilities for DUS examination for granting PVP for new varieties. ONSSA conducts DUS tests for species for which it has the expertise, such as cereals and food legumes. For other species, the DUS examination from another UPOV member country can be considered for granting the PVP. The breeder directly purchases the result from the other

member country and submits the report for examination by ONSSA. The novelty examination is based on the breeder's statement (Form C) and by conducting a search in existing variety databases (UPOV, OECD, EU, national lists, etc.). The report of the examination for DUS, novelty, and denomination are presented to CCPOV. After reviewing the reports, if the Commission proposes protection for the new varieties of plants, the decisions are published in the PVP bulletin to inform the public and to permit possible objections. After three months, if there are no objections, ONSSA will prepare the ministerial order for approval and publication in the official bulletin. After the publication, the PVP certificates are issued by the Director General of ONSSA.

2.4.5 Major achievements

Since implementation of the PVP law started in Morocco, 501 applications have been submitted; 242 protection certificates were granted; and 206 applications are under examination. In addition, the PVP expired for 11 varieties and applications were rejected or withdrawn for 42 others (Table 2.4).

The number of PVPs granted by sector is shown in Table 2.5. Among field crops, INRA appeared to have been granted more PVP than the private sector, while the private sector is more dominant in other crops.

In addition to requests from Morocco, PVP grants were made for varieties from such countries as England, France, Holland, Italy, Ireland, South Africa, Spain, and the USA.

2.4.6 Key challenges

In Morocco, the process for granting PVP for new varieties does not meet any major legal, institutional, or technical constraints. Breeders must enforce their legal rights on the varieties for which a PVP certificate is granted. For royalty collection, breeders may use a licensing mechanism and/or other effective royalty collection arrangements, including the creation of an entity to oversee enforcement.

2.4.7 Lessons learned

There was a net increase in varieties introduced and protected from foreign companies, mainly for cereals. There were no specific plans for national breeding programs by the domestic or foreign private sectors in Morocco. However,

Table 2.4: PVP applications and grants in Morocco to April 2014

	Number of applications	Number of protected varieties	Number of varieties under examination	Applications withdrawn, or protection expired/ abandoned
Fruit trees	179 (37 INRA)	76 (26 INRA)	92 (9 INRA)	11
Field crops	87 (52 INRA)	75 (49 INRA)	7	5
Potato	58	41	2	15
Grapes	32	9	10	13
Vegetables	50	16	28	2
Berries	92	23	67	2
Roses	3	2		1
Total	**501**	**242**	**206**	**49**

Source: ONSSA.

Table 2.5: PVP granted for crop varieties from public and private sector, 2006–2013

Species	Number of applications		Number of protected varieties		Protection expired	
	Private	INRA	Private	INRA	Private	INRA
Durum wheat	7	14	5	14		2
Bread wheat	12	6	9	6	1	3
Barley	2	7	2	7		
Oats		3		3		1
Triticale	1	1	1	1		
Faba bean	8		4			
Chickpea						
Lentil		5		5		
Maize		5		5		
Vetch		2		2		
Sunflower	1	2	1	2		
Rapeseed		1		1		
Cotton		3		3		
Total	**31**	**49**	**22**	**49**	**1**	**6**

Source: ONSSA.

the PVP gave an opportunity for INRA to protect an important and significant number of varieties of fruit trees (citrus, date palm, figs, and almonds).

2.4.8 Recommendations

In Morocco, Law 9-94 on plant breeders' rights provides both the public and private sectors with equal opportunities to protect and exploit plant variety rights. Creating a strong royalty enforcement mechanism will ensure the benefits are accrued, encouraging and attracting investments from both the foreign and domestic private sectors.

2.5 Variety licensing

2.5.1 Introduction with historical context

SONACOS was established in 1975 as a national parastatal body to produce and market the seeds of varieties developed by INRA. It enjoyed a virtual monopoly position for agricultural seeds until 1990 when, in response to economic liberalization, access to INRA varieties and the seed market was opened to the private sector. This policy change encouraged the entry of private sector players and increased interest in licensing varieties from national and international sources.

2.5.2 Regulatory frameworks

One significant innovation in the seed system introduced in 1992 was the decision to offer all new INRA varieties through an open tender system (Appel d'offre), rather than passing them automatically to SONACOS as a "sole agent". INRA licensed its varieties to both the public and the private sectors, under an agreement called "Contrat de concession des obtentions végétales". The license is granted based on the highest combined offer of the concession fee, paid at the time of signing the contract, and the royalty, paid on certified seed sales to farmers.

2.5.3 Institutional arrangements

INRA varieties and Moroccan seed companies

Prior to the 1990s, all INRA varieties were commercialized through SONACOS based on a contractual agreement of a 2.5% royalty on the sale of certified seed. After 1990, the licensing of INRA varieties was made through open and

competitive bidding. The system did not work well because some varieties licensed to private companies were not commercialized. Since 2002, despite competitive bidding arrangements by INRA, none of its varieties have been licensed to public or private seed companies. At the time of this study, INRA was preparing new terms for the licensing agreements, taking into consideration minimum seed sales for licensee companies. The new royalty rates will be based on the varietal performance and/or quality traits.

Foreign varieties with Moroccan seed companies

In addition to the INRA varieties, SONACOS and the private seed companies also entered into licensing agreements with foreign seed companies to introduce pre-basic and basic seed and produce and market certified seed (R1 and R2) in Morocco. Under this agreement the royalty rates and payment mechanisms are specified. The system permitted the introduction and use of foreign varieties, allowing Moroccan farmers to take advantage of new technologies developed elsewhere.

2.5.4 Technical procedures

In Morocco, seed production for all commercial and domestic use or for the export market, must be registered in the national variety catalogue after meeting DUS and VCU requirements. The granting of PVP, introduced in 2002, provides both the public and private sectors with equal opportunities to protect and exploit plant variety rights by licensing. The foreign varieties licensed to SONACOS or the private seed companies are registered in the Moroccan official catalogue after meeting the requirements for DUS and VCU tests.

2.5.5 Major achievements

Prior to 1989, about 35 INRA wheat varieties were ceded to SONACOS. Among these were three bread wheat (Achtar, Marchouch, and Kenz) and two durum wheat (Karim and Marzak) varieties that are still under commercial seed production. Others were dropped for various reasons. To date, about 82 bread and durum wheat varieties have been conceded to public and private seed companies. These include SONACOS (54) and four private seed companies (Marosem [9], Deltasem [3], Agrin Maroc [5] and Nabat Chaouia [11]) (see Figure 2.3). Among these, however, only seven bread wheat and eight durum wheat varieties from INRA are licensed to SONACOS, while two of each were licensed to the private sector (see Figure 2.4). Since 2002, despite calls for

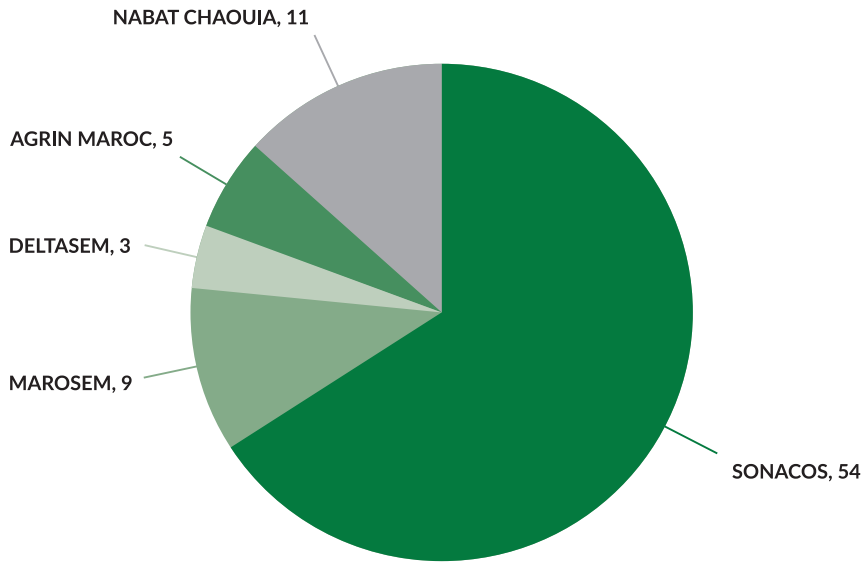

Figure 2.3: Number of bread and durum wheat varieties licensed to SONACOS and private seed companies

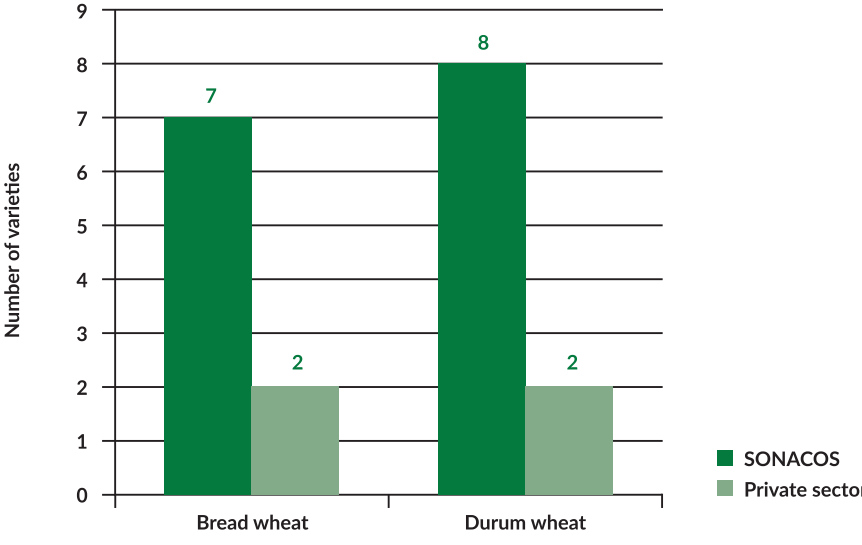

Figure 2.4: Number of INRA varieties, by type, licensed to SONACOS and private seed companies

open competitive bidding arrangements (in 2004), no INRA variety has been licensed to either public or private seed companies.

2.5.6 Key challenges

Access to foreign varieties gave Moroccan farmers choices. In 2013, for example, bread wheat varieties licensed from foreign companies represented about 44% of the certified seed multiplication program. For durum wheat, foreign varieties represented 48% of the certified seed multiplication program. These trends show a rapid decline in the country's seed/varietal sovereignty and its dependence on foreign varieties. INRA should be making a concerted effort to develop and promote its own varieties to avoid dependence on foreign varieties and it should invest in capacity and facilities. INRA may also develop partnerships with seed companies for "co-ownership" of PVP.

2.5.7 Lessons learned

Initially, the payment of royalties from seed producers to INRA was a very positive element in the Moroccan system, primarily because of the close relationship with SONACOS. The introduction of a tendering system was an innovative attempt to involve the private sector, but it did not work as expected. A flaw in the licensing contracts provided absolute exclusivity to the recipient seed company for the use of the licensed varieties but did not stipulate any obligation for commercialization of these. Such a licensing mechanism allowed the seed companies to not multiply and market the seed of some of these varieties. This has resulted not only in a monetary loss to INRA, but represents a waste of several years of research and technological progress.

2.5.8 Recommendations

Future licensing agreements should contain a performance review clause or a minimum seed production and marketing requirement to avoid any such perverse motives. Each variety offered should also be accompanied by a clear statement about its key attributes and merits.

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Chapter 3: Seed production and commercialization

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3 Seed production and commercialization

3.1 Executive summary

In Morocco in 2013, the use of certified wheat seed was 19%. This is considerable compared to many countries but is still short of the common or standard practice of a 25% seed renewal rate for self-pollinated crops. Conscious of the importance of the availability of certified seed for food security and economic growth, the Moroccan government made considerable efforts to strengthen the seed sector through policy reforms. This included the 1970s' initiative to develop a seed industry which ensured seed security based on national operators. These operators included research institutes (INRA), seed growers (mainly SOGETA and SODEA), seed marketing (SONACOS), and seed quality control and certification (now ONSSA).

Recently, the state has tried to install instruments to encourage the use of improved inputs (such as seeds and fertilizers) through its new agriculture transformation plan known as the Green Morocco Plan (GMP). The GMP consists of two pillars:

- Pillar I: Accelerated development of a modern and competitive agriculture sector characterized by market-responsive value addition
- Pillar II: Empowerment of vulnerable actors and continuing the fight against rural poverty through improved farm incomes.

The specific objectives for the seed sector development in the GMP are to increase, by 2020, the share of certified seed in the total seed use for the self-pollinated crops of food legumes to 10%, of forages to 30%, and of cereals to 62%. To achieve these objectives, regulatory reforms relating to plant breeders' rights and effective public-private partnerships for seed-delivery systems have been put in place. The contribution of the formal sector was around 16% before 2009 compared with 27% in 2012/13, showing an average increase in certified seed use of 69%. In addition to the direct and indirect subsidies

given to farmers and seed companies, the increase in certified seed use could be attributed to policies and regulatory reforms and to building an effective public-private partnership in seed sector development.

For enhanced seed production and commercialization in a sustainable and economically viable way, the following issues required attention:

- Building a robust and economically viable variety maintenance and early generation seed production system
- More innovative approaches in the targeting of subsidies to bring about improved seed system diversification and more active private sector participation in seed sector development
- Expansion of the seed production and distribution network based on an effective seed demand forecast
- Introduction of grain quality grading based on grain pricing.

3.2 Seed production and import

3.2.1 Introduction with historical context

In Morocco, the cultivation of cereals occupies 62% of the agricultural area and, consequently, constitutes the most important crop. Moroccan agricultural policy often paid special attention to the enhancement of the cereals sector, seeking to raise the levels of productivity, improve the incomes of the farmers, and increase cereal self-sufficiency. The use of certified seeds by farmers constitutes one means to tap into the potential value of genetic improvement. Therefore, very early on, the government took the necessary measures to equip the country with a strong seed sector. The seed sector constitutes the principal pillar in modernizing the agricultural sector for all crops. Indeed, seeds are the key element in the production and support of the rest of the investment in the crop sector. A sustainable increase in production and productivity is largely dependent on two factors, the development of new high-yielding and adapted varieties, and the effectiveness of the seed system in providing a timely supply of an adequate amount (quantitative and qualitative) of seed to farmers.

The analysis of the trend in cereal production in Morocco illustrates some improvements. For instance, wheat yields have increased from a 10-year average in the 1980s of 1.2 t/ha to 1.5 t/ha for the period 2000–2010 – an average increase of 23% (FAOSTAT 2018). During this latter period, yield variability has been substantial, with a minimum yield of 0.6 t/ha in drought years and a maximum yield of 2 t/ha in normal years. The increase in yield is

attributed to a combination of factors, including the use of improved varieties, certified seeds, fertilizers, and crop management practices.

Historically, the organized seed sector in Morocco started in the 1920s with the establishment of an agricultural research and variety development program. Significant development of the seed sector took place in the 1970s when the state took the initiative to develop the national seed industry to ensure seed security through national operators. These operators include research institutes (INRA), seed growers (mainly SOGETA and SODEA), seed production and commercialization units (SONACOS), and seed quality control and certification (DPVCTRF, currently ONSSA). Attention was given to field crops (cereals, food legumes, and forages). Moreover, the 1970s saw the establishment of appropriate regulation and the emergence of professional associations in the seed sector working towards creating an environment of fair competition. Formal seed industry development started with the development (by INRA) of improved varieties using germplasm from national sources (genetic materials and land races) or elite germplasm introduced from CGIAR and other advanced international research institutes.

The national seed sector has seen very significant growth in recent years. While the area covered by certified seed for cereals has reached 19%, that of legumes stands at less than 1% of the total area cultivated with these crops in the country. Recent progress in the broader certified seed use rates should not conceal the differences among crops. For example, in 2013, within cereals, the certified seed use rates were, for bread wheat 33% and for durum wheat 16%. The informal seed sector dominates the cereal sector, claiming a share of 67% for bread wheat and 84% for durum wheat.

Liberalization of the seed sector since the 1980s has been characterized by:

- The integration of newly established private companies
- The introduction of foreign varieties
- The licensing of INRA and private sector varieties
- Increased participation of private contract seed growers
- Increased certified seed production by both public and private seed companies.

Of 100 seed companies, 94 work on high profit margin crops (vegetables, potato, sugar beet, sunflower, and legumes) indicating that the private sector focuses on these crops. Only five companies – one public (SONACOS) and four

private (Deltasem, Marosem, Agrin Maroc, and Aphysem) – are involved with low-margin crops (cereals and legumes). The market for certified seed is a major industry in Morocco and one of the largest in Africa. It has a turnover of nearly MAD 3 billion for all seeds, with cereals accounting for about 30% of this.

The seed sector comprises many actors who operate under a legal framework consisting of seed laws, regulations, and decrees. It includes:

- Regulatory institutions governing various aspects of imports, production control, and certification
- More than 1,200 seed growers who are members of AMSP and responsible for seed production under contractual agreements with public and private seed companies
- Nearly 140 accredited commercial seed dealers engaged in the distribution of seeds through public and private networks covering all agricultural areas in the country with about 500 selling points
- Professional associations of seed companies (AMSP) that are active players in the seed sector and are involved in the development and implementation of seed strategy and policy.

The favorable and diverse production environments provide great opportunities for expansion of the seed sector. As part of the country's efforts to ensure food security, the state provided various forms of support to the seed sector. The main instruments used include:

- Direct subsidies on certified seed prices given to farmers, the state partially absorbing the prevalent seed market price to farmers
- Indirect subsidies, absorbed by the state, on the costs of quality control and certification of seeds
- Tax and customs duty exemptions for imported pre-basic and basic seeds used for multiplication
- Giving priority to seed multiplication in large irrigation schemes developed and administered by regional offices of agriculture
- Extension activities to promote, popularize, and create awareness of the use of certified seed of improved varieties and the associated management technologies
- Making available to the seed companies state distribution networks for marketing
- Granting a subsidy for carry-over (seed security) stocks through a state contribution to the cost of storage.

3.2.2 Regulatory frameworks

Promulgation of the first regulation on the production of seeds was made in 1940. The law (Dahir) governing the production and marketing of seed and seedlings was first introduced in 1969 (Law [Dahir] No. 1-69-169 of 25 July 1969) with modifications and supplements in 1977 (Law [Dahir] No. 1-76-472 of 19 September 1977). These laws are aligned with international standards. More recently, the government has adopted a new national agricultural development strategy – the GMP – which came into effect in 2008.

Some of the regulations governing seed production and commercialization include:

- Prohibiting the production and/or commercial use of any variety (national or foreign) unless it has been registered in the Moroccan official catalogue and agreement reached through a breeder or partnership agreement with seed companies
- Application of the seed law and regulations equally to all seed businesses regardless of the size of their operations
- Incentives encouraging partnerships between state and private actors (local and foreign) in the seed sector by granting long-term leases for land and subsidizing investments
- Provision to encourage the clustering of smallholder farmers for seed production (individually or in producer cooperatives) and encouraging investment in seed facilities under GMP.

3.2.3 Institutional arrangements

The institutions involved in seed production and commercialization are described based on their roles and responsibilities:

INRA (Institut National de la Recherche Agronomique)

INRA is responsible for variety development, evaluation, and maintenance as well as early generation seed production (G0-G1) of its own varieties, developed and released in the country.

Public or private seed companies

Public (SONACOS) or private (Marosem, Deltasem, Agrin Maroc, and Nabat Chaouia) seed companies are responsible for importing G0-G1 seed of foreign varieties registered for commercialization in Morocco. They are also responsible for producing basic seed of domestic or imported varieties on their own farms

or through contractual arrangement with farmers. Production of certified seed (R1, R2) is undertaken through contractual arrangement with Association Marocaine des Multiplicateurs de Semences (AMMS) or other farmers. They are responsible for seed processing and storage as well as marketing and distribution through public or private networks.

AMMS (Moroccan Seed Growers' Association)

AMMS is an association of seed multipliers of certified seed under a contractual agreement with public or private seed companies. Some members have seed processing and storage facilities, which they make available to seed companies. The seed production regulations do not require membership of the AMMS. However, the AMMS provides the opportunity to stand together and have better bargaining power in seed production (pricing, receiving, processing, and seed analysis). While contracts are established between seed companies and individual seed growers, all other general negotiations take place through AMMS. Regardless of whether they are members of AMMS or not, all 1,200 contract seed growers in Morocco must abide by the general agreements between seed companies and AMMS.

ONSSA (Office National de Sécurité Sanitaire des Produits Alimentaires)

All seed production must meet the field and laboratory standards prescribed in the national regulations. For locally produced seed, ONSSA ensures that all quality standards are observed during seed production, processing, storage, and marketing. It undertakes field inspection of seed production fields and the sampling and testing of processed seed. It issues certificates for approved seed lost for commercialization. For imported seeds, ONSSA ensures that they have compliance certification.

3.2.4 Technical procedures

Variety licensing

National varieties

SONACOS had exclusive use rights on all varieties developed and registered by INRA until 1988. This was to ensure the smooth functioning of the national seed system. Among 35 INRA wheat varieties exclusively conceded to SONACOS before 1988, only five are still under commercial seed production – the bread wheat varaieties Achtar, Marchouch, and Kenz and the durum wheat varieties Karim and Marzak. The remaining 30 varieties were dropped from certified seed production because of their low productivity and/or disease susceptibility

Table 3.1: Distribution of acquisition rights by public and private sector

Company	Bread wheat varieties	Durum wheat varieties
Public seed company (SONACOS)	Rajah, Amal, Mehdia, and Aguilal	Yassmine, Amjad, Tarek, Ourgh, Marjana, and Tomouh
Private seed companies	Tilila, Massira	Anouar, Jaouhar

compared to the newly released varieties. Tilila wheat variety (INRA 1736) was the first variety licensed under the new framework to a private seed company (Marosem). Since the liberalization of licensing, the use rights for 22 varieties have been granted under various tenders.

The cereal seed sector is characterized by low profitability (low margin). Hence, the number of seed companies engaged in this sector is limited to five (four private and one public). Table 3.1 summarizes the acquisitions rights of wheat varieties from INRA since 1989 that are registered in the national variety catalogue and licensed within the tendering framework. It clearly shows that of 22 varieties licensed, SONACOS acquired 17 (77%). During 2000–2012, seven wheat varieties – six durum (Razzak, Chaouia, Nassira, Amria, Marouan, and Faraj) and one bread (Kharrouba) – were registered in the national catalogue. These varieties have yet to be licensed to public or private seed companies.

Foreign varieties

The number of foreign varieties registered in the Moroccan official catalogue increased during 2000–2012. Of the 34 new durum wheat varieties released, 28 were foreign (82%). Likewise, of the 32 bread wheat varieties released during the same period, 31 were foreign (91%). All the foreign varieties are covered by a framework of partnership agreements with Moroccan seed companies. For more information and data, please visit the following websites:

- For bread wheat: http://www.onssa.gov.ma/fr/images/controle_semences/catalogue_officiel/BLE_TENDRE.pdf
- For durum wheat: http://www.onssa.gov.ma/fr/images/controle_semences/Homologation_varietes/Varietes_inscrites_catalogue_officiel/LISTE-CATALOGUE-BLE-DUR.pdf

Seed production and import

GMP cereal seed sector plan

GMP seeks, among other things, to improve the income of farmers, especially those producing low-margin crops, by improving productivity. This is very

Table 3.2: National projected certified seed production and use by 2020

Crop	Target seed production*		Target seed use**	
	Quantity (tonnes)	Share of total supply (%)	Quantity (tonnes)	Share of total supply (%)
Cereals	280,000	100	280,000	45
Bread wheat	140,000	100	140,000	62
Durum wheat	90,000	100	90,000	60
Barley	50,000	100	50,000	29
Rice	480	20	2,400	100
Maize	1,200	30	4,000	30
Food legumes	1,900	50	3,800	10
Forage crops	1,800	30	6,000	31
Potatoes	80,000	66	120,000	45
Sunflower	670	60	1,120	100
Canola	300	100	300	100
Vegetables	120	30	400	20

* Target national seed production for total target seed use.
** Target certified seed use for both national production and imports.

dependent on the use of certified seeds and improved varieties. To this effect, the state has adopted a clear policy of support with ambitious, but well-defined, objectives. The specific objectives of seed sector development in the GMP include:

- Increasing the share of certified seeds in total seed use for all crop species to meet the national targets by 2020 (Table 3.2)
- Increasing the share of total certified seed use in national certified seed production targets by the year 2020 (Table 3.2).

Meeting these objectives requires major changes in the seed sector. The government developed a special framework partnering with professional associations of seed companies and seed growers. Hence, an agreement (also called the contract program for 2009–2020) was signed by the government and FNIS, which is a joint body of AMMS and AMSP. To achieve these goals, the seed sector improvement program defined the following five priorities:

- Strengthening seed multiplication capacities
- Developing and improving marketing conditions

- Developing and improving research programs
- Harmonizing and adapting current regulations and reinforcing seed quality control capacities (facilities, human resources, budget, etc.)
- Overseeing and guiding the seed business organization.

The commitments of each party, particularly for those crop species with limited profitability, were defined in the agreement. Then an action plan was developed by all stakeholders, in which specific responsibilities were assigned to the different stakeholders along with the necessary resources, deliverables, and timeframe. This, in turn, led to the development of contract programs with the government specifying the engagement of each stakeholder. Program management offices (PMOs) were also established to coordinate efforts. Alongside financial subsidies (subsidies to seed price and carry-over stock) there are other indirect subsidies supported by the state to minimize the seed cost. These include:

- The use without cost to the seed companies of state networks (storage facilities and personnel) for sales
- Free extension services
- General media promotion for the use of certified seed
- Seed quality control and analysis costs.

Seed production

There are two critical stages in seed production – early generation seed (breeder, pre-basic, and basic) production by NARS or companies and certified seed (R1 and R2) production under contract with growers by public or private seed companies. Arrangements for contractual seed multiplication programs consist mainly of:

- Selection of seed growers by seed companies based on their technical performance and their acceptance of the seed production principles and procedures, where priority is given to those that have access to irrigation
- Multiplication contracts specifying the agreement of the seed company and the seed grower. The contracts, which are renewed annually, define the species, varieties, class, quantities, area, and minimum quality requirements
- Payment by seed growers for the purchase of seed required for multiplication, including seed quality control fees payable to ONSSA based on area

- Declaration of the seed production fields, including the species, varieties, generation, and lot number of the seed planted, and a sketch locating the field site
- Implementation of the multiplication program observing the conditions specified in the national seed regulation provided by ONSSA
- Declarations submitted to ONSSA for field inspection and seed testing, which fully monitors, controls, and certifies the quality and quantity of the certified seed produced.

Early generation seed production

Variety maintenance has always been the responsibility of breeding programs. INRA and foreign seed companies have taken responsibility for their own varieties. Prior to 2002, INRA used to provide G3 seed to the seed companies for national varieties. However, since 2002/03, INRA has partly stopped producing G2 and G3 seed (Table 3.3). INRA completely stopped the program in 2005/06, for the seed companies to assume full responsibility of producing them (Table 3.3). From 2006 to 2014, the production of G2 was fully carried out by seed companies while INRA has been supplying only breeder seed (G1). The amount of G1 delivered by INRA to seed companies for the period of 2007 to 2012, on average, was about 90–100 quintals per year. Upon request from the seed companies, INRA resumed the production of G2 starting from 2014.

National varieties

Pre-basic and basic seed production of national varieties is carried out under the auspices of seed companies under contractual agreements with seed growers specifying the commitment of each party. The pre-basic and basic seed production program is implemented considering the overall national plan (GMP), commercial objectives, and strategic stock requirements of the seed companies at national and regional levels. The realization of the multiplication program is handled at the regional level according to the commercial objectives, production, storage, and capacities of the seed processing and treatment plants.

Foreign varieties

Pre-basic seeds of foreign varieties are generally produced by seed companies outside Morocco as are the basic seeds although sometimes they are produced by Moroccan seed companies within the country. The multiplication and declaration of the imported seeds of foreign varieties is done according to Moroccan regulations similar for national varieties. All five seed companies are involved in pre-basic and basic seed imports needed for their own seed

Table 3.3: Disengagement of INRA from variety maintenance

Year	Seed class	Share of INRA in total area (%)	Share of seed companies in total area (%)
2002/03	G2	100	
	G3	50	50
2003/04	G2	100	
	G3		100
2004/05	G2	50	50
	G3		100
2005/06	G2		100
	G3		100

Source: SONACOS.

multiplication programs. The quantity imported is based on the certified seed marketing plan and stocks needed for each company as well as the seed availability of the desired variety from foreign seed companies. On average, 10,000–20,000 quintals of pre-basic and basic seed are annually imported for exclusive use in the seed production program.

The seed companies are responsible for production planning, provision of source seed for multiplication, and contractual arrangement with seed growers. They follow up the implementation of the contract and provide new packaging materials at harvest. They are also responsible for the processing and storage of the cleaned seed. The seed growers are responsible for ensuring that the multiplication is done according to the contractual agreement and for delivering the harvested seed to the seed companies. ONSSA monitors that the seed is produced according to national standards through field inspections of production fields and sampling and laboratory testing of the processed seed before marketing.

Certified seed (R1 and R2) production

The production of certified seed is carried out only in Morocco. However, in the event of seed shortages, seed companies can import certified seed (R1 or R2) for direct commercial use for those varieties registered in the national official catalogue. Until 2013, imports of such seed classes for all cereals except barley were subjected to import tariffs of 49%, which made their price very

high in the absence of a special subsidy. Following recent trade agreements with the European Union (EU), seed imports from the EU are now exempt from the import tariffs apart from the basic duty of 2.5%.

The multiplication programs are often subjected to adjustments according to seed availability and commercialization progress at regional scales, commercial objectives and production, processing, storage, and marketing capacities. Between 2008 and 2012, the area used for multiplication increased from 40,000 ha to 70,000 ha (Figure 3.1). The area increase is a result of the increase in demand for seed. This has increased from 70,000 tonnes before 2008 to 125,000 tonnes in 2013. The reasons for this increase will be given in the section on commercialization.

Details of the seed multiplication program carried out during the last three years for all seed classes are shown in Table 3.4.

The wheat program analysis shows that 69 varieties were multiplied (Table 3.5) out of which 25 varieties (21 are new) occupied 80% of the total wheat area.

For the 2012/13 seed production program, the above figures changed slightly. At this time 27 varieties (14 bread and 13 durum wheat) represented 90% of the total area. Gross seed production reached almost 185,000 tonnes in 2013, which is equivalent to 160,000 tonnes of processed certified seed (after

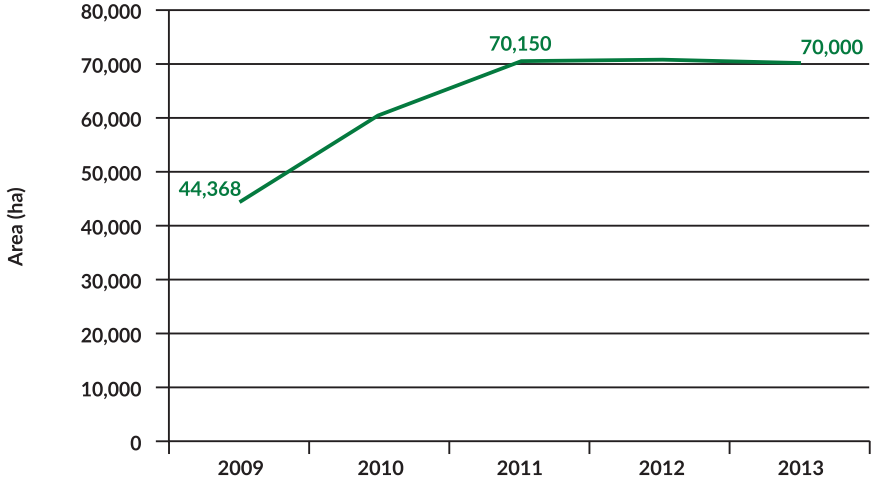

Figure 3.1: Trends in area (ha) for seed multiplication, 2009–2013

Table 3.4: Average area for the seed multiplication programs for a typical year (ha)

Crop	G2	G3	G4	R1	Total	Share of total (%)
Bread wheat	460	3,880	38,500	11,400	54,240	77.4
Durum wheat	152	1,615	12,250	900	14,917	21.3
Barley	12	95	800	0	907	1.3
Total	**624**	**5,590**	**51,550**	**12,300**	**70,064**	**100**
Share of total (%)	0.9	8.0	73.6	17.6	100	

Source: SONACOS.

Table 3.5: Number and importance of the wheat varieties under seed production

Species	Total number of varieties multiplied	Number of important varieties	Varieties less than 20 years of age	Area under important varieties (ha)	Share of area under important varieties (%)
Bread wheat	36	12	10	42,203	76.6
Durum wheat	33	13	11	12,863	23.4
Total	69	25	21	55,066	100

Source: SONACOS.

allowance for processing losses and rejection after seed quality analysis). With the carry-over stock, about 198,000 tonnes of certified seed was available, of which 154,000 tonnes were bread wheat and 44,000 tonnes were durum wheat. Hence, bread wheat seed constituted roughly 78% of the total certified and durum wheat seed 22%. Of this amount, about 57% of the certified seed is produced under rainfed conditions and the rest is grown in irrigated areas. In terms of seed producers, SONACOS' share was 91% and that of the private companies was 9%.

Seed processing, treatment, and storage

Seed processing

Harvested seeds from production fields approved by ONSSA and meeting the quality standards specified by the technical regulation (Compliance Bulletin)

are the only seeds eligible for processing. The statement to ONSSA contains information on seed grower, variety, generation, lot number, and estimated production. This operation is done in the facilities of the seed companies or can be performed by the seed growers within the framework of a joint agreement with the seed company. Seed processing is carried out by the seed companies on behalf of the seed growers and it is regarded as an additional service cost that is later deducted from the value of the approved certified seed. If the seed lot is rejected after analysis by ONSSA, the seed growers are expected to pay the cost of processing – MAD 17/quintal. The total processing capacity is spread over 14 regions and is estimated at nearly 25,000 quintals/day (wheat basis). SONACOS' capacity constitutes 80% of the total, private seed companies 8% and private seed growers 12% (see Table 3.6).

To meet the deadline of 15 October fixed for submission of samples for analysis, seed processing starts around the end of May. Assuming 80 full working days per season, the total processing capacity is estimated at 2 million quintals. Seed growers are in favor of reducing the delay in payment resulting from slow seed processing. This would require increasing storage and processing capacities and hence, the seed cost, to recover the additional investments. The deadline for the delivery of seed samples for quality testing has been extended from 15 September to 15 October by Decree (Dahir) No. 1-69-169 of 25 July 1969 (ONSSA 1969).

Seed treatment

Processed seeds which are sampled, tested, and approved by ONSSA laboratories should be treated against seed-borne diseases before commercialization. The fungicide used should also be approved and controlled by ONSSA. The active ingredients for the seed treatments used are difenoconazole (30 g/L difenoconazole FS), carboxin thiram (17% carboxin + 17% thiram EC) and tebuconazole (60 g/L tebuconazole CFS). The appropriate doses are 100 mL difenoconazole per 100 kg of seed, 200 mL carboxin thiram per 100 kg of seed, and 50 mL tebuconazole per 100 kg of seed.

Once the seed is approved and certified, the bags are sealed and tagged with two labels (one inside and another on the bag). The labels bear the lot number, which provides information about the crop, variety, seed class, year and region of production, and certificate number.

Table 3.6: National seed processing capacity by public and private sector

Companies	Number of companies	Number of processing units	Daily capacity (quintals/day)
Public seed companies	1	25	20,000
Private seed companies	4	4	2,000
Seed growers	7	7	3,000
Total		**36**	**25,000**

Source: SONACOS.

Seed storage

As stipulated in the seed regulation, the seed companies must satisfy the appropriate conditions of seed storage, which is an important evaluation factor during licensing. The seed production regulations in Morocco require strict lot identification, forbidding the mixing of seed lots. Consequently, more storage space is needed, leading to additional costs. Carry-over seed stocks need to be submitted for retesting for germination after 12 months of storage and cannot be kept for more than two years excluding the year of marketing. Holding carry-over stocks has cost implications in terms of the interest on financial expenses, the deterioration of germination capacity, and maintenance. If the germination capacities of treated carry-over stocks do not comply with the minimum standards, the seed is considered a total loss as it cannot be sold or used for any other purpose.

There are minimum quality requirements that should be met for maintaining the quality of seed. Therefore, seed storage units are constructed to meet minimum requirements for medium-term safe storage conditions. Moreover, companies apply all the technical interventions (pesticide use, storage sanitation, etc.) to meet the required minimum quality standards. The total capacity of the seed storage facilities is estimated at about 170,000 tonnes – all owned by seed companies engaged in the cereal seed sector, where SONACOS owns 82% of the total storage capacity (Table 3.7).

Seed production costs

In Morocco, the effects of weather conditions on seed production are significant and pose a major challenge. About 60% of the certified seeds produced in the country is produced under rainfed conditions. Of a total of 70,000 ha of seed production area, 43% is irrigated. Three major regions – Tadla (Beni Mellal,

Table 3.7: National seed storage capacity of the public and private sector

Companies	Number of companies	Total storage capacity (tonnes)	Remarks
Public seed companies (medium term)	1	140,000	
Private seed companies (medium term)	4	15,000	
Seed growers (temporary storage)	7	15,000	~ 10,000 tonnes temporary storage
Total		**170,000**	

Source: SONACOS.

Fquih Ben Salah), Chaouia (Settat, Benslimane), and Saïs (Meknes and Fez) – accounting for about 60% of total seed production, are mostly under rainfed conditions. The farm costs are variable and depend on climatic conditions, crop management, use of inputs, crop and variety, and farm size, which can influence unit production costs and farm income. Small farm size is generally associated with a low volume of production, increased per unit costs, and low net farm income. The average area of seed production per contract grower is around 58 ha. The area ranges from the minimum required by regulation – 7 ha under rainfed conditions and 3 ha under irrigated conditions – up to over 1,000 ha. Table 3.8 illustrates typical seed production costs under rainfed and irrigated systems in Morocco.

Farm income from seed production depends on the proportion of seed approved after final analysis by ONSSA. The breakeven points for a typical farm shown in the example in Table 3.8 are 2.6 t/ha for rainfed ones and 3.4 t/ha for irrigated ones.

Seed purchase system

Seed purchase can take three different modalities: (i) Net cleaned seed weight approved by an ONSSA official laboratory; (ii) Net cleaned seed after processing the raw product; and (iii) Gross or raw seed production from fields approved by ONSSA. Each system presents advantages and disadvantages for the two parties (contract seed producers and seed companies). The purchase on a net approved system is performance-based and applied by all seed companies in Morocco. Based on seed production approved by ONSSA, this system holds the seed grower responsible for maintaining quality from field production all the way up to the approval by ONSSA. This leads to better performance. Under this system, having a clean product (limited waste), the seed growers

Table 3.8: Estimated costs and income for a typical farm growing wheat under rainfed and irrigated conditions

Description/ yield level	Rainfed			Irrigated		
	4 t/ha and 10% waste	3.5 t/ha and 12% waste	Breakeven yield: 2.6 t/ha	Gross yield of 5 t/ha with 10% waste	Gross yield of 5 t/ha with 12% waste	Breakeven yield: 3.4 t/ha
Net total cost MAD/ha	8,704	8,704	8,704	11,644	11,644	11,644
Total income MAD/ha	13,909	11,728	8,712	17,386	13,909	11,646
Cost MAD/ tonne gross	2,176	2,486	3,347	2,328	2,911	3,475
Income MAD/ tonne gross	3,477	3,350	3,350	3,477	3,477	3,477
Benefit MAD/ tonne	1,301	864	Balance	1,149	566	Balance

Notes: Typical farm areas are 7 ha for rainfed environment and 3 ha for irrigated ones.
A fixed price is used for the calculation of income.
Source: SONACOS.

will be better remunerated since the purchase prices are calculated taking into consideration the average waste (cleanout).

The purchase price for R2 certified cereal seed is based on the market price of grain plus a premium of 15% applied on R2, i.e. price of R2 (gross) = 1.15 × declared grain price (gross standard quality). Since certified seed prices are subsidized by the state, the purchase prices of certified cereal seeds are fixed annually by the government authority in charge of agriculture. The certified seed price for R2 generation is based on:

- For bread wheat: the prices announced in the circular of the Ministry of Agriculture and Fisheries (MoAF) based on the prevalent market price at harvesting time
- For durum wheat: the prices set by the MoAF considering the actual market changes for the period 1 May to 15 July of the relevant year.

The purchase price of the net approved R2 is calculated mainly based on the price of raw R2 and the average proportion of the cleanout waste (processing loss) and its value. An example demonstrating the certified seed price fixing procedures is provided in Table 3.9.

Table 3.9: Certified seed price fixing procedure – an example

Serial no.	Description	Value in MAD/quintal
1	Declared grain price (raw)	280
2	Premium at 15%	42
3	Price of raw R2 (1+2)	322
4	Assumed proportion of waste (%)	15
5	Value of waste	21
6	Value of approved Net (3+4+5)	358
7	Cost of processing gross Net	17
8	Purchase price of approved Net (7+8)	375

Source: SONACOS.

It should be noted that if the processing operation is carried out by the seed company on behalf of a seed grower, the processing cost of 17 MAD/quintal (raw) will be deducted from the above price (375 MAD/100 kg, in the case of R2 bread wheat seed). Therefore, the approved purchase price per quintal, paid by seed companies is the same for all seed growers (for the same species and varieties). Moreover, the amount received by each seed grower for his/her approved production varies according to the productivity per hectare and the rate and the value of its processing waste. The higher the productivity and the lower the waste, the higher the income by farmers per unit of produce. The seed purchase prices for the other generations are based on the following calculations relative to R2 generation: (i) R1 = R2 + 15 MAD/quintal; (ii) G4 = R2 + 30 MAD/quintal; and (iii) G3 = R2 + 130 MAD/quintal. For illustration, Table 3.10 below provides the purchase prices applied for the production season of 2013.

3.3 Seed commercialization

3.3.1 Procedures for determining seed sale prices and their subsidies

Like seed purchases, the subsidized sale prices of the other seed classes are fixed based on the sale prices of R2, using the fixed increments that are progressive across generations as follows: (1) R1 = R2 + 15 MAD/quintal; (2) G4 = R2 + 30 MAD/quintal; and (3) G3 = R2 + 130 MAD/quintal.

Table 3.10: Purchase price (MAD/quintal) for bread and durum wheat seed, 2013 crop season

Crop	G3	G4	R1	R2
Bread wheat	505	405	390	375
Durum wheat	560	460	445	430

Source: SONACOS.

Direct subsidy

In addition to the indirect subsidies discussed in the introductory section, the state provides direct subsidies on seed use price and seed security carry-over stocks. Historically, subsidies were variable components of seed pricing until 2010/11. The intervention of the state through subsidies depended on the shortage/availability of the grain and seed harvests as well as international grain prices, which influences national grain prices. Table 3.11 provides the historical (2005/06) seed price subsidy level before the application of the new multiannual ministerial decree on seed price subsidies instituted for five years starting from 2010/11.

From 2010/11 and with the aim of giving incentives to all operators, especially seed companies, the state instituted a new subsidy system for seed prices based on an index for grain prices. This was done using a joint decree of the MoAF and the Ministry of Economy and Finance. The decree also includes the storage premium given as a subsidy (TGR 2010). Based on the new decree, the certified seeds of G3, G4, R1, and R2 wheat and barley varieties will be subsidized in such a way that the difference between the subsidized seed prices and grain prices does not exceed the figures given in Table 3.12. These prices show a systematic increase over the years.

For example, the maximum subsidized seed price, based on the grain price with the differential shown in Table 3.13, is provided in Table 3.14 below for the 2013/14 crop season.

Imported basic (G3 and G4) seeds of wheat are subsidized so that the sale price will match the corresponding domestically produced seeds. The subsidies given to the imported classes are 500 MAD/quintal for G3 and 400 MAD/quintal for G4. Subsidies designed to encourage certified seed use can be implemented in two ways:

- The subsidy can be given directly to the seed user and the user is responsible for purchasing seed at the unsubsidized (actual) price
- The seed users pay the subsidized price and the state pays the difference (the subsidy) directly to the seed companies.

Table 3.11: Historical seed price and subsidy levels for bread and durum wheat

Subsidy	Crop	2005/06	2006/07	2007/08	2008/09	2009/10
Maximum subsidized sale price (R2) (MAD/quintal)	Bread wheat	325	315	335	375	305
	Durum wheat	370	354	375	570	350
Subsidy (MAD/quintal)	Bread wheat	100	100	115	130	150
	Durum wheat	80	100	115	115	135

Note: Subsidies are applied only to G3, G4, R1, and R2 and not to G1 and G2. The G3 subsidy was introduced in 2006/07 and that for G4 in 1996/97.
Source: SONACOS.

Table 3.12: Price differences between subsidized certified seed and grain

Crop year	2010/11	2011/12	2012/13	2013/14	2014/15
Price differential (MAD)	30	35	40	45	50

Source: MoAF and Ministry of Economy and Finance.

Table 3.13: Grain price and maximum subsidized seed prices according to a fixed difference (MAD/quintal), 2013/14 crop season

Description	Crop		
	Bread wheat	Durum wheat	Barley
Grain price	280	325	270
Difference fixed in the Decree	45	45	45
Maximum seed sale price (R2)	325	370	315

Source: SONACOS.

Table 3.14 shows the subsidized seed prices for the year 2013/14 (from 1 September 2013). Table 3.15 provides the corresponding subsidy levels. Table 3.16 shows the evolution of the selling prices and subsidies for bread and durum wheat from 2010 to 2014.

3.3.2 Seed sales

The density and distribution of sale points is important for effective and efficient seed marketing. In recognition of this, the state has decided to incorporate the transportation costs for seed delivery to sale points into the calculation of the sale price. Moreover, the state has allowed seed companies to freely use the public networks, which have over 380 sale points. The total number of sale points in the country is about 500 (Table 3.17) with a three-year average total annual sales volume of about 1.2 million quintals (Table 3.18). Before 2009, the volume of certified seed sales did not exceed 0.8 million quintals. This increase in certified seed use is partly a result of efforts made by the seed companies and all state structures, and partly a result of the subsidies, which constitute 34% of the calculated selling price of certified R2 seed.

Around 60% of the total certified seed sales of 1.2 million quintals takes place in three regions – Chaouia (Settat, Benslimane), Saïs (Meknes and Fez), and Doukala-Abda (El Jadida and Safi). The share of new varieties (released after 2000) in the total volume of sales increased from 20% in 2008/09 to 43% in 2013/14.

Subsidy on carry-over seed stock

The subsidy for carry-over certified seed stock is fixed at the rate of MAD 45/quintal/year (MAD 5/quintal/month over a nine-month period). The quantities of carry-over seed stocks have been fixed by decree for the period 2011–2015 at an annual level of 22,000 tonnes, distributed proportionally among seed companies according to their share in the total volume of seed sales.

3.3.3 Marketing

Determining the level of certified seed use is a major concern to the seed companies and the public authorities. Seed demand forecasting is complex, but is still being done based on:

- Historical statistical data on domestic seed sales

Table 3.14: Maximum subsidized seed prices (MAD/quintal), 2013/14 crop season

Crop	G3	G4	R1	R2
Bread wheat	455	355	340	325
Durum wheat	500	400	385	370
Barley	445	345	330	315

Table 3.15: Subsidy (MAD/quintal) if maximum sale prices did not exceed those shown in Table 3.14

Origin of production	Generations	Crop		
		Bread wheat	Durum wheat	Barley
National	G3, G4, R1, R2	170	180	160
Imported	G3	500	500	500
	G4	400	400	400

Table 3.16: Evolution of the sale prices and subsidies for bread and durum wheat

Subsidy type	Crop	2010/11	2011/12	2012/13	2013/14
Maximum subsidized sale price (R2) (MAD/quintal)	Bread wheat	310	325	330	325 (320*)
	Durum wheat	355	370	375	370 (365*)
Subsidy (MAD/quintal)	Bread wheat	160	170	170	170
	Durum wheat	170	180	180	180

* Price applied by seed companies.
Note: Unsubsidized price = the maximum subsidized price + subsidy

Table 3.17: Number of distribution networks

Companies	Wholesale points	Retail points	Total
State networks	380–400		380–400
Seed companies	~30		~30
Other (cooperatives and private)		~70	~70
Total	**~430**	**~70**	**~500**

Source: SONACOS (Tables 3.14–3.17).

Table 3.18: Certified seed sales, 2008/09 to 2012/13

Crop season	Crop	Quantity (tonnes)	Share of total (%)
2008/09	Bread wheat	61,950	81.3
	Durum wheat	13,830	18.1
	Barley	440	0.6
	Total	**76,220**	**100.0**
2009/10	Bread wheat	93,100	76.5
	Durum wheat	28,000	23.0
	Barley	670	0.6
	Total	**121,770**	**100.0**
2010/11	Bread wheat	81,200	77.1
	Durum wheat	23,700	22.5
	Barley	420	0.4
	Total	**105,320**	**100**
2011/12	Bread wheat	95,200	77.8
	Durum wheat	26,700	21.8
	Barley	520	0.4
	Total	**122,420**	**100**
2012/13	Bread wheat	99,200	76.3
	Durum wheat	29,200	22.5
	Barley	1,600	1.2
	Total	**130,000**	**100**

Source: SONACOS.

- Varietal development plans of the seed companies
- Adjustments made based on information from regional networks involved in commercialization
- Adjustments made during the sale season based on carry-over stock.

The state has supported domestic production of bread wheat by intensification programs and commercialization, particularly by fixing a reference price and levying tariffs on bread wheat imports. These actions have increased the area used for bread wheat production.

However, the domestic commercialization of durum wheat is determined by the market forces of supply and demand. As a result, the quantity of durum wheat marketed in the formal sector remains only at about 1 million tonnes,

Table 3.19: Average level of certified seed use, 2003–2008

Crop	Area (000 ha)	Total seed needed (000 tonnes)	Average certified seed supply for 2003–2008 (000 tonnes)	Share of certified seed use (%)
Bread wheat	1,900	280	55	19.6
Durum wheat	1,100	140	13	9.3
Barley	2,100	200	2	1.0
Total	**5,100**	**620**	**70**	**11.3**

Source: SONACOS.

while bread wheat has reached about 2.5 million tonnes. In line with the increase in the cereal-growing area and estimated seed needs, the level of certified seed use has increased slightly (it is slightly higher for bread wheat than the rest) over the years to stabilize at the levels shown in Table 3.19 over the last decade.

Even though the average contribution of the formal sector has increased from 11.3% to about 19.6% between 2008 and 2013, the informal seed sector remains dominant. This emphasizes the need for better understanding of the role, the modalities of operation including prices, and the behavior of actors in the informal seed sector. The quantities of certified seeds that are marketed has increased by 86% from 70,000 tonnes before 2008/09 to 130,000 tonnes in 2012/13 (Table 3.20).

SONACOS accounts for 90% of the total volume of certified cereal seed sales. Over the last five years, the volume of sales by private seed companies has increased from 2,000 tonnes to more than 10,000 tonnes. Each private seed company is represented by just one regional seed unit compared with the 14 regional centers for SONACOS. This gives SONACOS a wide presence and more flexibility for inter-regional seed supply.

3.4 Opportunities, challenges, and lessons learned

3.4.1 Major achievements

The GMP and the partnership programs with the different actors in the seed value chain have significantly affected seed sector development. The changes in the formal sector can be summarized as:

- Expansion of the seed multiplication program for autumn cereals
- Increase in the conditioning, treatment, and storage capacity for certified seeds
- Improvement in certified seed use where the rate for autumn cereal reached 19%, against 11% before 2008
- Expansion of the seed distribution network for marketing
- Relative increase in the quantity of seeds of autumn cereal marketed by the private sector
- Reform of the seed regulations
- Consolidation of visible medium-term support for the seed sector by the state
- Establishment of FNIS.

3.4.2 Key challenges

Despite the achievements discussed above, the seed sector has weaknesses mainly characterized by:

- A decrease in INRA varieties registered in the official catalogue over the past 15 years, particularly for wheat, and the non-exploitation of recently registered INRA varieties
- A low level of cereal seed use considering the available seed quantities, which resulted in relatively large carry-over seed stocks
- The limited contribution of the private sector in achieving the GMP targets.

Table 3.20: Changes in the amounts and types of seed marketed between the 2008/09 and 2012/13 crop seasons

Crop	Average seed use before 2008/09 (000 tonnes)	Sales level reached in 2012/13 (000 tonnes)	Share of certified seed used in 2012/13 (%)	Increase (%)
Bread wheat	55	100	35	82
Durum wheat	13	28	20	115
Barley	2	2	1	0
Total	**70**	**130**	**21**	**86**
Average carry-over stocks	20	38		90

Source: SONACOS.

In addition, weak extension activities focused on certified seed promotion and use also pose a major constraint. Challenges related to marketing include:

- Annual variation in seed demand from the users frustrates efforts to establish realistic production plans for the medium term, given the nature of the seed production program
- Difficulty in matching varietal demand from seed users and the preferences of seed growers
- Limited availability of adequate quantities of seed of special varieties
- Rejection of limited amounts of imported seed lots makes it difficult for seed companies to respond to seed growers' demands for those specific varieties
- A grain pricing system that does not consider varietal differences or preferences by users
- The Decree fixing the large carry-over seed stock of 22,000 tonnes during 2011–2015. This imposes a heavy burden of managing, protecting, and maintaining the quality of large amounts of seed. This requires a large-scale operation and hence imposes extra costs on and risks for the seed companies.

3.4.3 Lessons learned

The average wheat acreage for the last decade has been 3 million ha, which needs on average 4.2 million quintals of seed (assuming an average seeding rate of 140 kg/ha). The amount of certified seed used in 2012/13 was 1.15 million quintals. Therefore, the average certified seed coverage compared to total seed use was 27% in comparison to the 16% before 2009. This shows an average increase in certified seed use of 69%. Possible reasons for this may include:

- The dynamics created by GMP, which made possible the broader participation of different actors in the seed sector – particularly in production and commercialization
- The medium-term vision provided by GMP in terms of the objectives and necessary support to the seed sector. It helped the seed companies to establish their medium-term plans in terms of seed multiplication, investment, financing, technical and human resources, and with partners (variety owners, ONSSA, banks, regional ministerial offices, etc.)

- The confidence of seed companies to develop medium-term plans and, hence, invest in infrastructure to increase capacity for production, processing, and treatment
- The efforts made to increase the availability of certified seed through increased acreage for and productivity of seed multiplication in both the rainfed and irrigated areas and technical support to seed growers
- The commitment of the state to subsidize seed prices and minimize the price difference between certified seed (R2) and grain so as not to exceed MAD 50/quintal in 2014 (20%). In previous years, highly variable certified seed prices exceeded grain prices by 50% even with subsidies
- The seed companies have become more proactive in promoting, popularizing, and commercializing the certified seed of high-yielding varieties
- The seed companies have increased their commercial networks from 380 sale points before GMP to about 500 since its launch by combining the use of state networks and private distributors.

3.5 Recommendations

Specific development plans have been drawn up within the PMO contract program of the seed sector concerning food legumes, potatoes, barley, and the constitution of stocks. The recommendations proposed in this chapter are complementary to the new contract program of the seed sector action plan. They are aimed at achieving sustainability of seed production and use of certified seed.

3.5.1 Inclusion of legumes in the production systems

- Legumes, for food or feed, are essential components of sustainable crop production systems. To ensure sustainable wheat-based production systems, actions are needed to include the production of seeds of food legumes and forages for rotation purposes.

3.5.2 Availability and licensing of varieties

- Strengthen the national breeding program by revitalizing wheat breeding; specifically the development of durum wheat varieties with end use quality

- Revise the terms for the licensing of INRA varieties with adequate conditions to ensure their multiplication and commercialization.

3.5.3 Securing seed production

- Define specific frameworks or guidelines for multiplication of pre-basic seed of national varieties
- Establish mechanisms to produce pre-basic and basic seed of foreign varieties in Morocco
- Maintain minimum seed production by multiplying seeds in irrigated areas
- Strengthen the professionalism of seed growers by imparting knowledge and skills.

3.5.4 Marketing and promotion of certified seed use

- Extend the current seed marketing network and exploit other private distributors of inputs
- Rehabilitate public markets (vendors and agents) and establish new agreements for seed – ONCA companies seen to specify the obligations of each party
- Build awareness of the use of certified seeds (trials, economics, etc.)
- Target seed distribution, taking into consideration the adaptation of varieties and production cycles to the target areas
- Study the factors limiting the contribution of private sector operators in the cereal seed sector
- Launch a study of the seed market and the informal seed sector.

3.5.5 Seed security stock

- Determine the levels of seed security stock needed for each crop group and generation
- Review the mechanisms for establishing and financing seed security stocks.

3.5.6 State support

- Set a long-term vision for the financial support of the seed sector from the state
- Review the level of support for seed security stocks.

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Chapter 4: Seed quality assurance and certification

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4 Seed quality assurance and certification

4.1 Executive summary

This chapter summarizes the regulatory frameworks and technical procedures in seed quality control and certification. ONSSA is responsible for the implementation of the relevant laws, regulations, and decrees for seed quality control and certification. In Morocco, only varieties registered in the official catalogue are eligible for varietal certification. Only seeds meeting field and seed standards can be labeled as "certified seed" and marketed to farmers. Thus both variety registration and seed certification are compulsory. Field inspection is carried out according to OECD seed schemes whereas sampling and testing of seed lots are conducted according to the rules, methods, and procedures of ISTA.

From 2006/07 to 2012/13, an analysis of data supplied by ONSSA shows a progressive increase in the area used for the production and quantity of certified wheat seed produced to meet the national demand. During the seven-year period, the bread wheat seed production area increased from 30,025 ha to 56,598 ha, an increase of 89%, with an average rejection rate of 5.6%. Likewise, the production area for durum wheat seed increased from 9,331 ha to 16,795 ha, an 80% increase, with an average rejection rate of 8%. The average total area dedicated to the production of certified seeds during the seven-year period was 59,023 ha. Of this area, 46,642 ha was for bread wheat and 12,561 ha was for durum wheat.

Like the area for seed production, the production of certified seed increased substantially during the seven-year period. For bread wheat, the quantity of certified seed controlled for seed quality increased from 39,716 tonnes (from 1,778 seed lots) to 127,440 tonnes (to 5,453 seed lots), a 220% increase in quantity with an average rejection rate of 8% (303 seed lots). For durum wheat the quantity of certified seed tested increased from 12,253 tonnes (from 577 seed lots) to 44,611 tonnes (to 1,276 seed lots), a 264% increase with

a rejection rate of 25.2% (321 seed lots). The average total annual certified seed production, during the seven years, was 112,046 tonnes, of which 85,035 tonnes was bread wheat and 27,011 tonnes was durum wheat. The rejection levels, both during field inspection and seed testing, are within the acceptable range given the high national field and seed standards. However, for the durum wheat-seed lots the average rejection level of 26.2% was substantially higher than that for bread wheat seed (8%). A previous study had shown also a high rejection rate for the certified seed of durum wheat, primarily the result of poor germination arising, particularly, from mechanical damage during harvesting.

Meeting the GMP targets of producing 280,000 tonnes of certified seed of cereals and increasing the rate of certified seed use (estimated to reach 40% by 2020) warrants an expansion of the current capacity. Improvements are required in the physical, financial, and human resources available for seed quality control and certification. During the study, a new reference seed testing laboratory for ONSSA was under construction. Four additional regional private sector laboratories, under the supervision of ONSSA, are planned for subsequent years.

The increase in the number of seed testing laboratories is required to cope with the substantial expansion in the certified seed production program. The envisaged training plan would also solve the capacity problem but may not ensure the economic feasibility of the seed certification scheme through government support alone. Accreditation of seed companies to undertake certain responsibilities of field inspection and seed testing is of paramount importance and should be accelerated, as envisaged in the plan. In 2009, an agreement between the Moroccan government and FNIS stipulated the gradual transfer of certain tasks of seed certification. FNIS will be accredited to undertake these activities based on international experience provided by OECD and EU, under the supervision of ONSSA. The accreditation system is expected to be established gradually by 2017.

4.2 Introduction with historical context

The main purpose of seed certification is to guarantee varietal purity, identity, and seed quality in terms of purity, germination, and seed health. In Morocco, seed certification started in the early 1920s and the first legislative texts were promulgated in the 1940s. Prior to 1980, seed certification was conducted by agricultural research and development services (Direction de la Recherche Agronomique). After 1980, the Service de Contrôle des Semences et des Plants

(DPVCTF) was established as an independent and official organization within the Ministry of Agriculture (MoA) and became responsible for seed certification. From 2010, the seed certification activity came under the responsibility of the Office National de Sécurité Sanitaire des Produite Alimentaires (ONSSA).

4.3 Regulatory frameworks

The Moroccan Seed Law No. 1-76-472 of 19 September 1977 is the basic text for seed production, control, certification, and trade. To implement the law, several regulations related to certification, importation, and the marketing of seeds were promulgated, in particular:

- Technical regulations for the production, control, and certification of cereal seeds were promulgated in 1977 and modified in 2013
- Technical regulations for the production, control, and certification of food legumes were promulgated in 1977
- A ministerial decree for seed imports was promulgated in 1993 and amended in 1994.

Control and certification are conducted based on officially adopted technical regulations specific for each species or group of species. The technical regulations define several things:

- The requirements for seed producers and seed growers
- The eligibility of varieties
- The generations for seed multiplication
- The specifications for seed production, including field size, previous crops, isolation, field and seed standards, field and laboratory control, seed treatment, labeling; and packaging.

4.4 Institutional arrangements

ONSSA is responsible for implementing seed certification. Each year, the seed growers enter into contractual agreements with seed companies for the multiplication of different seed classes (generations). Each seed grower declares the requirements of the technical regulations, including the area, crop, variety, and seed class under multiplication through the contracting seed companies. Following this declaration, an official control is conducted by ONSSA both in the field and in the laboratory. This control is made according to officially adopted regulations and procedures of seed certification within the national seed law

and implementing regulations and decrees. Only seeds fulfilling regulatory standards both in the field and the laboratory can be labeled as "certified seed" and marketed as such.

Following the certification (seed field inspection and laboratory seed quality testing) the seed will be treated and labeled under the supervision of ONSSA, the service in charge of seed control and certification. During the commercialization of seed, the Division de Contrôle de Produit Végétaux will take samples for marketing control. In case the decision to reject after field inspection or seed testing is contested by the grower or seed company, a committee, composed of representatives from ONSSA, the seed company, and the seed grower, will review the report and decide or make a recommendation.

4.5 Technical procedures

In Morocco, only registered varieties listed in the official catalogue are eligible for seed certification. All seed classes, including G1, are certified by ONSSA; and only certified seed can be multiplied from one generation to another or marketed to the farmers/end-users.

4.5.1 Application for certification

The seed growers will make declarations and submit the application for seed certification to ONSSA. The application specifies the grower, location (GPS), crop, variety, area, mother seed, seed class, and the seed company. After verification of the declaration, a lot number is assigned to the production. Annually about 1,200 seed growers – members of AMMS – are involved in the contract seed production program. The declaration should be submitted before 15 January for autumn sown species (cereals, food legumes, annual forage, and certain oil crops), before 15 April for spring sown crops (maize, sunflower, lucerne, sorghum, etc.) and before 15 June for summer sown crops (rice). For self-pollinated crops, such as wheat, the seed classes to be certified include pre-basic seed (G1 and G2), basic seed (G3 and G4), first reproduction (R1), and second reproduction (R2).

Field inspection

The minimum field size allowed for wheat-seed production is 3 ha in the irrigated areas and 7 ha in rainfed areas. Seed production fields should meet field standards in terms of cropping history, isolation, specification, and sowing methods as well as varietal purity, other crops, noxious weeds, and seed-borne diseases. Two field inspections are conducted during the growing season,

based on the technical regulations and procedures. The first of these occurs at the heading stage (cereals) to verify the field, variety, generation, varietal purity, and seed-borne diseases. The second takes place at maturity to identify the specific and varietal purity and to estimate the yield per hectare and total production based on yield components.

4.5.2 Seed testing

Seed production fields that meet these standards are harvested and transported to the processing centers of the seed companies. The seeds will be cleaned and subdivided into seed lots of 30 tonnes for cereals. Seed sampling and testing is carried out according to the rules, procedures, and methods developed for each species by ISTA. A composite sample will be subdivided into three sub-samples, each about 2 kg. One sample is retained by the seed company and two samples are sent to the laboratory – one for seed quality testing and the other as a reference sample to be kept until the next harvest time. Annually 10,000 to 12,000 seed samples are tested, corresponding to 48,000 to 52,000 laboratory analyses mainly for purity, germination, specific weight, and moisture content.

4.5.3 Post-control plots

The post control is conducted according to the procedures of the OECD seed certification scheme. The objective is to evaluate the seed control and certification systems. The post-control tests are conducted in the Varietal Control and Quarantine Station of ONSSA at Bouznika. For pre-basic and basic seed 100% of the lots are represented. These are used as pre-controls and provide an opportunity to remedy any quality issues and as a reference. For R1 and R2 seeds, 20% of the R1 lots and 10% of the R2 are represented.

4.5.4 Seed certification

Only seed lots fulfilling both the field and seed standards can be certified and, therefore, treated, labeled, and sealed. Labels with all the necessary information regarding variety, class, and seed quality standards are provided by ONSSA. Certified seeds of cereals produced and not sold in the same year can be stored and sold during the next two years, provided the quality is maintained (for germination). However, the carry-over seed lots should be tested for germination three months before marketing.

4.5.5 Market control

Seed quality control is carried out at all stages of production, processing, storage, and marketing and is exercised for seeds of all generations so that each seed lot can be traced back to its origin. ONSSA also undertakes market control where the quality of seed is monitored during seed marketing and distribution as part of market enforcement.

4.6 Major achievements

The seed certification scheme is an independent entity from seed production, processing, and marketing. The seed certification scheme, both for field inspection and laboratory seed testing, guarantees the quality of the seed available on the market. The seed system related to the production, control, certification, and marketing of seeds in Morocco is based on the adopted legislative and regulatory texts and procedures. These texts and procedures have been established in harmony with international regulations, methods, and procedures. This conformity allowed Morocco to join the OECD seed certification schemes in 1989, those of the EU in 1991, those of ISTA from 1964 to 2004, and those of UPOV in 2004 (Tourkmani 1994).

Table 4.1 shows the results of field inspection and laboratory analyses for bread wheat from the 2006/07 to the 2012/13 crop seasons. During the last seven years the area of the seed production fields has almost doubled from 30,025 ha to 56,598 ha. The average rejection level was 5.6%, which is quite acceptable. The major cause for rejection is more a lack of adherence to the production guidelines than the problem of seed quality, with a few exceptions to this. The number of seed samples analyzed increased from 1,778 to 5,453 – a three-fold increase – while the average rejection rate was 8% except in 2010/11. In this crop season there was an exceptionally high rejection level of 24% because of failure to meet the minimum standard for the specific weight of the seed lots. The amount of certified seed analyzed also tripled from 397,160 quintals to 1,274,401 quintals, with an average rejection of 64,368 quintals (8%), which is reasonable compared to the level recorded during the 2010/11 crop season.

Table 4.2 presents field inspection and laboratory analyses results for durum wheat from the 2006/07 to the 2012/13 crop seasons. During the last seven years the seed production area has increased 1.8-fold, from 9,331 ha to 16,795 ha. The average rejection level was 8%, which is slightly higher than for bread wheat, but still quite acceptable. Again, the major cause for rejection,

Table 4.1: Bread wheat field inspection and laboratory seed analyses results, 2006/07–2012/13 crop seasons

Crop season	Field inspection						Laboratory seed testing							
	Number of fields	Area planted (ha)	Area approved (ha)	Area rejected (ha)	Proportion of area rejected (%)	Main reasons for rejection	Quantity of seed analyzed (quintal)	Quantity of seed approved (quintal)	Quantity of seed rejected (quintal)	Proportion of seed rejected (%)	Number of seed samples	Number of seed samples rejected	Proportion of seed samples rejected (%)	Reasons for rejection
2006/07	964	30,025	27,216	2,809	9.4	Previous cropping	397,160	377,704	19,456	4.9	1,778	97	5.5	Other crops
2007/08	1,532	42,925	40,821	2,104	4.9	Previous cropping	772,455	718,545	53,910	6.9	3,516	264	7.5	Other crops
2008/09	1,166	32,951	30,860	2,091	6.3	Noxious weed	727,447	706,011	21,436	2.9	3,212	113	3.5	Other crops
2009/10	1,671	50,854	47,960	2,894	5.7	Previous cropping	697,761	659,766	37,995	5.4	3,143	185	5.9	Other crops
2010/11	1,953	57,334	56,127	1,207	2.1	Previous cropping	890,757	681,489	209,268	23.5	3,965	953	24.0	Specific weight
2011/12	1,852	54,546	52,124	2,422	4.4	Previous cropping	1,192,436	1,126,895	65,541	5.5	5,255	316	6.0	Other crops
2012/13	1,870	56,598	51,936	4,662	8.2	Noxious weeds	1,274,401	1,231,426	42,975	6.6	5,453	194	3.6	Other crops
Average	1,573	46,462	43,863	2,598	5.6		850,345	785,977	64,369	8.0	3,760	303	8.0	

Source: ONSSA.

with a few exceptions, was a lack of adherence to the production guidelines rather than a problem of seed quality.

The number of seed samples analyzed increased from 577 to 2,054, a 3.6-fold increase, while the average rejection was about 25.2%, which is exceptionally high. A previous study had also shown a high rejection rate for the certified seed of durum wheat primarily because of poor germination arising from mechanical damage during harvesting (Grass and Tourkmani 1999). Similarly, the amount of certified seed analyzed increased 3.6 times from 122,531 quintals to 446,614 quintals, with an average rejection of 65,393 quintals (25%). The rejection levels for durum wheat seed resulted from its admixture with other crop seeds; this was much higher than that of bread wheat.

4.7 Key challenges

Taking into consideration the expansion of the seed production program to meet the GMP target of 280,000 tonnes by 2020, the current capacity of seed certification needs to be rationalized in terms of the available physical, financial, and human resources. Accreditation of seed companies to undertake certain responsibilities of field inspection and seed testing is of paramount importance and should be accelerated. Morocco is a member of the OECD seed scheme and was previously a member of ISTA.

Despite the long history of ISTA membership, the national seed testing laboratory did not achieve ISTA accreditation; a consequence of bureaucratic hurdles at the time when this study was conducted. This has had repercussion on the international seed trade, where only accredited laboratories issue ISTA orange certificates, and for countries involved in the international seed trade. If the Moroccan seed sector wants to be linked to the global seed industry it needs to expedite the process for ISTA accreditation.

4.8 Lessons learned

During the last 35 years, Morocco has established a strong seed certification scheme. It adheres to OECD seed certification schemes for field inspection

Table 4.2: Durum wheat field inspection and laboratory seed analyses results, 2006/07–2012/13 crop seasons

Crop season	Field inspection						Laboratory seed testing							
	Number of fields	Area planted (ha)	Area approved (ha)	Area rejected (ha)	Proportion of area rejected (%)	Main reasons for rejection	Quantity of seed analyzed (quintal)	Quantity of seed approved (quintal)	Quantity of seed rejected (quintal)	Proportion of seed rejected (%)	Number of seed samples	Number of seed samples rejected	Proportion of seed samples rejected	Reasons for rejection
2006/07	370	9,331	8,616	715	7.7	Noxious weeds	122,531	93,327	29,204	23.8	577	146	25.3	Other crops
2007/08	492	10,721	9,798	923	8.6	Specific purity	193,224	127,741	65,483	33.9	958	331	34.6	Other crops
2008/09	545	12,549	11,292	1,257	10.0	Weeds and previous crops	296,212	185,796	110,416	37.3	1,375	520	37.8	Other crops
2009/10	548	11,744	10,709	1,035	8.8	Sowing techniques	186,980	144,423	42,557	22.8	933	216	23.2	Other crops
2010/11	572	12,505	11,545	960	7.7	Previous crop and harvesting before final control	301,438	223,280	78,158	25.9	1,404	372	26.5	Specific weight and germination
2011/12	703	14,280	13,760	520	3.6	Previous crops	343,780	279,756	64,024	17.8	1,631	340	20.8	Other crops
2012/13	870	16,795	15,201	1,594	9.5	Previous crops	446,614	378,705	67,909	15.2	2,054	320	15.6	Other crops
Average	585	125,611	10,160	1,001	8.0		270,111	204,718	65,393	24.2	1,276	321	26.2	

Source: ONSSA.

and control plot testing as well as ISTA rules, procedures, and methods used for laboratory seed testing to ensure quality. Morocco became a member of the OECD seed schemes in 2004 and was a member of ISTA until then. The national seed quality control and certification scheme is well established, though there are some shortcomings as indicated in the key challenges.

ONSSA ensures that only certified seeds with all the necessary accompanying information are marketed. It also undertakes market control to ensure that the seeds in the market comply with national standards. All carry-over seed lots should be tested for germination three months before marketing.

In 2009, a contract was signed between the government and FNIS, among others, stipulating the progressive transfer of tasks, such as VCU trials, field inspection, and laboratory seed quality analyses. FNIS will undertake these activities, based on international experience gained from the OECD and EU, under the supervision of ONSSA. The accreditation system will be established progressively from 2013 to 2017. The procedures will be elaborated and adopted defining the tasks of each party. A training program will be organized to strengthen the capacity of the staff.

Since 2012, the Seed and Plant Control Division (DCSP) has started a process to be certified for ISO 9001. Both the internal and white audits have been completed and the final audit will be accomplished in June 2014. DCSP will soon be ISO 9001 certified.

4.9 Recommendations

To fulfill the GMP targets, ONSSA has developed a strategy to strengthen and expand its operations by establishing physical facilities. These include a national reference laboratory and regional seed laboratories. It needs to develop a national accreditation system for field inspection and seed testing through the participation of the seed companies, and to secure ISO 9001 certification of the DCSP.

A new national seed testing laboratory is under construction at the ONSSA experimental station in Bouznika. All the necessary human resources and physical facilities will be made available for the new unit to be accredited by ISTA and to serve as a national reference laboratory. In parallel with the construction of a central seed testing laboratory, a network of regional seed testing laboratories will be progressively established in the major seed production areas – Berkane for the northeast region, Meknes for the Saïs plateau, Beni Mellal for Tadla and Haouz plains, and Taoudante for the south.

Continuous government support will be needed for ONSSA to implement the strategy developed for expanding its physical facilities and accreditations at national and international levels. Morocco needs to be integrated with the global seed industry and to achieve this objective it will require accreditation by international organizations, such as ISTA; this is of paramount importance. This will enable the government to strengthen the seed certification scheme in the country and at the international level.

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Chapter 5: Analysis of the adoption, impacts, and seed demand of improved varieties

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5 Analysis of the adoption, impacts, and seed demand of improved varieties

5.1 Executive summary

There is very limited information about the national level adoption of improved wheat varieties in Morocco. Except for some estimates based on secondary data, the same is true for household, regional, and national level seed use. A nationally representative sample of 1,230 farm households from 21 provinces distributed across 56 districts and 292 villages was selected. Using a variety of methods, including descriptive statistics, the Heckman selection model, duration analysis, propensity score matching, and endogenous switching regression this study attempted to provide:

- Accurate estimates of the current national and provincial adoption levels of improved varieties, with special attention to their release date
- An analysis of factors influencing the decisions and speeds of adoption of improved wheat varieties
- Estimates of the impacts on livelihoods' indicators, particularly yield, net income from wheat, and wheat consumption
- Estimates of farm, provincial, and national level seed demand.

Survey results show that there are 40 wheat varieties in farmers' hands. Of these, 19 have been identified as bread wheat varieties and 15 as durum wheat varieties, while the remaining 6 were not identified. Of the 34 bread wheat varieties identified, some of them were released as recently as 2010, but the majority (25) are more than 10 years old with 10 of them more than 20 years old. Of the 27 varieties for which the breeding programs were identified, 18 came from the INRA breeding program. Of all the varieties released by INRA, 94% have come from the joint INRA/ICARDA/CIMMYT program, showing strong collaboration between INRA and CGIAR.

Of the 40 wheat varieties found in farmers' hands, the top 10 varieties are being cultivated by more than 91% of wheat growers on 92% of the total

wheat area. Among the top 10 varieties, four, which are all at least 24 years old, cover 56% of the total wheat area – showing that old varieties still dominate the Moroccan wheat fields. The top two, in terms of number of growers, are Karim and Achtar, which are being cultivated by 38.1% of Moroccan farmers. The 17 varieties that came from the joint INRA/CGIAR breeding programs over the last 40 years are being cultivated by 81.8% of the wheat growers in the country – showing that the joint INRA/CGIAR varieties are still dominant among Moroccan farms.

Farmers had none of the INRA/CGIAR varieties released in the last 10 years and varieties which are between 10 and 20 years old are being cultivated by only 15% of farmers. This shows that the INRA/CGIAR varieties, which were released over 20 years ago, are still dominant in the Moroccan farmers' portfolios. The national adoption rates for more recent releases, generally, stand at very low levels. Only 16% of Moroccan wheat growers cultivate varieties that were released 10 or less years ago, while 48% of the farmers cultivate varieties 20 or less years old on 41% of the total wheat area. With an area-weighted national average varietal replacement rate of 22 years, very old varieties still dominate the Moroccan farmers' portfolios where more than 58% of the growers are still cultivating varieties that were released over 20 years ago. This raises some important questions: Are there new improved INRA/CGIAR varieties that are superior to these old ones? Are there new and better varieties from INRA/CGIAR that the farmers are not aware of or are these newer varieties not reaching them? Are these old varieties performing well and still better than more recent INRA/CGIAR ones and, hence, farmers prefer them?

Survey results showed that farmers are not up-to-date in terms of new varieties and, when they are, seeds of new varieties are often not available. This confirms that lack of information and non-availability of the seeds of the most recent varieties in the market provide part or all the explanation for the dominance of old wheat varieties. Among the many other factors, access to seed proves to be an important factor in determining farmers' adoption decisions. The combined effect of factors affecting access to seed (i.e. proximity to seed source, the ability to use certified seed, and the ability to buy seed from seed companies in adequate quantities and in a timely fashion) helps explain why improved varieties have been adopted by just 15% of farmers. While this figure is high in and of itself, it is not high enough to be the whole reason for the poor adoption levels. Instead, farmers' characteristics were found to be the

most important explanatory variables. These accounted for 45% of the total variation. These were followed by farm characteristics, which explained 19% of the variation.

In a quest to develop a deeper understanding of the role of gender in varietal adoption, qualitative analysis was also carried out using a separate survey conducted in the Saïs region of Morocco. The analysis identified gender gaps in access to information on wheat production. A bias in favor of men in establishing the traits of improved wheat varieties, also plays a part. The findings revealed that landowners' (often male) access to wheat-related innovations through diverse means, such as farmers' field schools are other factors. While it is often assumed that men transmit knowledge to their wives, our findings reveal that women called all wheat varieties "technique" as opposed to men who knew the variety names and used technical terms for improved agronomic practices. This indicates a large knowledge gap about wheat varieties. These considerations for women's improved access to information about new wheat varieties are particularly important as our survey results show that women make adoption decisions, mainly with regards to varieties grown for home consumption, and their trait preferences generally differ from those of men.

The adoption of improved wheat varieties led to a 482 kg/ha (49%) increase in yields, a MAD 1,324/ha (48%) higher net income, and a 29.6 kg/capita/year (60%) increase in wheat consumption. Given the 41% adoption levels, these gains clearly show that the improved varieties are contributing to improvements in livelihoods at household and national levels. The typical farmer in Morocco uses an average seeding rate for wheat of 176 kg/ha (250 kg/ha for irrigated areas and 157 kg/ha for rainfed areas). This translates to a national seed use rate of 5.12 million quintals/year. Of the total seed used, 43% is planted in favorable zones and 33% in intermediate ones, while the remaining 24% is used in the unfavorable and mountainous zones. Of the total wheat seed used nationally in the 2011/12 cropping season, 22% was confirmed to have come from the formal sector while the remaining 78% came from other sources, including local seed dealers, seed dealers in neighboring villages, and own-saved seed. The average seed replacement rate is 2.1 years; some farmers replace the seed every year and others have not replaced their seed for more than 10 years. Farmers stated that non-availability of the desired seeds and high seed prices are the most important problems regarding seed.

5.2 Introduction

5.2.1 Background

Durum wheat was introduced into the country around the seventh century AD. The first bread wheat cultivars introduced into the country were of Algerian origin. By 1929, bread wheat acreage reached 0.25 million ha, with European cultivars constituting about 33%. In the late 1940s, the bread wheat area increased to between 0.3 and 0.4 million ha while the durum wheat area was about 1 million ha (Grillot 1948). For the next four decades, the bread and durum wheat areas stabilized at about 0.5 and 1.2 million ha, respectively. These areas subsequently changed. By 2008–2012, the averages were 2.04 million ha for bread wheat and 0.94 million ha for durum wheat. In the early 1980s, wheat in general, and bread wheat in particular, constituted 43% and 31%, respectively, of the total area planted to cereals. By 2010, these figures had increased to 59% and 40%, showing the growing importance of wheat in general, and bread wheat in particular, in Moroccan agriculture (Figure 5.1).

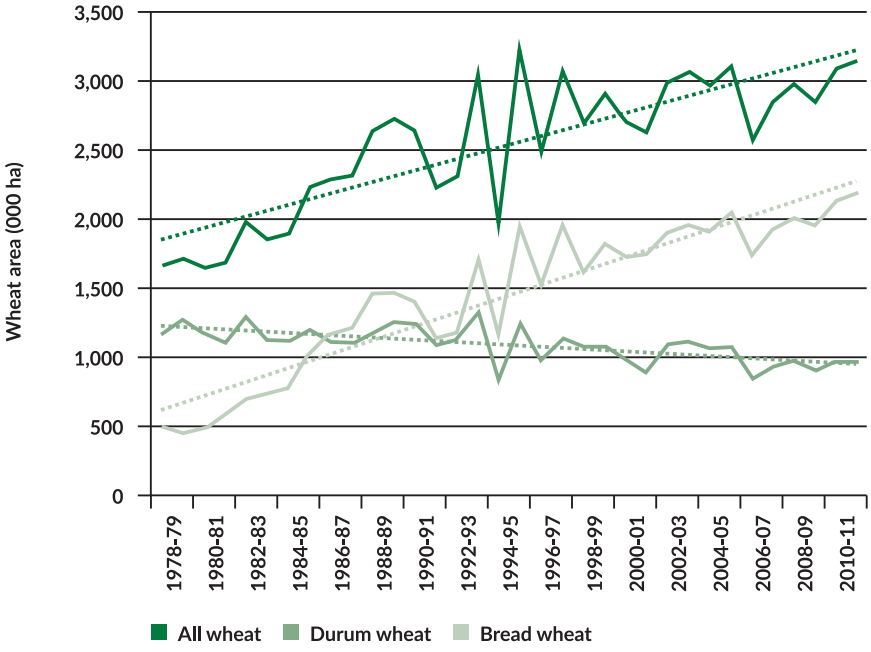

Figure 5.1: Trends in the wheat area in Morocco

Source: Directorate of Strategies and Statistics (DSS) – MoA.

While the areas of both bread and durum wheats have been increasing since the 1980s, the spectacular increase in the bread wheat area is essentially the result of the intensification policies that have been pursued by the government since the early 1980s. The policy was launched by the Ministry of Agriculture in 1985 with the objective of increasing bread wheat production through wider adoption of improved varieties. The policy incentives that were used to encourage the production of bread wheat by farmers included guaranteed prices for the producer and fixed marketing margins. Currently, the value of bread wheat production represents 47% of the total value of cereals while durum wheat and barley constitute 27% and 23%, respectively.

During the 1960s and 1970s, wheat yields at the national level remained at low levels – about 0.9 t/ha. The main reason for this was the low yield potential of the cultivars that existed in the country. With the arrival, in the 1980s, of a new and improved bread wheat variety, Nasma, and a durum wheat variety, Kyperounda, yield levels started to increase (Figure 5.2). After a decade, in 1990, average yields had reached about 1.21 t/ha for durum wheat and 1.3 t/ha for bread wheat. With the introduction of many newer and improved varieties (such as Marchouch and Achtar for bread wheat and Cocorit and Karim for durum wheat) in subsequent years, significant increases in wheat yields were observed in Morocco. They reached a 10-year average (for 2003–2012) of 1.53 t/ha for durum wheat and 1.57 t/ha for bread wheat. These figures represent a 26% increase in durum wheat yields and a 20% increase in bread wheat yields since 1990. A series of government interventions were responsible for this increase. They included a re-orientation of the breeding program more towards disease and drought tolerance, establishment of a certified seed subsidy program, and the launching of a large-scale demonstration of new cultivars through the national agricultural extension program.

While the trend in the cultivated areas showed a consistent, though slight, increase over the years, yield and production during the same period exhibited high variability. Rainfall variability is believed to be the major reason behind these fluctuations (Figure 5.3). With a 10-year average of about 2.96 million ha for the total wheat area and a total wheat production of 4.65 million tonnes, domestic production in Morocco falls far short of meeting national consumption needs. The country is left dependent on imports for about 50% of its domestic demand. As a result, wheat imports have generally exhibited an increasing trend, especially since 1995 (Figure 5.4).

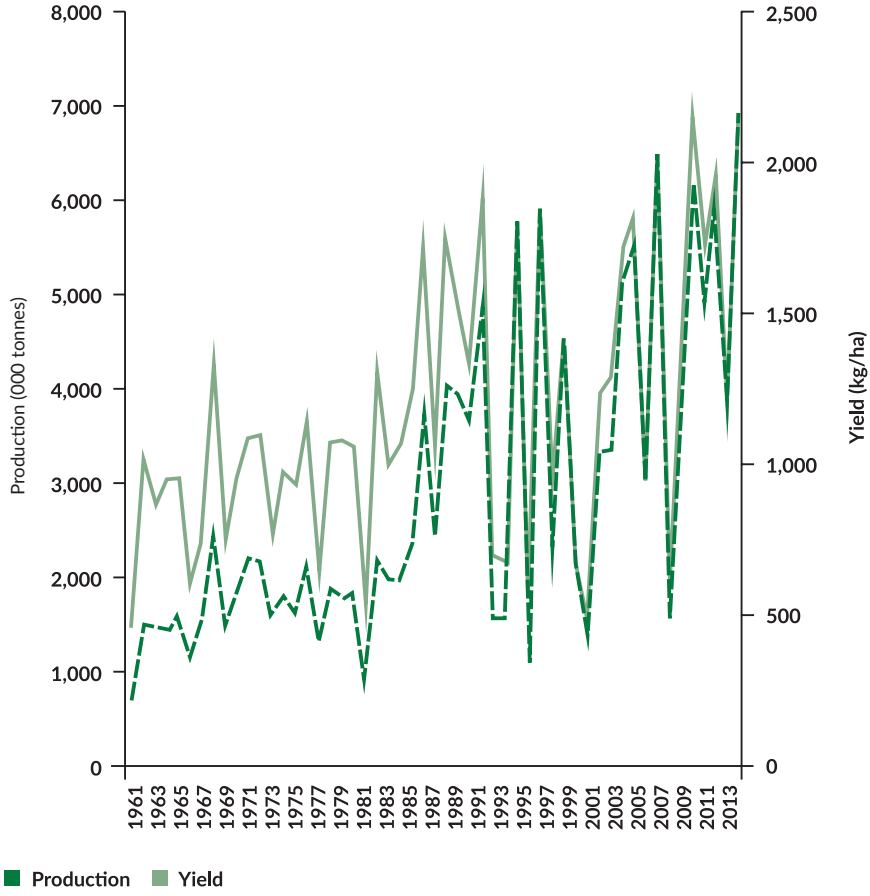

Figure 5.2: Trends in production and yield of wheat in Morocco, 1961–2013

Source: FAOSTAT 2018 (http://www.fao.org/faostat/en/#data/QC).

Low yield levels in Morocco are the primary reason for the mismatch between production and consumption. Even though Morocco has achieved substantial yield increases over the years, current yield levels of about 1.5 t/ha remain far behind both the global average of over 3 t/ha and the African average of 2.3 t/ha (FAOSTAT 2014). The Government of Morocco has demonstrated its commitment to the development of the wheat sector, among other things, by its sizeable investment in the INRA wheat breeding program. In Morocco,

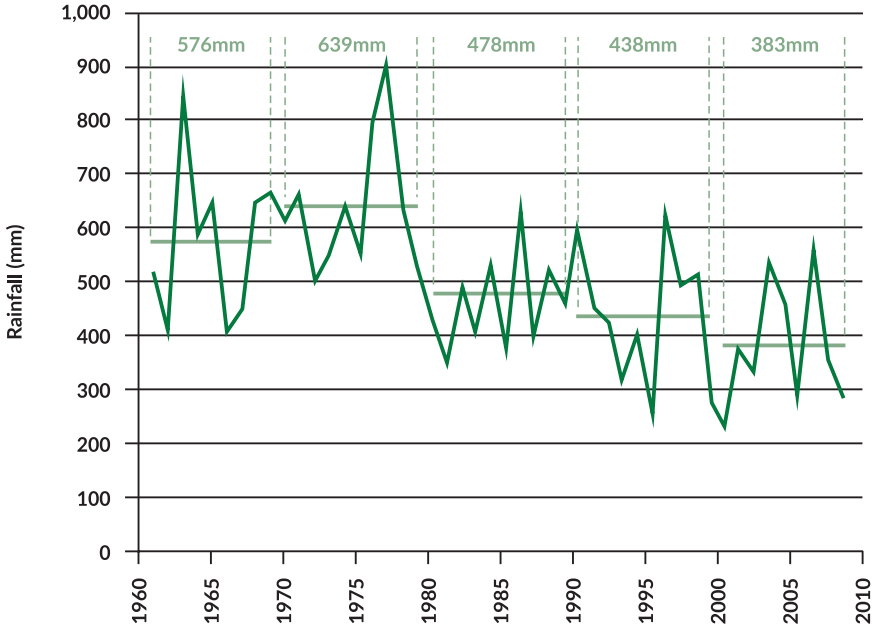

Figure 5.3: Rainfall pattern in Morocco 1960–2010

Source: Nasarellah (2012).

this investment has averaged about USD 0.3 million/year – making the wheat program at INRA one of the leading wheat breeding programs in the region.

5.2.2 Brief history of wheat breeding program

Morocco was home to various local wheat land races that have been used by Moroccan farmers since before the 1920s. However, these varieties had several limitations, including poor yield potential, lack of adaptive capacity, and instability of traits. For these reasons most of them are now out of production (Nasarellah 2012). The land races were predominantly late maturing, tall and hence susceptible to lodging, and they had poor resistance to diseases. As a result, early wheat breeding programs in the country focused on the development of early maturing varieties and resistance to Septoria and rust. After independence, the wheat breeding program gave priority to drought tolerance and resistance to Hessian fly, which was the main constraint for wheat production in semi-arid zones. More recently, the wheat breeding program has included grain quality into the breeding objectives.

INRA has also been actively working with international research organizations, such as the International Wheat Improvement Center (CIMMYT) and the International Center for Agricultural Research in the Dry Areas (ICARDA). These organizations have made tremendous investments in further developing the capacity of INRA with training and joint development and release of several improved wheat varieties. As a result, several durum wheat varieties adapted to Moroccan conditions have been jointly developed. These have a wide spectrum of traits (such as high yields, semi-dwarf, lodging resistance, drought tolerance, and resistance to Hessian fly and various fungal diseases). These varieties released by INRA included 25 bread wheats and 34 durum wheats. Given the strong national agriculture research system in the country and the active collaboration with international agricultural research institutions, the current yield levels are rather depressing. This calls for a

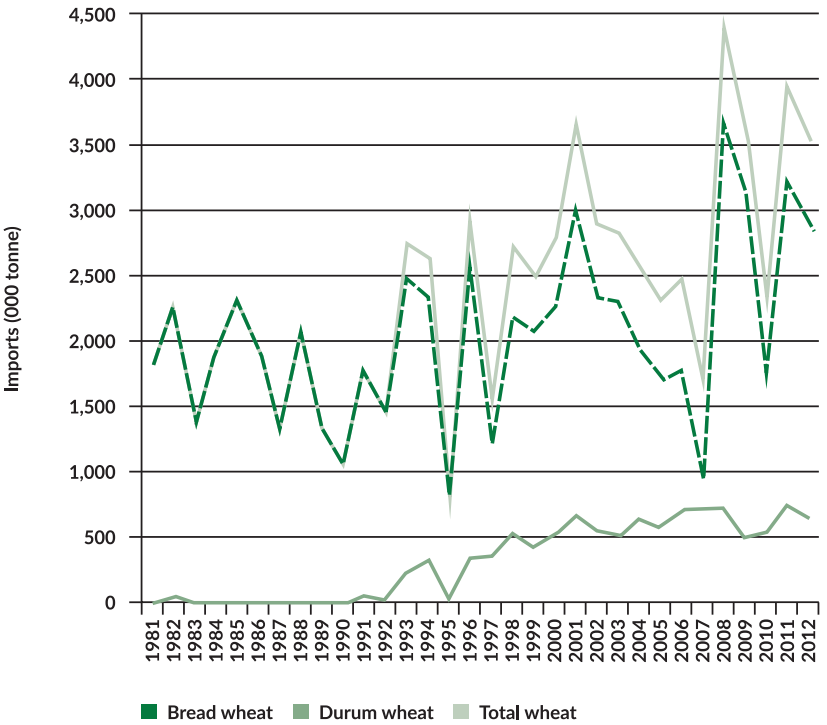

Figure 5.4: Trends in Moroccan wheat imports 1981–2012

Source: Directorate of Strategies and Statistics (DSS) – MoA.

thorough study to understand the current adoption levels and underlying reasons that prevent Moroccan wheat farmers from exploiting the yield potentials of available varieties.

5.3 Objectives

Over the years, about 60 improved varieties of wheat have been released by INRA. While national level data on wheat varietal adoption is scanty, most of the new varieties appear not to have reached farmers. Access to seeds of improved varieties, in general, and certified seeds, in particular, is often cited among the major determinants of successful adoption among farmers. Many studies conducted in both the developing and developed world cite farm, farmer, socio-economic, institutional, biophysical, and ecological factors as important determinants of adoption. This report, therefore, aims to make authoritative statements about the current levels of adoption of improved wheat varieties and their impacts, based on reliable estimates generated using statistically representative national data. Particularly, the report attempts to:

- Provide an exhaustive list of varieties that are in farmers' hands
- Determine the current levels of use (in terms of the proportion of farmers using and the share of the area planted) of each of the local land races found in farmers' hands and identify the provinces in which they are grown
- Determine the adoption levels of improved wheat varieties (in terms of both the proportion of farmers using and the share of the area planted) at national, regional, and provincial levels
- Determine the current adoption levels by variety and by agro-ecological classifications
- Identify the major determinants for the decision to adopt improved wheat varieties and the speed of implementing that decision
- Identify farmers' preferences and breeders' objectives and conduct a congruence/divergence analysis
- Determine the types of seed from the different sources used by farmers and the reasons for farmers' decisions to use these types and sources
- Determine the total seed demand by source
- Measure the effects of the adoption of new improved wheat varieties on farm households' incomes and wheat consumption
- Make comparisons between the net margins for wheat grain and wheat seed production.

5.4 Survey design

According to the Ministry of Agriculture (MoA), Morocco is subdivided into six agro-climatic zones. These are the favorable zone, the intermediate zone, the unfavorable south, the unfavorable east, the mountainous zone, and the Saharan zone. Cereal production in the Saharan zone is essentially limited to barley and represents only about 2% of Morocco's rainfed cereals. The unfavorable east zone also has similar characteristics. Therefore, as wheat production is either non-existent or very much limited, both agro-ecological zones were excluded from this study. Thus, the four zones considered in this study were the favorable, intermediate, unfavorable south, and the mountainous ones.

A careful study of the data on wheat production in the various provinces of Morocco was undertaken to identify the limitations in financial and human resources. All participants in the CRP3.1-funded Wheat Adoption and Seed System Analysis Project inception workshop, held 28–30 June 2012, decided to limit the coverage of the survey to 90% of total national production and not more than 15 provinces. Accordingly, the top 15 wheat producing provinces, which account for about 79% of total wheat production, were selected for inclusion in the survey (Table 5.1). During the preparation for the survey, the study team learned that a new administrative reclassification has taken place in 2009. The 15 provinces selected for the survey became 21. This reclassification led to the distribution of wheat areas as follows:

- The wheat area of Berrechid represents 34% of the wheat area of old Settat
- The wheat area of Guercif represents 20% of the total wheat area of old Taza
- The wheat area of Sidi Bennour represents 47% of the wheat area of old El Jadida
- The wheat area of Sidi Slimane represents 20% of the wheat area of old Kénitra
- The wheat area of Rehamna represents 67% of the wheat area of old El Kelâa
- The wheat area of Moulay Yaâcoub represents 87% of the wheat area of old Fez.

Table 5.1: Major wheat producing provinces of Morocco (according to the old classification)

Rank by production	Province	Production (000 tonnes) (10-year average for 2002–2011)	Share of total national production (%)	Cumulative share of production (%)	Agro-ecological zone	Water source	Experts' opinion on the climate change impact and extent of adoption of improved wheat varieties (1=low and 5=high)		Expert estimates of adoption rate (Share of area [%])
							Extent of climate change impact	Level of adoption of improved wheat varieties	
1	Sidi Kacem	395.99	8.60	8.60	1	3	1	3	45
2	Beni Mellal	390.08	8.47	17.08	4	2	5	4	75
3	Settat	374.57	8.14	25.21	2	3	3	4	75
4	El Jadida	345.70	7.51	32.72	2	2	3	4	75
5	Taounate	305.66	6.64	39.36	1	3	4	2	15
6	El Kelâa	277.89	6.04	45.40	3	3	2	3	45
7	Khemisset	256.64	5.58	50.98	1	3	3	4	75
8	Kénitra	234.40	5.09	56.07	1	2	1	4	15
9	Fez	175.45	3.81	59.88	1	3	3	5	100
10	Safi	170.04	3.69	63.58	3	3	5	3	45
11	Benslimane	159.85	3.47	67.05	1	3	4	5	100
12	Khenifra	144.02	3.13	70.18	4	3	4	4	75
13	Meknes	142.61	3.10	73.27	1	3	3	3	45
14	Taza	141.59	3.08	76.35	1	3	3	2	15
15	El Hajeb	106.62	2.32	78.67	1	3	2	5	100
16	Tanger	87.91	1.91	80.58	1	3	5	1	8
17	Oujda	80.17	1.74	82.32	5	3	2	2	15
18	Nador	74.96	1.63	83.95	5	2	2	3	45
19	Marrakech	72.88	1.58	85.53	3	3	5	2	15
20	Chefchaouen	69.79	1.52	87.05	1	3	5	2	15
21	Larache	62.32	1.35	88.40	1	2	5	1	8
22	Khouribga	59.44	1.29	89.69	2	3			
23	Errachidia	54.19	1.18	90.87	6	1			
24	Ifrane	43.15	0.94	91.81	4	3			
25	Figuig	41.45	0.90	92.71	5	1			
26	Azilal	38.79	0.84	93.55	4	3			
27	Casablanca	37.92	0.82	94.37	1	3			

Rank by production	Province	Production (000 tonnes) (10-year average for 2002–2011)	Share of total national production (%)	Cumulative share of production (%)	Agro-ecological zone	Water source	Experts' opinion on the climate change impact and extent of adoption of improved wheat varieties (1=low and 5=high)		Expert estimates of adoption rate (Share of area [%])
							Extent of climate change impact	Level of adoption of improved wheat varieties	
28	Taroudante	35.49	0.77	95.14	6	3			
29	Tetouan	34.11	0.74	95.89	1	3			
30	Ouarzazate	33.85	0.74	96.62	6	1			
31	Rabat	28.76	0.62	97.25	1	3			
32	Agadir	25.91	0.56	97.81	3	3			
33	Al Hoceima	25.65	0.56	98.37	5	3			
34	Essaouira	22.56	0.49	98.86	3	3			
35	Boulmane	22.43	0.49	99.34	5	3			
36	Tan-Tan	12.21	0.27	99.61	6	3			
37	Chichaoua	10.58	0.23	99.84	3	3			
38	Tiznit	5.19	0.11	99.95	6	3			
39	Tata	1.51	0.03	99.98	6	3			
40	Guelmim	0.75	0.02	100	6	3			
	Total (or National)	**4,603.1**							**53%**

Key to agro-ecological zones: 1 – favorable; 2 – intermediate; 3 – unfavorable south; 4 – mountainous; 5 – unfavorable east; 6 – Saharan
Key to water sources: 1 – irrigated; 2 – partly irrigated; 3 – rainfed

As a result, the survey was carried out in 15 provinces (21 provinces according to the new classification). Most statistics that exist in the country are also based on the old classification. The last census for Morocco took place in 1996 and hence was too old to serve as our sampling frame; it was crucial to look for an alternative one. The Directorate of Strategy and Statistics (DSS) at the MoA has established a national sample of 20,000 farm households for its annual agricultural surveys on crop production. The sample was based on the "area frame" approach using the following steps:

- To create more homogeneous groups of farms, five strata representing different farm sizes were established for the survey

- With high resolution maps drawn from satellite images acquired by the MoA, and other available maps, very accurate stratification of the land was done. The stratification was done on topographic maps where sampling is based on a geographic information system (GIS) application, which gives the global positioning system (GPS) coordinates of the sample households
- Validation was done using maps and actual interviews on the ground by enumerators from the DSS
- Data was consolidated and verified in the office
- Strata were identified, and boundaries delineated digitally
- A GIS application was used to build area frames for the different strata from which the samples were drawn randomly
- A total of 20,000 farm households were selected from the selected segments; these became the master sample for the annual national agricultural surveys.

The area frame sampling technique is used for many purposes: crop areas, yields, the use of fertilizers, seeds, etc. So, in the initial design, existing estimates of coefficients of variation for many variables were collected and the largest estimate was used to cover all issues. The master sample that was generated now supports all studies and surveys conducted by the DSS. Consequently, the sample for cereal crops is deemed to be the best option as the sampling frame for this study.

The team of scientists from INRA and ICARDA involved in this study used power analysis to determine the minimum sample size that ensured 95% confidence and 3% precision levels for capturing the adoption levels of improved wheat varieties up to 53% (the national estimate by experts). The minimum sample size required was 1,061 households. Then, to account for possible absences or any unwillingness of farmers to participate in the survey, the sample was inflated upwards with an additional 15% of households. This increased the final sample size to 1,230. Therefore, a sample of 1,230 farm households was drawn up for this study from the master sample described above, using a stratified sampling approach, where provinces, districts, and villages were used as strata. The total sample was distributed proportionally across 292 villages spread across 56 districts that were randomly drawn from the 21 provinces. The distribution of the samples across the 21 provinces (of the new administrative classification) selected for the survey is provided in Tables 5.2 and 5.3.

Table 5.2: Distribution of sample households for the wheat adoption study, Morocco

Region	Province	Average wheat area, 2002–2011 (000 ha)			No. of wheat growers in 2011 (000)	Sample statistics				
								No. of households		
		Bread wheat	Durum wheat	Total		No. of districts	No. of villages	Male headed	Female headed	Total
Chaouia-Ouardigha	Benslimane	54.96	25.41	80.37	13.92	3	10	26	1	27
	Berrechid	131.96	133.9	90.39	20.70	2	13	40	3	43
	Settat			175.47	40.19	3	33	80	2	82
Doukkala-Abda	El Jadida	95.98	79.46	92.98	64.08	3	16	70	6	76
	Sidi Bennour			82.46	56.82	2	17	63	5	68
	Safi	74.74	73.59	148.33	63.25	3	19	128	2	130
Fez-Boulemane	Fez	69.79	29.72	12.94	3.64	1	1	8	0	8
	Moulay Yacoub			86.57	24.34	2	7	52	0	52
Gharb-Chrarda-Bni Hces	Kénitra	94.03	13.36	85.97	30.66	3	17	49	10	59
	Sidi Slimane			21.42	7.67	1	8	17	1	18
	Sidi Kacem	144.94	32.59	177.53	44.40	5	22	63	4	67
Marrakech-Tensift-Alhaouz	El Kelâa	155.36	67.91	73.68	20.33	2	12	36	2	38
	Rehamna			149.59	41.27	2	12	75	2	77
Meknes-Tafilalet	El Hajeb	48.95	9.88	58.83	9.02	3	7	22	0	22
	Khenifra	67.09	37.25	104.34	28.05	2	11	58	0	58
	Meknes	71.78	4.49	76.27	13.73	1	11	29	0	29
Rabat-Salé	Khemisset	127.62	29.58	157.2	32.67	4	25	61	6	67
Tadla-Azilal	Beni Mellal	153.68	37	190.68	46.06	3	7	89	1	90
Taza-Alhoceima-Taounate	Taounate	103.26	80	183.26	61.16	4	24	117	7	124
	Taza	32.83	70.34	82.54	39.24	5	14	75	0	75
	Guercif			20.63	9.81	2	6	20	0	20
Total sample		**1,426.97**	**724.48**	**2,151.45**	**671.01**	**56**	**292**	**1,178**	**52**	**1,230**
Total national		**1,930.07**	**979.90**	**2,909.97**	**Not available**					
Sample as a share of the national total				**73.9%**						

Table 5.3: Distribution of sample farms by province and farm size

Province	0 to < 1 ha	1 to < 3 ha	3 to < 5 ha	5 to < 10 ha	10 to < 20 ha	20 to < 50 ha	50 to < 100 ha	> 100 ha	Total
El Jadida	8	19	16	19	9	3	1	1	76
Sidi Bennour	7	18	15	17	8	1	1	0	67
Kénitra	6	20	16	7	5	2	2	1	59
Beni Mellal	4	20	16	25	17	7	1	0	90
Taounate	12	44	20	22	21	3	2	0	124
Settat	3	24	17	15	12	7	3	2	82
Berrechid	3	12	9	8	6	3	2	1	43
El Kelâa	2	7	6	11	7	3	1	1	38
Rehamna	4	14	13	20	15	7	2	2	77
Khenifra	0	2	9	14	17	9	7	0	58
Fez	0	1	2	2	1	1	0	1	8
My Yacoub	3	9	12	16	4	4	2	2	52
Meknes	0	6	5	9	7	1	1	0	29
Khemisset	2	18	10	16	11	5	2	3	67
Taza	6	22	14	16	9	4	2	2	75
Guercif	2	5	3	4	2	1	2	1	20
El Hajeb	0	1	1	5	11	3	0	1	22
Safi	8	30	28	28	19	11	5	1	130
Sidi Kacem	7	11	19	15	7	4	2	2	67
Sidi Slimane	2	3	5	4	2	1	0	1	18
Benslimane	1	3	6	6	5	5	1	0	27
Total	**79**	**289**	**241**	**279**	**195**	**85**	**39**	**22**	**1,230**

In addition to the sample of 1,230 wheat-grower households, an additional sample of 83 wheat seed growers was randomly drawn from the 1,200 farm households that are members of the Moroccan Seed Growers Association (AMMS). The total area dedicated for wheat seed production in 2009 was 42,000 ha, which increased to about 65,000 ha in 2013 (an increase of about 55%). The distribution of the sample of seed growers is presented in Table 5.4.

Table 5.4: Distribution of sample seed producers for the wheat adoption study, Morocco

Region	Province	No. of districts	No. of villages	Number of households		
				Male headed	Female headed	Total
Chaouia-Ouardigha	Berrechid	2	6	30	0	30
Rabat-Salé	Khemisset	1	5	21	2	23
Tadla-Azilal	Beni Mellal	1	1	30	0	30
Total		**4**	**12**	**81**	**2**	**83**

5.5 Methodology

5.5.1 Modeling the adoption of new agricultural technologies

Previous empirical studies on the adoption and diffusion of agricultural innovations found that a wide variety of different factors affect farmers' adoption decisions (Feder et al. 1985; Foster and Rosenzweig 1996; Kohli and Singh 1998; Meinzen-Dick et al. 2004). Gender of the household head (Adugna 2002; Overfield and Fleming 2001), literacy level, and farming experience (Rahm and Huffman 1984) are important determinants of adoption. Many other variables also significantly influence farmers' adoption decisions. These included household size (Smith 1997; Tadesse and Kassa 2004), physical and financial capital, including access to credit (Kansana et al. 1996; Putler and Zilberman 1988), and landholding size (Daku 2002; Doss and Morris 2000; Gabremadhin and Haggblade 2001). Farm income (Abebaw 1999; Degu 2004), availability and accessibility to technologies such as seeds, and distance to input sources (Doss 2003; Nwosu 1995) also influence adoption decisions.

Schultz (1995), Doss (2003), and Wale and Yallew (2007) hypothesized that the probability of adoption of a new technology will depend on the ability of farmers to perceive the advantages and compatibility with existing socio-economic conditions. There is general agreement that farmers' levels of knowledge on improved agricultural technologies influences their technology preference. For example, studies by Abebaw (1999) and Doss (2003) reported that adopters have better knowledge of fertilizer application than non-adopters. Farmers' attitudes towards risk, access to information on the productivity of the technology, and yield and price stability are all important factors (Feder

et al. 1985; Kaguongo et al. 1997; Kristjanson 1987). Those technologies that involve lower risk have a greater appeal to smallholders, who tend to be more risk-averse (Meinzen-Dick et al. 2004).

Factors affecting the decision to adopt

The use of binomial and multinomial qualitative choice models in the analysis of adoption of technologies is well established in the adoption literature (Feder et al. 1985). One purpose of qualitative choice models is to determine the probability that an individual with a given set of attributes will make one choice over another (Green 2000). The two most popular functional forms used for adoption models are the probit and the logit models. Dimara and Skuras (2003), however, acknowledging the contributions that previous adoption studies using dichotomous adoption decision models had made to the design of improved policies, contended that dichotomous adoption models have an inherent weakness. They indicated that even though most decision-making processes concerning innovation adoption involve a multistage procedure, static adoption models often consider the process as a single stage. Dimara and Skuras (2003) argued that the basic tenet of a single stage decision-making process characterizing dichotomous adoption decision models is a direct consequence of the full information assumption embedded in the definition of adoption. However, the full information assumption is often violated and, hence, analysis of the adoption decision using logit, probit, and Tobit models may suffer from model misspecification.

Over the years, several authors have tried to overcome these limitations in various ways. Byerlee and Hesse de Polanco (1986) and Leathers and Smale (1991) suggested a sequential adoption decision model. By assuming that previous adoption models did not adequately consider the dynamic learning process, Abadi Ghadim and Pannell (1999) suggested the use of a dynamic adoption decision model, which includes farmers' personal perceptions, managerial abilities, and risk preferences. Dimara and Skuras (2003) assumed that adoption of innovations involves a multistage process. They drew from the literature that many of the sample populations in previous adoption studies did not have the necessary information and level of awareness concerning the new technology (violating the full information assumption) and suggested a partial observability model.

To account for differential exposure among farmers, Diagne and Demont (2007) used the "treatment effect" framework to consistently estimate population adoption rates and their determinants for new rice varieties in

Côte d'Ivoire. This study applied the two-stage regression method to correct for selectivity bias and endogeneity problems in the data. This represents an improvement on other impact assessments of crop technologies (e.g. Hossain et al. 2003). Accordingly, a first-stage probability of the adoption estimate is derived which accounts for farmers' prior exposure to the new varieties by including a participation variable. Results are subsequently used to correct for the treatment effect in a second-stage income equation.

Given its potency in terms of correcting selectivity bias, the Heckman model (Heckman 1979) is used here to study the determinants of adoption of improved wheat varieties in Morocco where the two-step Heckman procedure (Kumar 1994) is used for parameter estimation. In the first step of the Heckman model, the so-called selection equation is estimated where the dependent variable, which is the adoption dummy (taking a value of 1 if adoption has taken place and 0 otherwise), is regressed on a number of exogenous variables. These include farm size, wheat area, seed source, agro-ecological zones, and the characteristics of the household head (gender, age, education, and experience). Moreover, to handle the issue of non-exposure bias, proxy variables (participation in farm trials and/or field days for the new wheat variety), which indicate whether the household has the minimum amount of information necessary for making adoption decisions, are included in the selection equation. The selection equation takes the form:

$$Z_i^* = W_i\alpha + \varepsilon_i$$
$$Z_i = \begin{cases} 1, \text{ if } Z_i^* > 0 \\ 0, \text{ if } Z_i^* \leq 0 \end{cases} \quad (1)$$

Where:

Z_i is the observed behavior of a household with respect to technology adoption; it takes a value of 1 if adoption is observed and 0 otherwise. In this step, the probability of (propensity to) adopt is estimated

W_i is the vector of covariates for observation *i,* which include farmer and farmer characteristics, such as age; gender; education; off-farm employment of the household head; whether or not the farmer hosted demonstration trials and/or participated field days; farm size; wheat area; agro-ecological zone; and distance from seed sources

α is a vector of coefficients

ε_i are random disturbances.

In the second step, the outcome equation is estimated where area cultivated with the improved wheat variety is regressed on the estimate of Z_i from the

first step estimation and some of the explanatory variables included in the selection equation. Two dummy variables included in the selection equation as explanatory variables are not included in the outcome equation because these variables may be important in deciding whether to adopt the variety, but not so much on the decision regarding the area to be allocated for the variety. The exclusion of these variables will help the possible identification problem that might be introduced because of the non-linearity in the selection equation (Sartori 2003). The outcome equation takes the form:

$$Y_i = \begin{pmatrix} X_i\beta + u_i, \text{ if } Z_i^* > 0, \\ \text{if } Z_i^* \leq 0 \end{pmatrix} \quad (2)$$

Where:

Y_i is the dependent variable of the outcome equation (total area under the improved wheat varieties)

X_i is the vector of covariates including the inverse Mills ratio, derived from the first-stage equation, which corrects for selectivity bias and endogeneity (Greene 1998) and some of the covariates from the first step estimation

β is a vector of coefficients

u_i are random disturbances assumed identically, independently, and normally distributed with mean zero and a constant variance.

Factors affecting speed of adoption

Duration analysis (DA) (Cleves et al. 2002; Kiefer 1988) is used to analyze the time lag for the adoption of improved wheat varieties by farmers. This approach adds a dynamic element to the dichotomous choice methods by combining both individual adoption decisions and the cumulative aspect of innovation diffusion. DA is concerned with the timing of events where the event variable represents the transition from one state to another (Henry and Butler 2012). The purpose of DA is to statistically identify those factors that have a significant effect (both positive and negative) on the length of a spell. A spell starts at the time of entry into a specific state and ends at a point when a new state is entered (Dadi et al. 2004).

The early DA work, applied in social sciences, was focused on factors affecting employment periods (Lancaster 1972). DA has been applied to choices in other fields, like agriculture, considering the adoption of new production systems, such as sustainable practices in one Brazilian state (De Souza et al. 1999), conservation tillage in Australia (D'Emden et al. 2006), and organic agriculture in the UK (Burton et al. 2003).

DA studies the time (t) from when the innovation is available to the farmer until he adopts the technology. Functional forms that have been tested for parametric duration models include the logistic, Weibull, exponential, log normal, log logistic, and Gompertz probability distributions. Our data follows a Weibull distribution (Abdulai and Huffmann 2005; Karshenas and Stoneman 1993). The Weibull model is suitable for modeling adoption where the hazard is duration dependent. So, we model the optimal time of adoption of the improved wheat varieties using DA assuming the Weibull distribution. The Weibull model estimates two ancillary parameters, $\beta 0$ and p, and assumes the form

$$h0(t) = ptp - 1exp(\beta 0)$$

which collapses to the exponential model when $p = 1$. Individual covariates can be introduced in several ways, but the most common is to assume a proportional hazards model, where the effect of a covariate on the hazard is proportional to the baseline hazard. A proportional hazards model with a constant baseline hazard ($h0$) was specified in this study. So, given a vector of parameters (β) to be estimated, the relationship between the hazard rate $h(t)$ and explanatory variables xt can be defined as:

$$h(t) = h0 \exp(\beta' xt) = \exp(\beta 0) \exp(\beta' xt)$$

The length of time farmers waited before adopting the improved wheat variety is used as the dependent variable in the analysis. Duration is measured by the number of years that have elapsed since the improved wheat variety was first introduced in Morocco. Four major varieties have been used here, two bread wheat and two durum wheat. Several variables that describe the farm and farmer's characteristics are included as explanatory variables for the variation in the duration of adoption for the four varieties.

5.5.2 Measuring the impact of improved wheat varieties

Generally, impact studies face three interrelated challenges. The first and major challenge is one of establishing a viable counterfactual to predict the outcome in the absence of the intervention. Second, it is often difficult to attribute the impacts to an intervention. The third challenge relates to coping with long and unpredictable lag times. Other issues that may cause confounding errors include endogeneity in program placement, selection bias, and other changes that take place simultaneously with the treatment.

Common methods used for impact evaluation include experimental approaches, longitudinal comparisons (before and after), cross-sectional comparisons (participants versus non-participants), and quasi-experimental methods, including propensity score matching (PSM), the endogenous switching regression (ESR), and the instrumental variables (IV) approaches. The only method that completely removes biases is the experimental approach, which constructs an estimate of the counterfactual situation by randomly assigning households to participant and non-participant groups. Random assignment ensures that both groups are statistically similar (i.e., drawn from the same distribution) in both observable and unobservable characteristics, thus avoiding program placement and self-selection biases. However, such an approach is often not feasible for two reasons:

- It requires planning where treatment and non-treatment groups need to be randomly adopted and hence baseline and post intervention data need to be collected – a situation which is often impossible
- Random assignment of treatments is difficult for demand-driven treatments such as agricultural technologies where farmers make their own decisions whether to adopt (i.e. participation becomes a choice variable, thereby introducing the endogeneity problem).

As a result, very few studies use an experimental design, and some studies that have used control groups have run into design problems (Smale et al. 2001).

Given that the data for this study comes from one shot cross-sectional data, the experimental design approach is not feasible. Hence, the quasi-experimental approaches become the second-best option. Among the quasi-experimental approaches, ESR and IV are potent in reducing biases introduced by both observable and unobservable factors. IV is often preferred to ESR, but the challenge of finding a good instrument, especially when it is not planned for during program design makes it less popular. PSM does not require baseline data. Moreover, it is the second-best alternative to experimental design in minimizing selection biases from observable factors when the treatment assignment is not random (Baker 2000). Therefore, ESR along with PSM are used in this study. The rationale behind using the two methods is that by taking the difference between the impact estimates generated by both methods, we can see if unobservable factors are important in determining the final impact. If indeed non-observable factors are important, further studies will be needed to identify what these factors are and target them to enhance impact.

Propensity score matching

The main advantage (and drawback) of PSM is the degree to which observed characteristics drive program participation. If selection bias from unobserved characteristics is likely to be negligible, then PSM may provide a good comparison with randomized estimates (Khandker et al. 2010). Another advantage of PSM is that it does not necessarily require a baseline or panel survey, although in the resulting cross-section, the observed covariates entering the logit model for the propensity score would have to satisfy the conditional independence assumption (CIA). CIA states that if the observable differences in characteristics between the treated and untreated groups are controlled for, then the outcome that would result in the absence of the treatment is the same for both groups (Bryson et al. 2002). This assumption allows the counterfactual outcome for the treatment group to be inferred and, therefore, for any differences between the treated and non-treated to be attributed to the effect of the program.

The PSM method (Becker and Ichino 2002) provides a more refined way of comparing the performance of participant and non-participant farmers by accounting for their inherent differences. The basic concept is to compare non-participant farmers who are like the participant farmers in all relevant characteristics except, for example, the adoption of improved wheat varieties. The differences in the outcomes of participant farmers and the selected non-participant farmers can then be attributed to the adoption of the improved wheat varieties.

The use of PSM to minimize selectivity bias thus suggests that these differences are the result of adoption of the improved wheat varieties rather than the intrinsic characteristics of the sampled households. However, like the simple mean comparison, PSM may misinterpret the treatment effect, because it only controls for observed variables, and hidden self-selectivity bias may remain.

The propensity score is the probability of an individual adopting the technology given his/her observed covariates X. It is obtained from the fitted simple logistic regression model by substituting the values of the covariates (Rosenbaum and Rubin 1985). In this study, the logistic model is estimated to identify the factors influencing adoption of improved wheat varieties as follows:

$$Prob(Adoption = 1) = 1/(1+e^{-z}) \quad (3)$$

where $Z = \beta_0 + \sum_{i=1}^{n} \beta_i X_i + \varepsilon_j$

Adoption is a dichotomous dependent variable taking a value of 1 if improved wheat variety adoption takes place and 0 otherwise.

X_i is the vector of variables included in the model

β_0 and β_i are parameters to be estimated

ε_j is the error term of the model; and e is the base of natural logarithms.

The main purpose of the propensity score estimation is to balance the observed distribution of covariates across the groups of adopters and non-adopters (Lee 2013). Since we do not condition on all covariates, but on the propensity score, a balancing test is normally required after matching to ascertain whether the differences in the covariates in the two groups in the matched sample have been eliminated. In such a case, the matched comparison group can be considered a plausible counterfactual (Ali and Abdulai 2010). Although several versions of balancing tests exist in the literature, we use the mean absolute standardized bias (MASB) between adopters and non-adopters suggested by Rosenbaum and Rubin (1985). They recommend that a standardized difference of greater than 20% should be considered too large and an indicator that the matching process has failed.

The main problem with using the MASB approach is that there is no clear criterion for testing the success of PSM. However, in empirical studies, it is often assumed that a MASB below 3%, or 5% after matching, is acceptable (Caliendo and Kopeinig 2008). Rosenbaum and Rubin (1985) argue that, after matching, a total bias of more than 20% should be considered as large. Following Sianesi (2004), we also make comparison of the pseudo R2 and p-values of the likelihood ratio test of the joint significance of all the regressors obtained from the logistic regression before and after matching the samples. After matching, there should be no systematic differences in the distribution of covariates between the two groups. As a result, the pseudo R2 should be lower and the joint significance of covariates should be rejected (or the p-values of the likelihood ratio should not be significant).

Endogenous switching regression

The difference in the outcomes of interest between adopters and non-adopters may not only be a result of observable heterogeneity, but also of unobserved heterogeneity. Therefore, we use an ESR to account for both observable and unobservable endogeneity of the adoption decision by simultaneously estimating the adoption function (Equation 3) and the outcome equation of

interest for each group. Following Di Falco et al. (2011) and Shiferaw et al. (2014) the ESR can be estimated as follows:

$$y_1 = X_1\omega_1 = +\varepsilon_1 \text{ if } D = 1 \quad (4)$$

$$y_0 = X_0\omega_0 = +\varepsilon_0 \text{ if } D = 0 \quad (5)$$

where y_i is a vector of dependent variables representing outcomes for adopters (y_1) and non-adopters (y_0), X_i is a matrix of explanatory variables, ω_i is a vector of parameters to be estimated, and ε_1 and ε_0 are error terms.

The error terms from the three equations ε, ε_1, and ε_0 are assumed to have a trivariate normal distribution with mean vector zero and the following covariance matrix:

$$cov(\varepsilon, \varepsilon_1, \varepsilon_0) = \begin{bmatrix} \sigma^2_{\varepsilon 0} & \sigma_{\varepsilon 1 \varepsilon 0} & \sigma_{\varepsilon 0 \varepsilon} \\ \sigma_{\varepsilon 1 \varepsilon 0} & \sigma^2_{\varepsilon 1} & \sigma_{\varepsilon 1 \varepsilon} \\ \sigma_{\varepsilon 0 \varepsilon} & \sigma_{\varepsilon 1 \varepsilon} & \sigma^2_{\varepsilon 0} \end{bmatrix} \quad (6)$$

where σ^2_ε is the variance of the selection equation (Equation 3), $\sigma^2_{\varepsilon 0}$ and $\sigma^2_{\varepsilon 1}$ are the variances of the outcome equations for non-adopters and adopters while $\sigma_{\varepsilon 0 \varepsilon}$ and $\sigma_{\varepsilon 1 \varepsilon}$ represent the covariance between ε_1 and ε_0. If ε is correlated with ε_1 and ε_0, the expected values of ε_1 and ε_0, conditional on the sample selection, are non-zero:

$$E(\varepsilon_1 | D = 1) = \sigma_{\varepsilon 1 \varepsilon} \frac{\phi(Z_i\omega_i)}{\Phi(Z_i\omega_i)} = \sigma_{\varepsilon 1 \varepsilon}\lambda_1 \quad (7)$$

$$E(\varepsilon_0 | D = 0) = \sigma_{\varepsilon 0 \varepsilon} \frac{-\phi(Z_i\omega_i)}{1-\Phi(Z_i\omega_i)} = \sigma_{\varepsilon 1 \varepsilon}\lambda_1 \quad (8)$$

where ϕ and Φ are the probability density and the cumulative distribution function of the standard normal distribution, respectively. If $\sigma_{\varepsilon 1 \varepsilon}$ and $\sigma_{\varepsilon 0 \varepsilon}$ are statistically significant, this would indicate that the decision to adopt and the outcome variable of interest are correlated, suggesting evidence of sample selection bias. Therefore, estimating the outcome equations using ordinary least squares would lead to biased and inconsistent results and Heckman procedures (Heckman 1979) are normally used. In the face of heteroscedastic error terms, the full information maximum likelihood estimator can be used to fit an ESR that simultaneously estimates the selection and outcome equations to yield consistent estimates. The ESR can be used to compare the actual

expected outcomes of adopters (9) and non-adopters (10), and to investigate the counterfactual hypothetical cases that the non-adopters did adopt (11) and the adopters did not adopt (12) as follows:

$$E(y_1|D = 1) = X_1\omega_1 + \sigma_{\varepsilon 1\varepsilon}\lambda_1 \quad (9)$$

$$E(y_0|D = 0) = X_0\omega_0 + \sigma_{\varepsilon 0\varepsilon}\lambda_0 \quad (10)$$

$$E(y_0|D = 1) = X_1\omega_0 + \sigma_{\varepsilon 0\varepsilon}\lambda_1 \quad (11)$$

$$E(y_1|D = 0) = X_0\omega_1 + \sigma_{\varepsilon 1\varepsilon}\lambda_0 \quad (12)$$

Finally, we calculate the average treatment effect on the treated (ATT) as the difference between (9) and (12) and the average treatment effect on the non-adopters (ATU) as the difference between (11) and (10). We also compute the effect of base heterogeneity for the group of adopters (BH_1) as the difference between (9) and (11), and for the group of non-adopters (BH_2) as the difference between (12) and (10).

Several factors, such as varieties used, and the amounts of fertilizers, seed, labor, and tillage, are important in determining yield which, in turn, will affect income and consumption. Moreover, whether farmers participated only by hosting demonstration trials, only by attending field days, or both can have effects on farmers' adoption decisions as they are included in the estimation of both the PSM and ESR. A check on the variance inflation factor (VIF) showed that the data is free from multicollinearity with VIF values, which are much less than the VIF threshold of 10 (Leahly 2001). To create a more homogenous dataset, logarithmic transformation of all the continuous variables (such as income, consumption, farmer's age, years of education, distance to the nearest seed market, farm size, wheat area, value of assets, and all quantities of inputs) included in the ESR regression have been made. The Stata software (StataCorp 2009) was used for all econometric estimation in this study.

5.6 Results

5.6.1 Characterization of the sample of wheat grain and wheat seed producing households

Most of the respondents were the heads of households. They were relatively old, married men with low levels (on average 2.6 years) of education. More than half (52%) of the household heads were illiterate with another 33% having no more than either primary or Koranic education (Table 5.5).

Table 5.5: Characteristics of household heads

Variable	Minimum	Average	Maximum
Share of respondents who are household heads (%)		98.1	
Share of female household heads (%)		4.2	
Share of married household heads (%)		95.7	
Share of household heads for whom agriculture is the main source of employment (%)		86.6	
Share of household heads who are members of one or more cooperatives (%)		9.6	
Share of household heads who are community leaders (%)		1	
Age of household head (years)	22	59.4	100
Number of years the respondent has been living in this village	5	55.2	100
Education of household head (years)	0	2.6	14
Share of household heads who are illiterate (%)		52	
Share of household heads who have primary school or Koranic education (%)		33.3	
Share of household heads who have secondary school education (%)		11.4	
Share of household heads with university education (%)		3.3	

The average family size in the surveyed farm households was 7.04; 54% of the families were male and 46% female. The typical Moroccan farm household comprises family members spanning a wide range of ages. The majority (about 61%) are in the productive age range of 15 to 65 years. Children under 15 years old account for about 31%, showing that the population is growing older relative to the past when the young population constituted over 50% (Table 5.6).

Agriculture is the main source of employment. The majority (83%) of the farm households in the surveyed area derive their income mainly from agriculture. For the typical sample farm household, agriculture constitutes 74.4% of total family income. For some households in the survey, the contribution of agriculture to family income is 100% while for a few others, it is as low as 5% (Table 5.7).

In terms of family labor contributions to agriculture, only 68% of the family members who are in the productive age range of 15–65 years are involved in their own farm activities, spending, on average, 78% of their time on these.

Table 5.6: Household demographics

Age group	Minimum	Mean	Maximum
Total	**0**	**7.1**	**32**
< 7 years old	0	0.8	16
8–15 years old	0	1.3	13
15–65 years old	0	4.3	19
> 65 years old	0	0.6	9
Total male	**0**	**3.81**	**22**
< 7 years old	0	0.46	11
8–15 years old	0	0.71	9
15–65 years old	0	2.31	11
> 65 years old	0	0.32	5
Total female	**0**	**3.25**	**16**
< 7 years old	0	0.41	13
8–15 years old	0	0.59	6
15–65 years old	0	2.00	10
> 65 years old	0	0.25	6

Table 5.7: Share of agriculture in the family income

	Minimum	Mean	Maximum
Share of households for which agriculture is main source of income (%)		82.7	
Share of agriculture in the total family income (%)	5	74.42	100
Number of rooms in the house	1	4.71	18

Most (69%) family farm labor contributions come from male members (Table 5.8).

The average farm size among the sample households is 12.49 ha, of which 85% is cropped under rainfed conditions. This figure has not changed much over the last 10 years. The typical farm household owns about 10.77 ha (86.2% the total land it operates) while the rest is either leased or sharecropped (Table 5.9). The total land holding by male-headed households is 12.35 ha and that of female-headed households is 14.98 ha. The corresponding figures for the wheat area are 5.86 ha and 5.93 ha, respectively.

Table 5.8: Family labor in agriculture

	Minimum	Mean	Maximum
Total number of family members working on family farm	0	2.96	16
Number of male family members working on family farm	0	2.04	10
Number of female family members working on family farm	0	0.92	8
Share of time spent on agriculture by family members working on own farm (%)	5	77.96	100

Table 5.9: Land holding and land tenure (ha)

	2011–2012			10 years ago		
	Minimum	Mean	Maximum	Minimum	Mean	Maximum
Total cropped area	0.2	12.49	600	0.2	12.6	600
Irrigated area	0	1.9	400	0	1.7	400
Owned area	0.1	10.77	595	0.1	10.5	400
Rented area	0	0.5	595	0	0.27	320
Given for rent	0	0.6	100	0	0.59	100
Sharecropped out	0	0.1	70	0	0.12	70
Sharecropped in	0	0.3	22	0	0.23	25

Most farmers in the sample (92%) reported that for their households, cereals rank first in terms of the area covered, while 2% of farm households ranked legumes as the first in importance – showing the absence or low level of the practice of crop rotation. In particular, bread wheat is ranked top in importance by 54% of the sample households, followed by durum wheat (24%) and barley (13%). Disregarding the species, wheat is ranked as the single most important crop by 78% of the farmers (Table 5.10).

Our results show that there is very low machinery ownership, with only 21% of the sample farm households owning a tractor and only 5% owning a combine harvester. However, the ratio of machinery to operated land seems to be high with one tractor for every 50 ha of land and one combine harvester for every 208 ha of land (Table 5.11). Other sources reported a national average of 158 ha per tractor and 1,120 ha for every combine harvester (FAO 2011a). Livestock production is also an important activity in the survey areas, with the typical farm household owning about 5 cattle, 26 small ruminants, and 1.5 equines.

Table 5.10: Proportion of farmers assigning a specific ranking of importance to a crop in the farmer's crop portfolio (%)

	Rank of importance (in terms of area covered)					Total
Crop type	1	2	3	4	5 or more	
Bread wheat	54	28	7	2	9	100
Durum wheat	24	31	14	4	28	100
Barley	13	15	32	10	31	100
Faba bean	0	7	15	19	59	100
Lentils	0	1	1	5	93	100
Maize	1	4	6	5	84	100
Pea	2	0	2	5	91	100
Chickpea	0	2	2	2	94	100

Table 5.11: Asset ownership

Asset/Indicator	Minimum	Mean	Maximum
Number of rooms in the house	1	4.71	18
Estimated value of the house (MAD)	2,000	144,544	3,000,000
Number of tractors owned	0	0.25	6
Number of combine harvesters owned	0	0.06	2
Number of water pumps owned	0	0.25	5
Number of cars/pick-ups owned	0	0.18	3
Number of trucks owned	0	0.03	2
Number of cattle (oxen and cows) owned	0	5.28	300
Number of small ruminants (sheep, goats) owned	0	26.08	665
Number of equines (mules, donkeys, horses) owned	0	1.48	20

5.6.2 Adoption of improved wheat varieties

Using our survey of 1,230 farm households distributed across 21 provinces, we found that there are 40 wheat varieties in farmers' hands (Annex I). Nineteen of the varieties have been identified to be bread wheats and another 15 to be durum wheats; the remaining 6 were not identified. Of the 34 identified varieties, 10 are more than 20 years old, 15 are between 11 and 20 years, and

9 are 10 years old or less. Of the 40 varieties, the names of the institutions that released 33 of them were identified while those of the remaining 7 were not. Information on the pedigree, selection history, and institutional origin of the varieties was scanty. We have documented in Annex I as much information as we were able to collect from different sources, including the national database, the Wheat Atlas database, and INRA and ICARDA scientists. Of the 27 varieties for which the breeding programs were identified, 18 came from an INRA breeding program. Of the 18 varieties that were released through the INRA breeding program, 1 contains INRA material, 11 contain CIMMYT material, 1 contains ICARDA material, and 5 contain material from the joint ICARDA/CIMMYT program. Thus, 94% of the varieties released by INRA are the fruit of the strong collaboration between INRA and CGIAR.

Adoption rates (proportion of farmers cultivating improved varieties)

Adoption rate by variety

Of the 40 wheat varieties that were found in farmers' hands, the top 10 varieties were being cultivated by more than 91% of wheat growers. Among the top 10 varieties, 4 are at least 24 years old. The top four varieties cover 56% of the total wheat area. This shows that old varieties still dominate the Moroccan wheat fields. It is worth noting here that the top two varieties in terms of the number of growers are Karim and Achtar, which are being cultivated by 38.1% of Moroccan farmers (Table 5.12).

The 17 varieties that are identified to have come from the collaborative work between the INRA and CGIAR breeding programs over the last four decades are being cultivated by 81.8% of the wheat growers in the country – showing that the joint INRA/CGIAR varieties are still the favorite varieties among Moroccan farmers. When this is disaggregated by year of release of the varieties none of the INRA/CGIAR varieties released in the last 10 years was found in farmers' hands. And varieties that are between 10 and 20 years old are being cultivated by only 15% of farmers. This shows that the INRA/CGIAR varieties released more than 20 years ago are still dominant in the Moroccan farmers' portfolios.

Adoption rate by province

The adoption rate for newly released varieties is highest in Berrechid, with 72.1% of farmers cultivating varieties of 10 years old or less. This is followed by Safi, Khemisset, and Settat which have adoption rates of 40.3%, 37.8%, and 31.7%, respectively. In contrast Khenifra province is dominated by very old varieties, with 98.3% of growers there cultivating varieties which are more

Table 5.12: Proportion of growers adopting a specific variety (%)

Adoption rank	Variety name	Number of communities in which variety was found	Proportion of farmers adopting (%)	Cumulative adoption rate (%)
1	Karim	60	19.21	19.21
2	Achtar	58	18.90	38.11
3	Merchouch	52	14.07	52.18
4	Marzak	55	11.37	63.55
5	Amal	43	9.84	73.39
6	Radia	43	6.32	79.71
7	Arrehane	31	3.61	83.32
8	Saidi	27	3.14	86.46
9	Wissam	16	2.48	88.94
10	Crioca	30	2.40	91.34
11	Salama	21	1.74	93.08
12	Bread wheat (local)	10	1.44	94.52
13	Rajae	7	0.70	95.22
14	Baida	3	0.61	95.83
15	Viton	7	0.57	96.40
16	Nassim	7	0.52	96.92
17	Beldi	8	0.48	97.40
18	Aguilal	5	0.39	97.79
19	Tigre	6	0.35	98.14
19	Cocorit	5	0.35	98.49
21	Durum wheat (local)	3	0.17	98.66
22	El Wafia	2	0.13	98.79
22	Manal	1	0.13	98.92
22	Anouar	2	0.13	99.05
25	Oum Rabia	1	0.09	99.14
25	Kanz	2	0.09	99.23
25	Mehdia	1	0.09	99.32
25	Massira	2	0.09	99.41
25	Irride	2	0.09	99.50
25	Mazrouba	2	0.09	99.59
31	Prosse Pero	1	0.04	99.63
31	Amjad	1	0.04	99.67
31	Faiza	1	0.04	99.71

Adoption rank	Variety name	Number of communities in which variety was found	Proportion of farmers adopting (%)	Cumulative adoption rate (%)
31	El Manar	1	0.04	99.75
31	Tomouh	1	0.04	99.79
31	Vitrico	1	0.04	99.83
31	Ouissane	1	0.04	99.87
31	Ourgh	1	0.04	99.91
31	Krifla Kahla	1	0.04	99.95
31	Jouda	1	0.04	99.99
Total		**522**	**99.99**	

than 20 years old. Other provinces where these 20 years and older varieties dominate include Beni Mellal (95.6%), Rehamna (76.6%), and El Kelâa (76.3%) (Table 5.13). The adoption rates disaggregated by gender show that 64% of women-headed households and 31% of men-headed households are adopters of improved wheat varieties less than 20 years old.

Adoption rate by agro-ecological zones

Among the four major wheat growing agro-ecological zones in Morocco, the unfavorable south is, surprisingly, leading the rest of the agro-ecologies in terms of the percentage of farmers cultivating more recent varieties. For example, 33.1% of the wheat growers in the unfavorable south are cultivating varieties which are 10 years old or less, while the corresponding figure for the intermediate zone is 20.4%, the favorable zone 8.6%, and the mountainous zone 1%. The whole picture changes when the cut-off point for the varietal age is increased to 20 years. Almost 50% of the farmers in the favorable zone grow varieties which are less than 20 years old. The corresponding figure for the unfavorable south is 46.5%, the intermediate zone 45.9%, and the mountainous region 3.4% (Table 5.14).

Adoption rate – national level

The national adoption rates for more recent varieties generally stand at very low levels. Less than 1% of Moroccan wheat growers cultivate varieties released five or less years ago. The corresponding figure for varieties released up to 10 years ago stands at 16%, which is still very low. The very old varieties still dominate the Moroccan farmers' portfolios, where more than 58% of

Table 5:13: Proportion of farmers planting wheat varieties of different release dates, by province (%)

Year	Beni Mellal	Benslimane	Berrechid	El Hajeb	El Jadida	El Kelâa	Fez	Guercif	Kénitra	Khemisset
1921	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1982	90.0	100.0	100.0	100.0	98.7	100.0	100.0	100.0	100.0	100.0
1984	87.8	100.0	100.0	100.0	98.7	100.0	100.0	100.0	100.0	100.0
1985	75.6	90.9	93.0	77.3	90.7	84.2	62.5	72.2	85.2	94.6
1988	40.0	86.4	90.7	68.2	85.3	73.7	37.5	44.4	82.0	89.2
1991	4.4	40.9	86.0	40.9	36.0	23.7	37.5	27.8	36.1	73.0
1993	4.4	40.9	86.0	40.9	36.0	23.7	37.5	27.8	36.1	73.0
1994	1.1	40.9	79.1	27.3	32.0	23.7	25.0	22.2	4.9	73.0
1995	1.1	40.9	79.1	27.3	32.0	7.9	25.0	0.0	4.9	73.0
1996	1.1	40.9	79.1	22.7	32.0	7.9	0.0	0.0	4.9	73.0
1997	1.1	4.5	72.1	9.1	10.7	7.9	0.0	0.0	1.6	37.8
2003	1.1	4.5	72.1	9.1	10.7	7.9	0.0	0.0	1.6	37.8
2004	1.1	4.5	72.1	9.1	10.7	7.9	0.0	0.0	1.6	37.8
2005	0.0	4.5	67.4	9.1	4.0	5.3	0.0	0.0	1.6	32.4
2006	0.0	0.0	7.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2007	0.0	0.0	7.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2010	0.0	0.0	4.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2011	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2012	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Khenifra	Meknes	My Yacoub	Rehamna	Safi	Settat	Sidi Bennour	Sidi Kacem	Sidi Slimane	Taounate	Taza
100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
89.7	100.0	100.0	100.0	97.3	100.0	98.5	100.0	100.0	100.0	100.0
87.9	100.0	100.0	100.0	97.3	100.0	98.5	100.0	100.0	100.0	100.0
58.6	96.6	92.3	84.4	71.8	63.4	80.6	93.8	100.0	83.2	70.0
58.6	89.7	69.2	67.5	62.4	53.7	73.1	90.8	100.0	60.4	48.6
15.5	79.3	65.4	23.4	51.7	47.6	41.8	64.6	72.2	42.3	45.7
1.7	79.3	65.4	23.4	51.7	47.6	41.8	64.6	72.2	42.3	45.7
1.7	27.6	21.2	19.5	45.0	43.9	25.4	13.8	16.7	22.8	44.3
1.7	27.6	19.2	10.4	44.3	43.9	25.4	13.8	16.7	22.8	2.9
1.7	24.1	7.7	10.4	44.3	43.9	25.4	13.8	16.7	11.4	2.9
0.0	13.8	7.7	7.8	40.3	31.7	22.4	12.3	11.1	8.1	0.0
0.0	10.3	7.7	7.8	40.3	31.7	22.4	12.3	11.1	8.1	0.0
0.0	10.3	7.7	7.8	40.3	31.7	22.4	12.3	11.1	7.4	0.0
0.0	6.9	7.7	6.5	34.2	25.6	17.9	12.3	11.1	6.0	0.0
0.0	0.0	0.0	0.0	0.0	1.2	0.0	0.0	0.0	0.7	0.0
0.0	0.0	0.0	0.0	0.0	1.2	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	1.2	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

the growers are still cultivating varieties released more than 20 years ago (Table 5.15).

Adoption rate – by wheat species

Provincial adoption levels for bread wheat varieties generally follow similar patterns to those for total wheat (regardless of species) reported in Section 5.2.1. Berrechid leads all provinces in the proportion of farmers adopting recent bread wheat varieties (Table 5.16). In this province 72.4% of the farmers cultivate varieties 10 years old or less. Berrechid is followed by Settat (47.7%), Khemisset (41.2%), and Safi (36.8%). When it comes to old varieties, 97.4% of farmers in Khenifra province are still cultivating varieties over 20 years old, followed by Beni Mellal (94.5%), and El Kelâa (92.3%). At the national level, the number of farmers cultivating improved bread wheat varieties five years old or less account for less than 1% of the total number of national bread wheat growers. While the figures improve slightly when the cut-off points are

Table 5.14: Proportion of farmers in each agro-ecological zone that has adopted varieties released in different years (%)

Year	Favorable	Intermediate	Unfavorable south	Mountain
1921	100.0	100.0	100.0	100.0
1982	100.0	99.4	98.5	89.9
1984	100.0	99.4	98.5	87.8
1985	84.6	87.6	71.0	68.9
1988	71.1	76.4	61.3	47.3
1991	49.7	45.9	46.5	8.8
1993	49.7	45.9	46.5	3.4
1994	27.3	32.2	41.6	1.4
1995	20.6	29.6	39.0	1.4
1996	16.4	27.7	39.0	1.4
1997	8.8	20.4	33.1	0.7
2003	8.6	20.4	33.1	0.7
2004	8.4	20.4	33.1	0.7
2005	7.4	16.9	27.5	0.0
2006	0.2	1.0	0.4	0.0
2007	0.00	0.96	0.37	0.00
2010	0.00	0.64	0.37	0.00
2011	0.00	0.00	0.00	0.00
2012	0.00	0.00	0.00	0.00
Proportion in total national number of growers (%)	40.27	26.37	21.65	11.71

raised to 10 years and 20 years, more than 53% of the total number of national bread wheat growers are still cultivating varieties which are older than 20 years (Table 5.17).

Once again, Berrechid leads all provinces in terms of the proportion of farmers adopting recent durum wheat varieties (Table 5.18). In this province 71.4% of farmers cultivate varieties up to 10 years old, followed by Safi (51.4%), Benslimane (33.3%), and Sidi Bennour (20%). With varieties up to 20 years old Berrechid still leads nationally with 71.4% of farmers cultivating these old durum varieties, followed by El Kelâa (58.3%), Safi (54.3%), and Meknes (33.3%).

The national figures for durum wheat show that, even though they are still very low, adoption rates of improved durum wheat varieties released five or less years ago are slightly higher than those for bread wheat. However, when the cut-off points are raised to 10 and 20 years, durum wheat loses to bread wheat. Only 11% of durum wheat farmers cultivate varieties which are up to 10 years old, while the majority (72%) are still cultivating varieties more than 20 years old (Table 5.19). These figures contrast sharply with the 90% adoption rate from the WANADDIN project survey cited by Belaid et al. (2005). One possible source of discrepancy is in the definition of improved varieties. Belaid et al. (2005) do not make any distinction between varieties based on their release dates, while this paper pays special attention to the year of release. In this report, a 90% adoption corresponds to all varieties which were released during the last 27 years (between 1986 and 2013). Any variety released before 1993, though improved, is considered very old. Therefore, a separate category, namely "obsolete improved" varieties is established for such varieties.

Degree of adoption (proportion of the wheat area under improved varieties [%])

Degree of adoption by variety

The top 10 varieties of the 40 wheat varieties found in Moroccan farmers' hands cover more than 92% of the total wheat area. This is consistent with the adoption rate of 91% for the top 10 varieties presented in sub-section 'Adoption rate by variety' on page 117. Among the top 10 varieties, four are at least 24 years old and cover 56% of the total wheat area, showing that old varieties still dominate in Moroccan wheat fields. The top two varieties in terms of area grown are Achtar and Merchouch. The two varieties constitute over 35.2% of the total national wheat area. The 17 varieties that are identified as having come from the joint INRA/CGIAR breeding programs are being cultivated on 79.41% of the total wheat area in the country – showing that the INRA/CGIAR varieties still dominate the landscape (Table 5.20). Further disaggregation of the degree of adoption by year of release of the varieties shows that none of the INRA/CGIAR varieties released in the last 10 years are found in Moroccan wheat fields. Even the varieties between 10 and 20 years old are being cultivated on only 21% of the total wheat area in the country. This shows that the INRA/CGIAR varieties released over 20 years ago still dominate, covering about 59% of the total wheat area in the country.

Table 5.15: Proportion of farmers planting wheat varieties of different release dates, national figures (%)
(adoption rates are generated by using number of growers in each province as weights)

Year	Beni Mellal	Benslimane	Berrechid	El Hajeb	El Jadida	El Kelâa	Fez	Guercif	Kénitra	Khemisset	Khenifra
1921	0.73	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.46
1982	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08
1984	0.89	0.16	0.23	0.32	0.54	0.51	0.22	0.41	0.92	0.15	1.30
1985	2.59	0.08	0.08	0.13	0.36	0.34	0.15	0.41	0.21	0.15	0.00
1988	2.59	0.82	0.15	0.39	3.34	1.61	0.00	0.25	2.88	0.46	1.91
1991	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.61
1993	0.24	0.00	0.23	0.19	0.27	0.00	0.07	0.08	1.95	0.00	0.00
1994	0.00	0.00	0.00	0.00	0.00	0.51	0.00	0.33	0.00	0.00	0.00
1995	0.00	0.00	0.00	0.06	0.00	0.00	0.15	0.00	0.00	0.00	0.00
1996	0.00	0.65	0.23	0.19	1.44	0.00	0.00	0.00	0.21	1.00	0.08
1997	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2003	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2004	0.08	0.00	0.15	0.00	0.45	0.08	0.00	0.00	0.00	0.15	0.00
2005	0.00	0.08	2.00	0.13	0.27	0.17	0.00	0.00	0.10	0.93	0.00
2006	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2007	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2010	0.00	0.00	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2011	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2012	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Share of total number of growers in the 21 provinces (%)	7.29	1.79	3.31	1.43	6.77	3.22	0.59	1.47	6.27	2.85	4.44

Meknes	My Yacoub	Rehamna	Safi	Settat	Sidi Bennour	Sidi Kacem	Sidi Slimane	Taounate	Taza	Total	Cumulative
0.00	0.00	0.00	0.31	0.00	0.09	0.00	0.00	0.00	0.00	1.7	100
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.2	98
0.07	0.30	1.02	2.92	2.31	1.08	0.33	0.00	1.95	1.72	17.4	98
0.15	0.89	1.10	1.08	0.62	0.45	0.17	0.00	2.65	1.23	12.8	81
0.22	0.15	2.88	1.23	0.39	1.90	1.40	0.41	2.11	0.16	25.3	68
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.6	43
1.12	1.70	0.25	0.77	0.23	0.99	2.73	0.83	2.26	0.08	14.0	42
0.00	0.07	0.59	0.08	0.00	0.00	0.00	0.00	0.00	2.37	3.9	28
0.07	0.44	0.00	0.00	0.00	0.00	0.00	0.00	1.33	0.00	2.1	24
0.22	0.00	0.17	0.46	0.77	0.18	0.08	0.08	0.39	0.16	6.3	22
0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.1	16
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.1	16
0.07	0.00	0.08	0.69	0.39	0.27	0.00	0.00	0.16	0.00	2.6	16
0.15	0.30	0.42	3.93	1.54	1.08	0.66	0.17	0.62	0.00	12.6	13
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.1	0.39
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.1	0.31
0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.2	0.23
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00
2.17	3.84	6.53	11.47	6.32	6.05	5.37	1.49	11.63	5.72	100.0	

Table 5.16: Proportion of farmers planting bread wheat varieties of different release dates, by province (%)

Year	Beni Mellal	Benslimane	Berrechid	El Hajeb	El Jadida	El Kelâa	Fez	Guercif	Kénitra	Khemisset
1921	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1982	83.6	100.0	100.0	100.0	98.6	100.0	100.0	100.0	100.0	100.0
1984	83.6	100.0	100.0	100.0	98.6	100.0	100.0	100.0	100.0	100.0
1985	63.6	94.7	100.0	78.9	90.1	80.8	50.0	66.7	84.7	97.1
1988	63.6	94.7	100.0	78.9	90.1	80.8	50.0	66.7	84.7	97.1
1991	5.5	42.1	93.1	47.4	38.0	7.7	50.0	16.7	37.3	79.4
1993	5.5	42.1	93.1	47.4	38.0	7.7	50.0	16.7	37.3	79.4
1994	1.8	42.1	82.8	31.6	33.8	7.7	33.3	0.0	5.1	79.4
1995	1.8	42.1	82.8	31.6	33.8	7.7	33.3	0.0	5.1	79.4
1996	1.8	42.1	82.8	26.3	33.8	7.7	0.0	0.0	5.1	79.4
1997	1.8	0.0	72.4	10.5	11.3	7.7	0.0	0.0	1.7	41.2
2003	1.8	0.0	72.4	10.5	11.3	7.7	0.0	0.0	1.7	41.2
2004	1.8	0.0	72.4	10.5	11.3	7.7	0.0	0.0	1.7	41.2
2005	0.0	0.0	65.5	10.5	4.2	3.8	0.0	0.0	1.7	35.3
2006	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2007	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2010	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2011	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2012	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**

Khenifra	Meknes	My Yacoub	Rehamna	Safi	Settat	Sidi Bennour	Sidi Kacem	Sidi Slimane	Taounate	Taza
100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
84.6	100.0	100.0	100.0	96.5	100.0	98.2	100.0	100.0	100.0	100.0
82.1	100.0	100.0	100.0	96.5	100.0	98.2	100.0	100.0	100.0	100.0
82.1	96.2	94.4	84.0	64.9	88.6	82.5	93.7	100.0	81.9	50.0
82.1	96.2	94.4	84.0	64.9	88.6	82.5	93.7	100.0	81.9	50.0
23.1	84.6	88.9	16.0	50.9	77.3	45.6	66.7	72.2	56.2	30.0
2.6	84.6	88.9	16.0	50.9	77.3	45.6	66.7	72.2	56.2	30.0
2.6	26.9	27.8	12.0	42.1	70.5	26.3	14.3	16.7	31.4	20.0
2.6	26.9	27.8	12.0	42.1	70.5	26.3	14.3	16.7	31.4	20.0
2.6	23.1	11.1	12.0	42.1	70.5	26.3	14.3	16.7	15.2	20.0
0.0	11.5	11.1	8.0	36.8	47.7	22.8	12.7	11.1	10.5	0.0
0.0	11.5	11.1	8.0	36.8	47.7	22.8	12.7	11.1	10.5	0.0
0.0	11.5	11.1	8.0	36.8	47.7	22.8	12.7	11.1	9.5	0.0
0.0	7.7	11.1	6.0	28.9	36.4	17.5	12.7	11.1	7.6	0.0
0.0	0.0	0.0	0.0	0.0	2.3	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	2.3	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	2.3	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 5.17: Proportion of farmers planting bread wheat varieties of different release dates, national figures (%)
(adoption rates are generated by using number of growers in each province as weights)

Year	Beni Mellal	Benslimane	Berrechid	El Hajeb	El Jadida	El Kelâa	Fez	Guercif	Kénitra	Khemisset	Khenifra
1921	1.00	0.00	0.00	0.00	0.12	0.00	0.00	0.00	0.00	0.00	0.63
1982	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11
1984	1.23	0.11	0.00	0.36	0.75	0.58	0.31	0.23	1.28	0.11	0.00
1985	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1988	3.57	1.12	0.21	0.54	4.60	2.22	0.00	0.34	3.97	0.64	2.43
1991	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.84
1993	0.22	0.00	0.32	0.27	0.37	0.00	0.10	0.11	2.69	0.00	0.00
1994	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1995	0.00	0.00	0.00	0.09	0.00	0.00	0.20	0.00	0.00	0.00	0.00
1996	0.00	0.90	0.32	0.27	1.99	0.00	0.00	0.00	0.28	1.38	0.11
1997	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2003	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2004	0.11	0.00	0.21	0.00	0.62	0.12	0.00	0.00	0.00	0.21	0.00
2005	0.00	0.00	2.02	0.18	0.37	0.12	0.00	0.00	0.14	1.28	0.00
2006	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2007	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2010	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2011	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2012	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Share of total number of growers in 21 provinces (%)	6.14	2.14	3.08	1.70	8.83	3.04	0.61	0.68	8.36	3.62	4.11

Meknes	My Yacoub	Rehamna	Safi	Settat	Sidi Bennour	Sidi Kacem	Sidi Slimane	Taounate	Taza	Total	Cumulative
0.00	0.00	0.00	0.42	0.00	0.12	0.00	0.00	0.00	0.00	2.3	100
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.1	98
0.10	0.20	0.93	3.82	0.53	1.12	0.46	0.00	2.04	0.56	14.7	98
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	83
0.31	0.20	3.97	1.70	0.53	2.61	1.94	0.57	2.90	0.23	34.6	83
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.8	48
1.55	2.24	0.23	1.06	0.32	1.37	3.76	1.14	2.80	0.11	18.7	47
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	29
0.10	0.61	0.00	0.00	0.00	0.00	0.00	0.00	1.83	0.00	2.8	29
0.31	0.00	0.23	0.64	1.06	0.25	0.11	0.11	0.54	0.23	8.7	26
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	17
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.00	0.1	17
0.10	0.00	0.12	0.95	0.53	0.37	0.00	0.00	0.22	0.00	3.6	17
0.21	0.41	0.35	3.50	1.59	1.24	0.91	0.23	0.86	0.00	13.4	14
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.11
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.11
0.00	0.00	0.00	0.00	0.11	0.00	0.00	0.00	0.00	0.00	0.1	0.11
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00
2.68	3.66	5.84	12.10	4.67	7.09	7.18	2.05	11.30	1.13	100.0	

Table 5.18: Cumulative proportion of farmers cultivating wheat varieties released in specific years or later, by province (%)

Year	Beni Mellal	Benslimane	Berrechid	El Hajeb	El Jadida	El Kelâa	Fez	Guercif	Kénitra	Khemisset
1921	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1982	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1984	94.3	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1985	94.3	66.7	78.6	66.7	100.0	91.7	100.0	75.0	100.0	66.7
1988	2.9	33.3	71.4	0.0	0.0	58.3	0.0	33.3	0.0	0.0
1991	2.9	33.3	71.4	0.0	0.0	58.3	0.0	33.3	0.0	0.0
1993	2.9	33.3	71.4	0.0	0.0	58.3	0.0	33.3	0.0	0.0
1994	0.0	33.3	71.4	0.0	0.0	58.3	0.0	33.3	0.0	0.0
1995	0.0	33.3	71.4	0.0	0.0	8.3	0.0	0.0	0.0	0.0
1996	0.0	33.3	71.4	0.0	0.0	8.3	0.0	0.0	0.0	0.0
1997	0.0	33.3	71.4	0.0	0.0	8.3	0.0	0.0	0.0	0.0
2003	0.0	33.3	71.4	0.0	0.0	8.3	0.0	0.0	0.0	0.0
2004	0.0	33.3	71.4	0.0	0.0	8.3	0.0	0.0	0.0	0.0
2005	0.0	33.3	71.4	0.0	0.0	8.3	0.0	0.0	0.0	0.0
2006	0.0	0.0	21.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2007	0.0	0.0	21.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2010	0.0	0.0	14.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2011	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2012	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Khenifra	Meknes	My Yacoub	Rehamna	Safi	Settat	Sidi Bennour	Sidi Kacem	Sidi Slimane	Taounate	Taza
100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	0.0	100.0	100.0
100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	0.0	100.0	100.0
100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	0.0	100.0	100.0
10.5	100.0	87.5	85.2	94.3	34.2	70.0	100.0	0.0	86.4	73.3
10.5	33.3	12.5	37.0	54.3	13.2	20.0	0.0	0.0	9.1	48.3
0.0	33.3	12.5	37.0	54.3	13.2	20.0	0.0	0.0	9.1	48.3
0.0	33.3	12.5	37.0	54.3	13.2	20.0	0.0	0.0	9.1	48.3
0.0	33.3	6.3	33.3	54.3	13.2	20.0	0.0	0.0	2.3	48.3
0.0	33.3	0.0	7.4	51.4	13.2	20.0	0.0	0.0	2.3	0.0
0.0	33.3	0.0	7.4	51.4	13.2	20.0	0.0	0.0	2.3	0.0
0.0	33.3	0.0	7.4	51.4	13.2	20.0	0.0	0.0	2.3	0.0
0.0	0.0	0.0	7.4	51.4	13.2	20.0	0.0	0.0	2.3	0.0
0.0	0.0	0.0	7.4	51.4	13.2	20.0	0.0	0.0	2.3	0.0
0.0	0.0	0.0	7.4	51.4	13.2	20.0	0.0	0.0	2.3	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.3	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 5.19: Proportion of farmers planting durum wheat varieties of different release dates, national figures (%)
(adoption rates are generated by using number of growers in each province as weights)

Year	Beni Mellal	Benslimane	Berrechid	El Hajeb	El Jadida	El Kelâa	Fez	Guercif	Kénitra	Khemisset	Khenifra
1921	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1982	0.59	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1984	0.00	0.30	0.84	0.24	0.00	0.31	0.00	0.89	0.00	0.28	4.74
1985	9.43	0.30	0.28	0.47	1.31	1.23	0.54	1.49	0.75	0.56	0.00
1988	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.56
1991	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1993	0.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1994	0.00	0.00	0.00	0.00	0.00	1.85	0.00	1.19	0.00	0.00	0.00
1995	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1996	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1997	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2003	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2004	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2005	0.00	0.30	1.96	0.00	0.00	0.31	0.00	0.00	0.00	0.00	0.00
2006	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2007	0.00	0.00	0.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2010	0.00	0.00	0.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2011	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2012	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Share of total number of growers in 21 provinces (%)	10.32	0.89	3.93	0.71	1.31	3.70	0.54	3.57	0.75	0.84	5.29

Meknes	My Yacoub	Rehamna	Safi	Settat	Sidi Bennour	Sidi Kacem	Sidi Slimane	Taounate	Taza	Total	Cumulative
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	100
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.6	100
0.00	0.54	1.23	0.56	7.01	0.99	0.00	0.00	1.70	4.76	24.4	99
0.55	3.22	4.01	3.92	2.24	1.64	0.60	0.00	9.66	4.46	46.7	75
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.6	28
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	28
0.00	0.27	0.31	0.00	0.00	0.00	0.00	0.00	0.85	0.00	1.7	28
0.00	0.27	2.16	0.28	0.00	0.00	0.00	0.00	0.00	8.63	14.4	26
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	12
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	12
0.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.3	12
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	11
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	11
0.00	0.00	0.62	5.04	1.40	0.66	0.00	0.00	0.00	0.00	10.3	11
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.28	0.00	0.3	1
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.3	1
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.6	1
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00
0.82	4.30	8.33	9.81	10.66	3.29	0.60	0.00	12.50	17.85	100.0	

Table 5.20: Degree of adoption (proportion of area) by variety (%)

Degree of adoption rank	Variety	Number of communities in which variety was found	Degree of adoption by share of area (%)	Cumulative degree of adoption by area (%)
1	Achtar	58	22.20	22.20
2	Merchouch	52	13.01	35.21
3	Amal	43	12.45	47.66
4	Karim	60	12.31	59.97
5	Radia	43	10.24	70.21
6	Marzak	55	8.25	78.46
7	Arrehane	31	7.09	85.55
8	Crioca	30	2.54	88.09
9	Saidi	27	2.45	90.54
10	Wissam	16	2.17	92.71
11	Salama	21	1.45	94.16
12	Bread wheat (local)	10	0.99	95.15
13	Rajae	7	0.90	96.05
14	Tigre	6	0.80	96.85
15	Nassim	7	0.64	97.49
16	Baida	3	0.44	97.93
17	Viton	7	0.37	98.30
18	Cocorit	5	0.26	98.56
19	El Wafia	2	0.25	98.81
20	Aguilal	5	0.14	98.95
21	Oum Rabia	1	0.13	99.08
22	Prosse Pero	1	0.11	99.19
23	Beldi	8	0.10	99.29
23	Kanz	2	0.10	99.39
25	Mehdia	1	0.08	99.47
25	Massira	2	0.08	99.55
25	Irride	2	0.08	99.63
28	Durum wheat (local)	3	0.06	99.69
28	Amjad	1	0.06	99.75
30	Manal	1	0.05	99.80
31	Mazrouba	2	0.03	99.83
31	Faiza	1	0.03	99.86
31	El Manar	1	0.03	99.89

Degree of adoption rank	Variety	Number of communities in which variety was found	Degree of adoption by share of area (%)	Cumulative degree of adoption by area (%)
34	Tomouh	1	0.02	99.91
34	Vitrico	1	0.02	99.93
34	Anouar	2	0.02	99.95
34	Ouissane	1	0.02	99.97
38	Ourgh	1	0.01	99.98
38	Krifla Kahla	1	0.01	99.99
40	Jouda	1	0.00	99.99
	Total	**522**	**99.99**	

Degree of adoption by province

With a degree of adoption of 62.6% (of area) for improved wheat varieties released in the last 10 years, Berrechid is leading all the provinces. It is followed by Safi (41.27%), Settat (39.96%), El Hajeb (32.15%), and Sidi Kacem (27.29%) which have the indicated shares of the wheat area covered by varieties 10 or less years old. In contrast, Khenifra province is dominated by very old varieties – 98.6% of its wheat fields are cultivated with varieties that are more than 20 years old. Other provinces where old varieties dominate include Beni Mellal, El Kelâa, and Rehamna (Table 5.21).

Degree of adoption (percentage of the area) by agro-ecological zones

As was the case for the number of growers presented in Table 5.14, the unfavorable south is the surprising leader of the rest of the agro-ecologies in terms of the proportion of the wheat area covered by more recent varieties. Here, 28.67% of all the wheat area is planted with varieties that are 10 years old or younger. The shares for the other areas are intermediate zone 12.49%, favorable zone 12.07%, and mountainous zone less than 1%. The favorable zone is the leader in areas cultivated with varieties 20 years of age or less. It is followed in order by the unfavorable south, intermediate, and mountainous zones (Table 5.22).

Table 5.21: Cumulative proportion of the wheat area under wheat varieties released in specific years or later, by province (%)

Year	Beni Mellal	Benslimane	Berrechid	El Hajeb	El Jadida	El Kelâa	Fez	Guercif	Kénitra	Khemisset
1921	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
1982	95.40	100.00	99.06	100.00	99.39	100.00	100.00	100.00	100.00	100.00
1984	94.19	100.00	89.66	99.36	99.39	100.00	100.00	100.00	100.00	100.00
1985	56.64	88.50	73.73	90.23	91.22	68.73	59.52	52.62	96.42	98.13
1988	22.04	79.38	67.62	86.94	76.04	51.28	45.63	31.81	95.73	89.92
1991	1.82	54.47	66.99	61.00	25.47	10.20	45.63	20.27	24.70	85.07
1993	1.82	54.47	66.99	61.00	25.47	10.20	45.63	20.27	24.70	85.07
1994	0.06	50.13	63.86	37.26	23.70	9.93	29.76	14.25	8.99	85.07
1995	0.06	50.13	63.86	37.26	23.70	7.24	25.79	0.00	8.99	85.07
1996	0.06	50.13	63.86	35.43	23.70	7.24	0.00	0.00	8.99	84.56
1997	0.06	10.85	62.60	32.15	8.80	7.24	0.00	0.00	0.21	12.79
2003	0.06	10.85	62.60	32.15	8.80	7.24	0.00	0.00	0.21	12.79
2004	0.06	10.85	62.60	32.15	8.80	7.24	0.00	0.00	0.21	12.79
2005	0.00	10.85	54.76	32.15	3.79	7.03	0.00	0.00	0.21	10.83
2006	0.00	0.00	5.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2007	0.00	0.00	5.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2010	0.00	0.00	2.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2011	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2012	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Khenifra	Meknes	My Yacoub	Rehamna	Safi	Settat	Sidi Bennour	Sidi Kacem	Sidi Slimane	Taounate	Taza
100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
82.75	100.00	100.00	99.84	99.31	100.00	99.41	100.00	100.00	99.13	100.00
78.81	100.00	100.00	99.67	99.25	98.35	99.41	100.00	100.00	99.13	94.83
46.83	94.87	92.63	55.67	91.04	64.01	67.97	98.97	61.80	81.68	48.52
43.78	86.00	73.91	42.32	81.45	50.82	50.53	93.18	49.06	62.38	27.19
10.68	73.37	58.83	10.48	75.86	48.97	26.18	81.00	35.08	52.63	26.00
1.41	73.37	58.83	10.48	75.86	48.97	26.18	81.00	35.08	52.63	26.00
1.41	37.48	24.00	8.53	48.91	44.85	17.91	35.23	5.41	23.72	24.82
1.41	37.48	23.56	3.28	43.08	44.85	17.91	35.23	5.41	23.72	1.69
1.41	35.90	3.46	3.28	42.96	44.85	17.91	35.23	5.41	6.79	1.69
0.00	14.99	3.46	2.93	41.27	39.96	15.66	27.29	4.14	6.01	0.00
0.00	13.41	3.46	2.93	41.27	39.96	15.66	27.29	4.14	6.01	0.00
0.00	13.41	3.46	2.93	41.27	39.96	15.66	27.29	4.14	5.22	0.00
0.00	9.47	3.46	2.52	36.88	34.50	10.34	27.29	4.14	5.22	0.00
0.00	0.00	0.00	0.00	0.00	0.62	0.00	0.00	0.00	0.30	0.00
0.00	0.00	0.00	0.00	0.00	0.62	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.62	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 5.22: Proportion of the wheat area in each agro-ecological zone that is under varieties released in different years (%)

Year	Favorable	Intermediate	Unfavorable south	Mountain
1921	100.00	100.00	100.00	100.00
1982	99.88	99.70	99.73	89.13
1984	99.41	98.34	99.30	86.58
1985	87.46	68.98	76.45	51.78
1988	78.26	55.14	63.16	32.80
1991	56.06	29.66	45.66	6.21
1993	56.06	29.66	45.66	1.62
1994	34.64	20.88	33.86	0.73
1995	32.31	18.06	30.57	0.73
1996	29.50	14.25	30.52	0.73
1997	12.13	12.49	28.67	0.03
2003	12.07	12.49	28.67	0.03
2004	11.96	12.49	28.67	0.03
2005	11.51	10.42	25.53	0.00
2006	0.04	0.72	0.15	0.00
2007	0.00	0.72	0.15	0.00
2010	0.00	0.30	0.15	0.00
2011	0.00	0.00	0.00	0.00
2012	0.00	0.00	0.00	0.00
Share of total wheat area in the four agro-ecological zones (%)	44.20	23.94	18.99	12.87

5.6.3 Degree of adoption

Share of the wheat growing area, national level

Wheat production in Morocco is characterized by the dominance of old varieties. Less than 1% of the total national wheat area is covered with varieties that were released five or less years ago. While the figure improves to about 15% when the cut-off point for varietal age is increased to 10 years, generally varieties 20 or more years old dominate the landscape with an area-weighted average varietal replacement rate of 21.9 years. About 41.1% of the total

national wheat area is under improved wheat varieties 20 years old or less (Table 5.23).

At the national level, female-headed households are growing improved wheat varieties 20 years old or less on an average of 3.29 ha (i.e., on 55% of their wheat area), while male-headed households have adopted the improved varieties on 1.52 ha (26% of their wheat area). This shows that female-headed households have adopted the improved varieties both in terms of the number of farm households and the intensity of adoption. A comparison of adoption rates and degree of adoption shows that the percentage of the area covered by the more recent wheat varieties is higher than the percentage of farmers who are cultivating more recent varieties. These results are an indication that farmers with relatively larger wheat areas are adopting more recent varieties than those with relatively small wheat areas. This is consistent with the theoretical expectation.

Share of the cultivated area, by wheat species

With a degree of adoption of 71.38%, Berrechid Province leads all other provinces in terms of the proportion of the bread wheat fields covered by more recent varieties – 10 years old or less (Table 5.24). Settat (58%), Safi (43%), and El Hajeb (34%) follow. Kinifra, Beni Mellal, and Rehamna are at the bottom of the list as the bread wheat fields in these provinces are dominated by very old varieties (Table 5.25). Berrechid also leads all provinces in terms of the percentage of durum wheat areas cultivated with more recent varieties (Table 5.26). In this province, 52% of the durum wheat areas are cultivated with varieties 10 years old or less. It is followed by Benslimane (41%) and Settat (23%). Some provinces (El Hajeb, El Jadida, Kénitra, Khenifra, Khemisset, Sidi Kacem, and Sidi Slimane) exhibit no trace of durum varieties less than 20 years old. For a country like Morocco, where a lot of investment is being made in research and where several potential varieties have been released, these results are rather disappointing. Understanding the root cause and devising mitigative measures should be a high priority if the country is to benefit from its own and CGIAR's investments in research and if it is to minimize and possibly eliminate its dependence on imports.

Also, at the national level, the degree of adoption of durum wheat varieties 20 years old or less stands at the very low level of 21%. Comparison between the national degrees of adoption of bread wheat varieties (Table 5.25) and durum wheat varieties (Table 5.26) shows that a relatively higher proportion of the total bread wheat areas are covered with more recent varieties than those under durum wheat.

Table 5.23: Proportion of the wheat area under varieties of different release dates, national figures (%)
(degrees of adoption are generated using the wheat areas in each of the provinces as weights)

Year	Beni Mellal	Benslimane	Berrechid	El Hajeb	El Jadida	El Kelâa	Fez	Guercif	Kénitra	Khemisset	Khenifra
1921	0.40	0.00	0.04	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.72
1982	0.11	0.00	0.41	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.16
1984	3.26	0.37	0.69	0.25	0.37	1.01	0.28	0.46	0.16	0.14	1.34
1985	3.01	0.29	0.27	0.09	0.69	0.56	0.10	0.20	0.03	0.61	0.13
1988	1.76	0.80	0.03	0.70	2.30	1.32	0.00	0.11	3.22	0.36	1.38
1991	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.39
1993	0.15	0.14	0.14	0.64	0.08	0.01	0.11	0.06	0.71	0.00	0.00
1994	0.00	0.00	0.00	0.00	0.00	0.09	0.03	0.14	0.00	0.00	0.00
1995	0.00	0.00	0.00	0.05	0.00	0.00	0.18	0.00	0.00	0.04	0.00
1996	0.00	1.26	0.05	0.09	0.68	0.00	0.00	0.00	0.40	5.29	0.06
1997	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2003	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2004	0.01	0.00	0.34	0.00	0.23	0.01	0.00	0.00	0.00	0.14	0.00
2005	0.00	0.35	2.15	0.87	0.17	0.23	0.00	0.00	0.01	0.80	0.00
2006	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2007	0.00	0.00	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2010	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2011	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2012	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Share of total wheat area in 21 sample provinces (%)	8.69	3.20	4.36	2.72	4.54	3.22	0.69	0.97	4.53	7.37	4.18

Meknes	My Yacoub	Rehamna	Safi	Settat	Sidi Bennour	Sidi Kacem	Sidi Slimane	Taounate	Taza	Total	Cumulative
0.00	0.00	0.01	0.05	0.00	0.02	0.00	0.00	0.07	0.00	1.25	100.00
0.00	0.00	0.01	0.00	0.14	0.00	0.00	0.00	0.00	0.19	0.90	98.75
0.18	0.33	2.87	0.61	2.85	1.28	0.08	0.53	1.42	1.68	21.26	97.86
0.32	0.84	0.87	0.72	1.10	0.71	0.46	0.18	1.57	0.77	12.31	76.60
0.45	0.67	2.07	0.42	0.15	0.99	0.98	0.19	0.79	0.04	22.44	64.29
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.44	41.86
1.28	1.55	0.13	2.01	0.34	0.34	3.67	0.41	2.35	0.04	13.90	41.41
0.00	0.02	0.34	0.43	0.00	0.00	0.00	0.00	0.00	0.84	2.45	27.52
0.06	0.90	0.00	0.01	0.00	0.00	0.00	0.00	1.38	0.00	2.18	25.07
0.75	0.00	0.02	0.13	0.41	0.09	0.64	0.02	0.06	0.06	8.09	22.89
0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	14.79
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.05	14.77
0.14	0.00	0.03	0.33	0.45	0.22	0.00	0.00	0.00	0.00	1.45	14.72
0.34	0.15	0.16	2.75	2.82	0.42	2.19	0.06	0.40	0.00	13.03	13.28
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.02	0.24
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.23
0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.11	0.11
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.57	4.46	6.52	7.46	8.31	4.06	8.02	1.38	8.13	3.63	100.00	

Table 5.24: Cumulative proportion of the wheat area under varieties released in specific years or later, by province (%)

Year	Beni Mellal	Benslimane	Berrechid	El Hajeb	El Jadida	El Kelâa	Fez	Guercif	Kénitra	Khemisset
1921	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
1982	91.45	100.00	98.28	100.00	99.25	100.00	100.00	100.00	100.00	100.00
1984	91.45	100.00	81.11	99.33	99.25	100.00	100.00	100.00	100.00	100.00
1985	39.36	93.49	80.54	90.93	93.56	70.63	50.72	35.53	96.54	98.14
1988	39.36	93.49	80.54	90.93	93.56	70.63	50.72	35.53	96.54	98.14
1991	1.82	59.50	79.39	63.80	31.34	10.75	50.72	12.18	24.90	92.85
1993	1.82	59.50	79.39	63.80	31.34	10.75	50.72	12.18	24.90	92.85
1994	0.11	53.58	73.67	38.97	29.16	10.35	31.40	0.00	9.07	92.85
1995	0.11	53.58	73.67	38.97	29.16	10.35	31.40	0.00	9.07	92.85
1996	0.11	53.58	73.67	37.06	29.16	10.35	0.00	0.00	9.07	92.29
1997	0.11	0.00	71.38	33.62	10.83	10.35	0.00	0.00	0.21	13.96
2003	0.11	0.00	71.38	33.62	10.83	10.35	0.00	0.00	0.21	13.96
2004	0.11	0.00	71.38	33.62	10.83	10.35	0.00	0.00	0.21	13.96
2005	0.00	0.00	57.07	33.62	4.67	10.05	0.00	0.00	0.21	11.82
2006	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2007	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2010	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2011	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2012	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Khenifra	Meknes	My Yacoub	Rehamna	Safi	Settat	Sidi Bennour	Sidi Kacem	Sidi Slimane	Taounate	Taza
100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
72.08	100.00	100.00	99.78	99.01	100.00	99.05	100.00	100.00	98.87	100.00
66.48	100.00	100.00	99.56	99.01	96.59	99.05	100.00	100.00	98.87	100.00
66.48	94.27	94.04	49.68	92.04	79.64	79.47	99.05	56.22	79.47	18.29
66.48	94.27	94.04	49.68	92.04	79.64	79.47	99.05	56.22	79.47	18.29
17.28	80.18	73.32	6.34	84.04	75.80	40.49	86.10	40.20	66.76	12.96
2.28	80.18	73.32	6.34	84.04	75.80	40.49	86.10	40.20	66.76	12.96
2.28	40.09	32.37	3.80	45.50	68.12	27.25	37.45	6.20	30.55	7.62
2.28	40.09	32.37	3.80	45.50	68.12	27.25	37.45	6.20	30.55	7.62
2.28	38.33	4.75	3.80	45.50	68.12	27.25	37.45	6.20	8.47	7.62
0.00	14.98	4.75	3.32	43.08	58.00	23.65	29.01	4.74	7.45	0.00
0.00	14.98	4.75	3.32	43.08	58.00	23.65	29.01	4.74	7.45	0.00
0.00	14.98	4.75	3.32	43.08	58.00	23.65	29.01	4.74	6.42	0.00
0.00	10.57	4.75	2.77	36.81	46.70	15.14	29.01	4.74	6.42	0.00
0.00	0.00	0.00	0.00	0.00	1.28	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	1.28	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	1.28	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

5.6.4 Factors affecting farmers' decisions, intensity, and speed of adoption

Factors affecting farmers' decisions and intensity of adoption

Looking at the adoption levels reported in Table 5.14, the number of farmers who have adopted varieties 10 years old or less is only 16% of the total number of national growers. However, the adoption level for varieties 20 years old or younger is 42%, which shows that there is a sizeable number of farmers cultivating them. So, using this cut-off point would provide a good representation of both adopters and non-adopters in our sample. For this study, improved varieties are defined as varieties released in or after 1993. Therefore, farmers who cultivate varieties released before 1993 are categorized as non-adopters. One can argue that, while certified seeds of these varieties are being produced, it is difficult to call them non-adopters. However, one should keep in mind the difference between new improved varieties and old improved varieties as well as the production of certified seed.

Parameter estimates for the Heckman selection model are provided in Table 5.28. Given the significant coefficient estimate on the inverse Mills ratio for the "area under improved varieties" equation, the Heckman selection model is an

Table 5.25: Proportion of the wheat area under bread wheat varieties of different release dates, national figures (%)
(degree of adoption is generated by using the bread wheat areas in each province as weights)

Year	Beni Mellal	Benslimane	Berrechid	El Hajeb	El Jadida	El Kelâa	Fez	Guercif	Kénitra	Khemisset	Khenifra
1921	0.54	0.00	0.06	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.98
1982	0.00	0.00	0.56	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.20
1984	3.32	0.21	0.02	0.30	0.29	0.88	0.38	0.41	0.21	0.17	0.00
1985	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1988	2.39	1.09	0.04	0.96	3.13	1.80	0.00	0.15	4.41	0.49	1.73
1991	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.53
1993	0.11	0.19	0.19	0.88	0.11	0.01	0.15	0.08	0.98	0.00	0.00
1994	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1995	0.00	0.00	0.00	0.07	0.00	0.00	0.24	0.00	0.00	0.05	0.00
1996	0.00	1.71	0.07	0.12	0.92	0.00	0.00	0.00	0.55	7.21	0.08
1997	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2003	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2004	0.01	0.00	0.47	0.00	0.31	0.01	0.00	0.00	0.00	0.20	0.00
2005	0.00	0.00	1.86	1.19	0.23	0.30	0.00	0.00	0.01	1.09	0.00
2006	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2007	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2010	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2011	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2012	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Share of total bread wheat area in the 21 sample provinces (%)	6.37	3.19	3.25	3.54	5.03	3.00	0.77	0.63	6.16	9.20	3.52

Meknes	My Yacoub	Rehamna	Safi	Settat	Sidi Bennour	Sidi Kacem	Sidi Slimane	Taounate	Taza	Total	Cumulative
0.00	0.00	0.01	0.07	0.00	0.03	0.00	0.00	0.10	0.00	1.70	100.00
0.00	0.00	0.01	0.00	0.19	0.00	0.00	0.00	0.00	0.00	0.87	98.30
0.25	0.26	3.25	0.50	0.93	0.68	0.10	0.70	1.65	0.90	17.72	97.44
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	79.72
0.61	0.92	2.82	0.57	0.21	1.35	1.33	0.26	1.08	0.06	30.38	79.72
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.61	49.34
1.75	1.81	0.17	2.74	0.42	0.46	5.00	0.54	3.07	0.06	18.39	48.73
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	30.34
0.08	1.22	0.00	0.00	0.00	0.00	0.00	0.00	1.87	0.00	2.95	30.34
1.02	0.00	0.03	0.17	0.55	0.12	0.87	0.02	0.09	0.08	11.02	27.39
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	16.37
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.00	0.06	16.37
0.19	0.00	0.04	0.45	0.62	0.29	0.00	0.00	0.00	0.00	1.97	16.31
0.46	0.21	0.18	2.62	2.48	0.52	2.98	0.08	0.55	0.00	14.29	14.33
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05
0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.05	0.05
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4.36	4.42	6.52	7.11	5.47	3.45	10.27	1.60	8.49	1.10	100.00	

Table 5.26: Proportion of the durum wheat area under varieties of different release dates, by province (%)

Year	Beni Mellal	Benslimane	Berrechid	El Hajeb	El Jadida	El Kelâa	Fez	Guercif	Kénitra	Khemisset
1921	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1982	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1984	94.3	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1985	94.3	66.7	78.6	66.7	100.0	91.7	100.0	75.0	100.0	66.7
1988	2.9	33.3	71.4	0.0	0.0	58.3	0.0	33.3	0.0	0.0
1991	2.9	33.3	71.4	0.0	0.0	58.3	0.0	33.3	0.0	0.0
1993	2.9	33.3	71.4	0.0	0.0	58.3	0.0	33.3	0.0	0.0
1994	0.0	33.3	71.4	0.0	0.0	58.3	0.0	33.3	0.0	0.0
1995	0.0	33.3	71.4	0.0	0.0	8.3	0.0	0.0	0.0	0.0
1996	0.0	33.3	71.4	0.0	0.0	8.3	0.0	0.0	0.0	0.0
1997	0.0	33.3	71.4	0.0	0.0	8.3	0.0	0.0	0.0	0.0
2003	0.0	33.3	71.4	0.0	0.0	8.3	0.0	0.0	0.0	0.0
2004	0.0	33.3	71.4	0.0	0.0	8.3	0.0	0.0	0.0	0.0
2005	0.0	33.3	71.4	0.0	0.0	8.3	0.0	0.0	0.0	0.0
2006	0.0	0.0	21.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2007	0.0	0.0	21.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2010	0.0	0.0	14.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2011	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2012	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Khenifra	Meknes	My Yacoub	Rehamna	Safi	Settat	Sidi Bennour	Sidi Kacem	Sidi Slimane	Taounate	Taza
100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	0.0	100.0	100.0
100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	0.0	100.0	100.0
100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	0.0	100.0	100.0
10.5	100.0	87.5	85.2	94.3	34.2	70.0	100.0	0.0	86.4	73.3
10.5	33.3	12.5	37.0	54.3	13.2	20.0	0.0	0.0	9.1	48.3
0.0	33.3	12.5	37.0	54.3	13.2	20.0	0.0	0.0	9.1	48.3
0.0	33.3	12.5	37.0	54.3	13.2	20.0	0.0	0.0	9.1	48.3
0.0	33.3	6.3	33.3	54.3	13.2	20.0	0.0	0.0	2.3	48.3
0.0	33.3	0.0	7.4	51.4	13.2	20.0	0.0	0.0	2.3	0.0
0.0	33.3	0.0	7.4	51.4	13.2	20.0	0.0	0.0	2.3	0.0
0.0	33.3	0.0	7.4	51.4	13.2	20.0	0.0	0.0	2.3	0.0
0.0	0.0	0.0	7.4	51.4	13.2	20.0	0.0	0.0	2.3	0.0
0.0	0.0	0.0	7.4	51.4	13.2	20.0	0.0	0.0	2.3	0.0
0.0	0.0	0.0	7.4	51.4	13.2	20.0	0.0	0.0	2.3	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.3	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

appropriate choice for correcting the selection bias that is introduced either by farmers themselves or by other factors over which they have no control. Model results show that neither the size of area dedicated to wheat nor the total crop land owned and/or cultivated have a significant role in affecting farmers' decisions whether to adopt improved varieties of wheat. Theoretically, one would expect larger wheat farms (often commercial) to find it worthwhile to invest in improved varieties, as they focus more on yield regardless of specific quality traits, which are important for own-home consumption. However, given the small share of own consumption in total wheat production, these results are not unreasonable.

Household heads' age, gender, and the number of years of education, as well as the number of family members working on the farm and access to credit all have positive and significant effects on the decision whether to adopt improved wheat varieties. These factors also have an effect on the share of the wheat area to be dedicated to the improved wheat varieties. These results are valid as older farmers (who are implicitly also often more experienced) and

Table 5.27: Proportion of the durum wheat area under varieties of different release dates, national figures (%)
(degree of adoption calculated using durum wheat areas in each of the provinces as weights)

Year	Beni Mellal	Benslimane	Berrechid	El Hajeb	El Jadida	El Kelâa	Fez	Guercif	Kénitra	Khemisset
1921	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1982	0.59	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1984	0.00	0.30	0.84	0.24	0.00	0.31	0.00	0.89	0.00	0.28
1985	9.43	0.30	0.28	0.47	1.31	1.23	0.54	1.49	0.75	0.56
1988	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1991	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1993	0.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1994	0.00	0.00	0.00	0.00	0.00	1.85	0.00	1.19	0.00	0.00
1995	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1996	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1997	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2003	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2004	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2005	0.00	0.30	1.96	0.00	0.00	0.31	0.00	0.00	0.00	0.00
2006	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2007	0.00	0.00	0.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2010	0.00	0.00	0.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2011	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2012	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Share of total durum wheat area in the 21 sample provinces (%)	15.09	3.21	7.42	0.45	3.20	3.80	0.46	1.79	0.14	2.33

Year	Khenifra	Meknes	My Yacoub	Rehamna	Safi	Settat	Sidi Bennour	Sidi Kacem	Sidi Slimane	Taounate	Taza	Total	Cumulative
1921	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	100
1982	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.6	100
1984	4.74	0.00	0.54	1.23	0.56	7.01	0.99	0.00	0.00	1.70	4.76	24.4	99
1985	0.00	0.55	3.22	4.01	3.92	2.24	1.64	0.60	0.00	9.66	4.46	46.7	75
1988	0.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.6	28
1991	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	28
1993	0.00	0.00	0.27	0.31	0.00	0.00	0.00	0.00	0.00	0.85	0.00	1.7	28
1994	0.00	0.00	0.27	2.16	0.28	0.00	0.00	0.00	0.00	0.00	8.63	14.4	26
1995	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	12
1996	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	12
1997	0.00	0.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.3	12
2003	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	11
2004	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	11
2005	0.00	0.00	0.00	0.62	5.04	1.40	0.66	0.00	0.00	0.00	0.00	10.3	11
2006	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.28	0.00	0.3	1
2007	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.3	1
2010	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.6	1
2011	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00
2012	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00
Share of total durum wheat area in the 21 sample provinces (%)	6.01	1.41	4.57	6.51	8.44	16.17	5.73	1.79	0.65	7.13	10.71	100	

Table 5.28: Parameter estimates from the Heckman selection model

Variables	Outcome equations‡		Selection equation†		Marginal effects
	Area under the new varieties		Adoption dummy		
	Coef.	Std. error	Coef.	Std. error	
Age (years)	0.064	(0.030) **	0.010	(0.004) **	0.001
Sex (1 = male, 0 = female)	0.104	(0.033) ***	0.579	(0.271) **	0.046
Number of years of education	0.162	(0.019) ***	1.957	(0.138) ***	0.154
Number of family members working on own farm (person days/ha)	0.097	(0.016) ***	0.140	(0.026) ***	0.011
Obtained credit from a bank (1 = yes, 0 = no)	0.115	(0.016) ***	0.636	(0.117) ***	0.050
Off-farm employment (1 = yes, 0 = no)	0.028	0.019	–0.351	(0.165) **	–0.028
Irrigated (1 = yes, 0 = no)	0.027	0.018	0.060	0.156	0.005
Wheat area (ha)	0.384	(0.013) ***	0.001	0.006	0.0001
Total cropped area (ha)	–0.001	0.003	–0.002	0.002	0.0001
Walking distance from seed sources (km)	–0.345	(0.008) ***	–0.078	(0.006) ***	–0.006
Hosted wheat demonstrations/ PVS trials (1 = yes, 0 = no)			1.692	(0.491) ***	0.133
Visited demonstration fields/ attended field days (1 = yes, 0 = no)			0.442	0.459	0.035
Used certified seed (1 = yes, 0 = no)	0.052	(0.015) ***	0.939	(0.116) ***	0.074
Seed from seed company (1 = yes, 0 = no)	0.037	(0.020) *	0.573	(0.153) ***	0.045
Seed from agro-dealers/agro-vets (1 = yes, 0 = no)	0.007	0.014	–0.225	0.118	–0.018
Price of seed	0.005	0.020	0.071	0.069	0.006
Farm in favorable zone (1 = yes, 0 = no)	0.176	(0.019) ***	1.671	(0.157) ***	0.132
Farm in intermediate zone (1 = yes, 0 = no)	–0.007	0.018	0.618	(0.166) ***	0.049
Inverse Mills ratio (λ)	0.407	(0.024***)	NA		
Constant	–0.021	0.133	–6.494	(0.525)***	
Rho	0.591				
Sigma	0.053				

Description of dependent variables:
† Selection equation: adoption dummy – a dummy variable for the adoption of the improved wheat variety which takes a value of 1 if the farmer is an adopter and 0 otherwise.
‡ Outcome equation: area under the new varieties (ha).
*, **, and *** respectively represent significance at the 0.1, 0.05, and 0.01 levels.

educated farmers are likely to better understand the benefits and have the knowledge and skills to better manage new technology packages. These would include wheat and other associated management practices, including use of fertilizer.

Generally, with their poorer access to information and productive resources – including land, labor, and financial capital – female-headed households are expected to be less likely to adopt new technologies than male-headed ones. Moreover, if female-headed households adopt new agricultural technologies at all, it would be expected that they would do it on a lower scale. Farmers with better access to credit are also likely to be more inclined to adopt new varieties as they will have the needed financial liquidity to purchase certified seeds and other complementary inputs, such as fertilizers, herbicides, pesticides, and the extra labor that might be needed. Having more family members working on the farm would also mean a greater need to make the farm enterprise profitable and their time on the farm worthwhile. Adopting new varieties can be a strategic way of achieving higher profitability. Moreover, more family labor would mean less stress in terms of meeting the higher management requirements of adopting technology packages.

Farmers who hosted demonstration trials on their own farms are also found to have a higher propensity to adopt improved wheat varieties. However, participating in field days alone does not significantly affect farmers' adoption decisions. These results are also consistent with theoretical expectations. Demonstration trials would give the farmer hands-on training and first-hand information about the pros and cons of the technology. Participation in field days, however, would not fully answer the questions and clear the doubts farmers may have about the technologies. Farmers located in the favorable and intermediate zones of Morocco have a higher propensity to adopt improved wheat varieties than those in the unfavorable south or mountainous zones. Naturally, investment in new technologies is likely to have a bigger effect in favorable areas than unfavorable ones and, hence, these results do not come as a surprise.

What is rather surprising is that whether the farm has access to irrigation does not have a significant effect on a farmer's decision to adopt improved varieties. This may be justified on the grounds that farmers who are in rainfed areas are desperate to get varieties that are early maturing and drought tolerant in order to minimize the risk to their crops. Hence, they are more eager to adopt new varieties than farmers with modern irrigation. Farmers who have other

forms of employment alongside their work on their farms are found to have less inclination to adopt improved wheat varieties. This result makes intuitive sense, as having alternative sources of income would make farmers less interested in investing in agriculture, as agriculture is often regarded as an inferior occupation. Moreover, having off-farm employment means that the person will not have enough time to devote to agriculture, so they will not be able meet the demands of adopting new varieties and the associated technology packages.

Holding all other factors constant, access to seed proves to be an important factor in determining farmers' adoption decisions. For instance, farmers who walk or drive long distances to seed sources have a lesser propensity to adopt improved varieties of wheat than those who live close by. This could be justified on two grounds. Living closer would lead to a better flow of information about the varieties and the seed. Moreover, the travel costs (both in terms of time and money) and the trouble of going to other places would discourage farmers – who are used to using their own-saved seed or seed exchanged with neighbors – from exploring improved varieties. Farmers who purchase certified seed are found to have a higher tendency to adopt more recent improved varieties than those who use uncertified seeds. Certified seeds are more indicative of improved varieties, which are not too old, than are seeds which are uncertified. This finding does not come as a surprise. Certified seed production often focusses on more recent varieties. However, depending on the definition of improved varieties, the results may change. For example, if adoption was to be defined as the use of varieties which are 10 years old or less, then the results would have been the opposite, as most cultivated varieties are more than 10 years old.

Also, farmers who get their seed from seed companies are more likely to adopt new varieties than those who get their seed from other sources, including local traders and seed dealers. This clearly shows the importance of having more seed distribution networks that are close to farmers. Moreover, though farmers' risk attitudes and preferences towards varietal attributes are vital to their adoption decisions, model results clearly show that the age of the cultivated varieties depends on the type and age of varieties for which certified seed is being produced and sold by seed companies. The combined effects of proximity to seed source, the ability to use certified seed, and the ability to buy seed from seed companies in adequate quantities and in a timely fashion can be quantified. These factors together result in a 13% increase in the propensity to adopt improved varieties.

In summary, the model results show that 79% of the total variation in adoption decisions was explained by all the variables included into the regression. The remaining 21% is explained by variables (such as farmers' risk attitudes) that were not included in the model. Among the variables included, farmer characteristics (such as age, gender, education, credit access, off-farm employment, and whether the farmer hosted demonstration trials), in general, were found to be the most important explanatory variables accounting for 45% of the total variation. This was followed by farm characteristics (such as the size of the wheat area, access to irrigation, the agro-ecological zone in which the farm is located, and the distance of the farm from the farmers' residences) that explained 19% of the variation. Variables that hamper access to seeds (such as distance to the seed source, availability of adequate quantities and quality of seed at the desired time, the choice to buy certified seed having seed companies as the source of the seed, and seed price) explained the remaining 15% of the total variation. While this figure is high it is not high enough to be the sole reason for poor adoption levels as is often heard among breeders, development practitioners, policy makers, and donors alike.

The not significant coefficient of the seed price variable would, at first glance, appear counterintuitive. However, the definition of improved varieties is "varieties which are 20 years old or younger". The major differences in seed prices are between seed that is or is not certified, rather than on whether the seeds are for new or old varieties. Given that the certified seed that is being produced and sold in the country includes both old and new varieties, the not significant coefficient of the seed prices should not come as a surprise. Moreover, given the high price subsidy for certified seeds, the price gap between certified and uncertified seeds is insignificant and, hence, seed prices are not expected to explain adoption decisions. In the outcome equation, almost all variables that affected the decision to adopt also affected the intensity of adoption in the same direction. The only exceptions to this are off-farm employment, the location of the farm in the intermediate zone, and the size of the wheat area. While farmers who have off-farm employment have a lower propensity to adopt, once they do adopt, they tend to adopt on a large scale. A possible explanation for this is that these farmers have better financial liquidity. Once they are convinced, they can afford to adopt the new varieties in bigger quantities, as capital for the purchase of complementary inputs may not be as limiting as is the case for farmers who do not have off-farm employment opportunities. Likewise, once the decision to adopt is made, farmers with

relatively larger wheat farms are more likely to plant the improved varieties on a larger scale than those with smaller farms.

Factors affecting farmers' speed of adoption

Analysis of the speed of adoption requires a definition of the release year as a reference point. Therefore, we have deliberately chosen to build duration models for the adoption of four of the most-adopted improved wheat varieties, two bread wheat varieties and two durum wheat ones. The bread wheat varieties (Achtar and Merchouch) cover 35% of the total area under bread wheat and 33% of the householders. The two durum wheat varieties (Karim and Amal) cover 77% of the total area under durum wheat and 82% of the householders. The only two variables which have consistent effects on the speed of adoption across all varieties are whether the seed is certified and whether seed was purchased from seed companies through their distribution networks (Table 5.29). Farmers who purchased certified seed and who did so from seed companies are more likely to adopt improved wheat varieties faster than farmers who did not use certified seed and who purchased their seed from sources other than seed companies. The other variables either had no significant effect on the speed of adoption or have mixed effects across varieties, which makes it difficult to explain.

For instance, farmers who are in the favorable zone of Morocco are less likely to adopt the variety Amal quickly, while farmers who are in the intermediate zone adopt Achtar and Karim relatively faster. With negative and significant coefficients, hosting demonstration trials appears to be an important factor that speeds up the adoption of three of the varieties, Merchouch, Karim, and Amal. It does not have a significant effect on the speed of adoption of Achtar.

5.6.5 The role of gender in varietal adoption

Given the limits imposed by cultural, social, historical, and physical factors, women are often at a disadvantage in adopting innovations and participating in extension programs (Blau and Kahn 2000; Doss 2001; Doss and Morris 2000; Gates 2014; Kerr 2012). Hence any intervention needs to pay special attention to gender-specific constraints. This not only ensures meaningful benefits for society, but also ensures that the benefits are equitable, and the innovations are relevant to women's needs and persistent problems. One of the main obstacles faced by women in farming is their lack of equitable access to resources, such as land, fertilizer, information, machinery, and labor. An FAO

study (FAO 2011b) suggests that providing women with equitable access to resources would decrease world hunger by up to 17% and increase world food production by up to 4%.

This section documents the extent of gender equity in accessing and benefitting from improved wheat varieties. It specifically presents how women and men access improved wheat varieties and related information on grain production.

A detailed analysis of gender decisions on varietal adoption in Morocco required additional data. To this effect, the Saïs region of Morocco was taken as a case study and a separate survey conducted. The survey involved three case studies, which are part of the global study "Innovation and Development Through Transformation of Gender Norms in Agriculture and Natural Resource Management – a Comparative Case Study". The case studies include a series of gender-disaggregated key informant interviews (with community leaders, wheat farmer innovators, and individuals representing typical poverty levels) and focus group discussions (with youth, the poor, and middle class). These sessions sought to understand the relationships among gender norms, agency, and agricultural innovations related to improved wheat varieties. It also sought to understand how these interactions support or hinder development outcomes. The studies were conducted in the districts of Betit, A'in Jom'a, and Sidi Sliman because they differ significantly in gender norms, levels of economic development, and biophysical dynamics. While Betit and Sidi Sliman are flourishing because of onion and fruit production, A'in Jom'a is inhibited in its economic development because of its dependence on rainfall. Women in A'in Jom'a are more likely to bear the burden of farming in the absence of men because of male outmigration that is mainly driven by drought.

In 2006, state-led land distribution efforts in Saïs provided men, for the most part, with land. A few women accessed land mainly as heads of households and some accessed land upon the death of their husbands (Bossenbroek and Zwarteveen 2015). Because landowners are often targeted for extension support and varietal demonstrations, women were largely marginalized from extension support in Saïs. To illustrate this, men reported mainly learning from farmer field schools, on-farm trials, and the extension services about the new varieties and agronomic practices. Women, however, emphasized the benefits of farmer-to-farmer learning (from neighbors, family, and friends). Among all respondents, women lacked knowledge about results related to ongoing varietal trials and innovations related to wheat more

Table 5.29: Maximum likelihood estimates of parameters for the hazard function for Moroccan farmers' adoption of improved wheat varieties

	Achtar			Merchouch	Merchouch	Karim			Amal		
Variable	Coef.	Std. error	Δ (%)	Coef.	Std. error	Δ (%)	Coef.	Std. error	Δ (%)	Coef.	Std. error	Δ (%)
Age (years)	0.0002	0.0011	−0.02	0.0004	0.0011	−0.04	−0.0006	0.0008	0.06	−0.0019	0.0018	0.19
Sex (1 = male, 0 = female)	0.0263	0.0780	−2.66	0.0015	0.0660	−0.15	0.0332	0.0755	−3.38	−0.0192	0.0720	1.91
Number of years of education	−0.0701	(0.0269)***	6.77	−0.0334	0.0267	3.29	0.0132	0.0198	−1.33	−0.0138	0.0257	1.37
Number of family members working on own farm (person days/ha)	−0.0032	0.0082	0.32	0.0040	0.0067	−0.40	0.0033	0.0058	−0.33	0.0124	0.0123	−1.25
Given credit by a bank (1 = yes, 0 = no)	0.0575	(0.0286) ***	−5.92	0.0250	0.0286	−2.53	−0.0014	0.0233	0.14	0.0540	0.0543	−5.55
Off-farm employment (1 = yes, 0 = no)	0.0514	0.0351	−5.27	−0.0152	0.0340	1.51	−0.0114	0.0316	1.13	0.0769	0.0579	−7.99
Irrigated (1 =yes, 0 = no)	−0.0158	0.0297	1.57	−0.0484	0.0387	4.73	0.0177	0.0293	−1.79	0.0283	0.0544	−2.87
Wheat area (ha)	−0.0004	0.0008	0.04	0.0008	0.0013	−0.08	−0.0019	0.0033	0.19	−0.0006	0.0012	0.06
Total cropped area (ha)	−0.0001	0.0004	0.01	0.0003	0.0004	−0.03	−0.0001	0.0003	0.01	0.0006	0.0006	−0.06
Walking distance to seed sources (km)	−0.0002	0.0012	0.02	0.0000	0.0011	0.00	−0.0005	0.0010	0.05	−0.0003	0.0023	0.03
Hosted wheat demonstration/PVS trials (1 = yes, 0 = no)	−0.1583	0.2948	14.64	−0.3208	(0.0960) ***	27.45	−0.5258	(0.0782) ***	40.89	−0.3580	(0.0893) ***	30.09
Visited demonstration fields/attended field days (1 = yes, 0 = no)	−0.0029	0.1062	0.29	−0.1476	0.0936	13.73	0.1378	(0.1394) **	−14.77	0.2211	0.1043	−24.74
Used certified seed (1 = yes, 0 = no)	−0.0995	(0.0324) ***	9.47	−0.7380	(0.0664) ***	52.19	−0.1570	(0.0235) ***	14.53	−0.3249	(0.0464) ***	27.74
Seed from seed company (1 = yes, 0 = no)	−0.2140	(0.0482) ***	19.27	−0.1986	(0.0383) ***	18.01	−0.0638	(0.0373) ***	6.19	−0.3068	(0.0543) *	26.42
Seed from agro-dealers/agro-vets (1 = yes, 0 = no)	−0.0079	0.0287	0.79	0.0614	(0.0278) **	−6.33	0.0094	0.0212	−0.94	−0.0356	0.0483	3.50
Price of seed	−0.0222	0.0171	2.20	−0.0148	0.0171	1.47	−0.0386	(0.0131) **	3.78	−0.0685	(0.0282) ***	6.62
Farm in favorable zone (1 = yes, 0 = no)	−0.0261	0.0390	2.57	0.0271	0.0323	−2.74	0.0652	0.0278	−6.73	0.1856	(0.1051) **	−20.39
Farm in intermediate zone (1 = yes, 0 = no)	−0.0571	(0.0309) *	5.55	0.0152	0.0327	−1.53	−0.0064	(0.0242) **	0.64	0.2465	0.1144	−27.95
Constant	3.1421	(0.1166) ***		3.1123	(0.1052) ***		3.2181	(0.0824) ***		2.8326	(0.1962) ***	
Weibull parameter (α)	3.6868	(0.1539) ***		4.5782	(0.2204) ***		4.8276	(0.1929) ***		3.2366	(0.1856) ***	

generally, such as conservation agriculture in addition to legume and wheat rotations.

Men displayed greater interest in wheat crop qualities featuring disease resistance, yield, and drought tolerance. Women expressed more concern for how varieties affect dough quality and the cleanliness of seeds. The women's concerns are linked to their prominent gender role of providing food for their families. These concerns also point to a lack of involvement of women in extension support. Extension agents were reported not to contact women because the agents are predominantly male. Research centers reported targeting men for their trials because men were the ones who owned the land. Seed cleanliness was deemed important by women because it would shorten the time and work needed later for seed cleaning. Women were not aware of

new wheat varieties and called almost all wheat varieties "technique". Men, on the other hand, knew the variety names of wheat crops and talked technically about improved agronomic practices. These included crop rotations, integrated pest management, conservation agriculture, and dual-purpose machinery (e.g., fertidrill). The presence of weed seeds, women complained, makes the cleaning process tedious.

Focus group discussions and interviews with women in Saïs revealed that both women and men in landed households of the middle class make joint decisions on varietal adoption. Regarding bread wheat that is grown for home consumption, results from interviews suggest that women in Saïs are the main decision-makers on varietal selection. Because varietal choice has implications for adoption, it is strategic to involve both men and women in varietal evaluation, demonstration of varietal attributes, and related extension advice. It is also strategic to involve women to address their specific concerns, one of which is reducing drudgery (Doss 2001; Gates 2014). Clearly a preference for clean seeds was emphasized by women for its ability to reduce workloads.

5.6.6 Impacts of using improved wheat varieties

A summary of the propensity scores for the estimates for the selection equation of the Heckman model are provided in Table 5.30. Based on the selection criteria of many of the covariates, which show no significant difference between adopters and non-adopters after matching Pseudo R2, and observations on support, the radius caliper (0.01) matching algorithm is selected. It performed better than the nearest neighbor and Kernel bandwidth matching algorithms. The common support region is, therefore, between 3.949E-32 and 0.88. Hence, 1,100 observations (48%) with propensity scores less than 3.649E-32 and over 0.88 are dropped from the analysis, which is a large loss of observations.

Impact per unit area

Impacts on yield

Estimates of the treatment effects from PSM are provided in Table 5.31. The results show that adoption of varieties less than 20 years old (the majority of which are 15–20 years old) provide, on average, a 425.4 kg/ha (35%) yield gain for adopters. If non-adopters were to adopt the improved varieties, they would have obtained 289.6 kg/ha higher yields showing that the benefit to those who have already adopted is higher, which may explain why they adopted while the others have not.

Table 5.30: Mean of estimated propensity scores

Group	Mean	Minimum	Maximum
Total households	0.33	3.949E-32	1.00
Non-adopters	0.1	3.949E-32	0.88
Adopters	0.87	1.09E-04	1

Source: Model results.

Table 5.31: Treatment effects on yield from PSM (kg/ha)

Group	Treatment group	Control group	Difference	S.E.	t-stat
Unmatched	1,818.6	1,243.5	575	55	10.5*
Average Treatment Effect on the Treated (ATT)	1,641	1,215.5	425.4	149	2.9**
Average Treatment Effect on the Untreated (ATU)	1,257.3	1,546.9	289.6		
Average Treatment Effect (ATE)			313.2		

* and ** show significance at 0.01 and 0.05 levels.

Estimates of the ESR are provided in Table 5.32. As the main objective of this section is one of measuring the impacts of adopting improved varieties, we will provide only a brief discussion of the regression estimates. Quantities of inputs (nitrogen and diammonium phosphate [DAP] fertilizers, and seeds) are found to have positive and significant effects on yield, as expected. Irrigated plots also give higher yields than non-irrigated plots. The same is true for larger farms and farms with a larger wheat area. The use of certified seeds also leads to higher yields than using uncertified seeds, showing a clear advantage to using certified seeds. Estimates of the treatment effects from ESR are provided in Table 5.33. The results show that adopters of 20 year old or younger varieties, on average, obtain about 482.4 kg/ha (49%) more yield than the counterfactual (i.e., what they would have obtained if they had not adopted). Taking an average grain price of MAD 3.15/kg and ignoring the cost implications of adoption of improved wheat varieties, this yield gain would translate into a gain in gross revenue of MAD 1,518/ha (USD 176/ha)[1].

[1] The exchange rate in 2012 was: 1 USD = 8.62 MAD

Table 5.32: Full information maximum likelihood estimates of the ESR model for yields (kg/ha)

Independent variables	Yield equation for adopter		Yield equation for non-adopter		Adoption of zero tillage (No = 0, Yes = 1)	
	Coef.	Std. Error	Coef.	Std. Error	Coef.	Std. Error
Age (years)	–0.040	(0.022)***	0.027	0.019	0.499	0.283
Sex (0 = male, 1 = female)	0.029	(0.018)***	0.034	0.028	0.318	0.311
Number of years of education	0.010	0.021	–0.015	0.016	4.084	(0.406)*
Number of family members working on own farm (person days/ha)	0.012	0.014	–0.008	0.010	0.404	(0.139)*
Get credit from a bank (1 = yes, 0 = no)	0.026	(0.016)***	–0.021	(0.009)**	0.402	(0.133)*
Off-farm employment (1 = yes, 0 = no)	0.010	0.015	–0.012	0.012	–0.201	0.186
Irrigated (1 = yes, 0 = no)	1.393	(0.020)*	1.333	(0.016)*	0.047	0.249
Wheat area (ha)	0.030	(0.010)*	0.075	(0.009)*	–0.850	(0.149)*
Total cropped area (ha)	0.006	(0.002)*	–0.003	0.002	–0.024	0.029
Walking distance from seed sources (km)	–0.004	0.008	0.012	0.010	–1.406	(0.111)*
Hosted wheat demonstration/ PVS trials (1 = yes, 0 = no)	–		–		0.996	(0.139)*
Visited demonstration fields or attended field days (1 = yes, 0 = no)	–		–		0.528	(0.183)*
Was the seed you used certified? (1 = yes, 0 = no)	0.218	(0.013)*	0.165	(0.010)*	–0.228	0.136
Seed from seed company (1 = yes, 0 = no)	0.017	0.012	0.046	(0.015)*	0.213	0.190
Seed from agro-dealers/agro-vets (1 = yes, 0 = no)	0.026	(0.011)*	–0.012	0.009	0.629	(0.196)*
Price of seed (MAD/quintal)	–0.014	0.015	–0.020	0.013	0.023	0.080
Farm in favorable zone (1 = yes, 0 = no)	0.020	0.021	–0.031	(0.013)**	–0.093	0.083
Farm in intermediate zone (1 = yes, 0 = no)	0.033	0.022	0.024	(0.011)**	0.079	0.210
Quantity of nitrogen fertilizer used (kg/ha)	0.016	(0.006)*	0.013	(0.005)*	1.614	(0.183)*
Quantity of DAP fertilizer used (kg/ha)	0.041	(0.006)*	0.055	(0.005)*	1.329	(0.527)*
Amount of seed used (kg/ha)	0.064	(0.016)*	0.099	(0.014)*	0.643	0.493
Constant	6.408	(0.128)*	5.678	(0.111)*	–3.340	(1.639)**

Independent variables	Yield equation for adopter		Yield equation for non-adopter		Adoption of zero tillage (No = 0, Yes = 1)	
	Coef.	Std. Error	Coef.	Std. Error	Coef.	Std. Error
Log likelihood						720.7
Rho	0.01	(0.150)	−0.412	(0.200)*		
Sigma	−1.984	(0.026)*	−1.761	(0.019)*		

At the current average adoption level of 1.6 ha/family, each farm household obtains about 771 kg/year more yield and MAD 2,429/year (USD 282/year) more revenue.

Given that ESR is good at correcting for biases both from observable and unobservable factors, the 13% higher yield effects from ESR relative to PSM shows that unobservable factors such as the skills of the farmers who have adopted the technology are important in explaining the differences in yield effects. In this case, the unobservable factors are leading to an underestimation of the yield impact, which ESR was able to correct while PSM could not.

Impact on net margins

Estimates of the treatment effects on net margins from PSM are provided in Table 5.34. The results show that adoption of improved wheat varieties under 20 years old (the majority of which are 15–20 years old) provides on average MAD 1,232/ha (33%) higher net wheat incomes for adopters. If non-adopters would adopt the improved varieties, they would have earned MAD 1,230/ha more net income, showing that the non-adopters would have almost the same benefits as the adopters if they were to adopt the new varieties. Given the average area under improved varieties per family of 1.6 ha, a typical adopter family currently earns MAD 1,971 of additional net wheat income each year.

Table 5.33: Average expected treatment and heterogeneity effects on yield from the ESR (kg/ha)

	Decision stage		
Sub-samples effects	To adopt	Not to adopt	Treatment
Farm households that adopted	1,454.9	972.5	482.4***
Farm households that did not adopt	1,285.9	978.5	307.4***
Heterogeneity effects	169.1	−6	175.1

Table 5.34: Treatment effects on net margins from PSM (MAD/ha)

Group	Treatment group	Control group	Difference	Std. error	t-statistic
Unmatched	5,421.3	3,716.5	1,704.8	195.0	8.74*
ATT	4,880.1	3,647.9	1,232.2	528.7	2.33**
ATU	3,759.6	4,989.9	1,230.3		
ATE			1,230.6		

* and ** show significance at 0.01 and 0.05 levels, respectively.

The estimates of the ESR are provided in Table 5.35. As the main objective of this section is to measure the impacts of adopting improved varieties, we will provide only a brief discussion of the regression estimates. From among the inputs, the quantities of DAP fertilizers used are found to have positive and significant effects on yields for both adopters and non-adopters, while the quantity of nitrogen fertilizer does not. Given that both have a positive effect on yields, this shows that adopters are using less DAP and hence are saving on costs, which leads to a gain in net income. Irrigated plots also give higher net incomes than non-irrigated ones because yield gains exceed any additional costs of irrigation. The use of certified seeds also leads to higher yields than uncertified seeds, showing there is a clear advantage to using certified seeds.

Table 5.36 presents the estimates of the treatment effects from the ESR. The results show that adoption of improved wheat varieties under 20 years old (the majority of which are 15–20 years old) provide, on average, a MAD 1,324/ha (48%) higher net wheat income for adopters. If non-adopters were to adopt the improved varieties, they would have earned MAD 1,059/ha more net income, showing that the benefit to those who have already adopted is higher, which may explain why they adopted while the others have not.

Given that ESR is potent in correcting for biases, both from observable and unobservable factors, the 7% higher effects on net income from ESR relative to PSM show that unobservable factors, such as the skills of the farmers who have adopted the technology, are important in explaining the differences in net income effects. In this particular case, the unobservable factors lead to underestimation of the net income effect, which the ESR was able to correct while the PSM could not.

Table 5.35: Full information maximum likelihood estimates of the ESR model for net income

Independent variables	Yield equation for adopter		Yield equation for non-adopter		Adoption of zero tillage (0 = no, 1= yes)	
	Coef.	Std. error	Coef.	Std. error	Coef.	Std. error
Age (years)	−0.094	(0.044)**	0.038	0.046	0.542	(0.286)***
Sex (0 = male, 1 = female)	0.066	(0.035)***	0.108	0.068	0.415	0.314
Number of years of education	−0.031	0.041	0.020	0.035	4.214	(0.394)*
Number of family members working on own farm (person days/ha)	−0.020	0.027	−0.039	0.024	0.393	(0.141)*
Obtained credit from a bank (1 = yes, 0 = no)	0.039	0.031	−0.015	0.023	0.415	(0.136)*
Off-farm employment (1 = yes, 0 = no)	0.005	0.030	−0.018	0.029	−0.234	0.188
Irrigated (1 = yes, 0 = no)	1.504	(0.039)*	1.746	(0.039)*	−0.006	0.250
Wheat area (ha)	0.027	0.020	0.098	(0.021)*	−0.859	(0.150)*
Total cropped area (ha)	0.008	(0.004)***	−0.004	0.005	−0.023	0.030
Walking distance from seed sources (km)	−0.017	0.015	−0.006	0.023	−1.416	(0.111)*
Hosted wheat demonstration/ PVS trials (1 = yes, 0 = no)	–				0.941	(0.139)*
Visited demonstration fields or attended field days (1 = yes, 0 = no)	–				0.600	(0.181)*
Used certified seed (1 = yes, 0 = no)	0.144	(0.026)*	0.147	(0.023)*	−0.251	0.138
Seed from seed company (1 = yes, 0 = no)	0.044	(0.024)***	0.033	0.036	0.185	0.192
Seed from agro-dealers/agro-vets (1 = yes, 0 = no)	0.005	0.021	0.000	0.023	0.627	(0.201)*
Price of seed	−0.076	(0.029)*	−0.180	(0.031)*	0.022	0.085
Farm in favorable zone (1 = yes, 0 = no)	0.063	0.041	0.058	(0.030)**	−0.066	0.083
Farm in intermediate zone (1 = yes, 0 = no)	0.010	0.044	0.019	0.025	0.110	0.208
Quantity of nitrogen fertilizer used (kg/ha)	0.010	0.012	−0.005	0.012	1.614	(0.187)*
Quantity of DAP fertilizer used (kg/ha)	0.046	(0.012)*	0.057	(0.012)*	1.515	(0.541)*
Amount of seed used (kg/ha)	0.123	(0.031)*	0.044	0.032	0.637	0.532
Constant	7.499	(0.252)*	6.993	(0.266)*	−3.743	(1.629)**

Independent variables	Yield equation for adopter		Yield equation for non-adopter		Adoption of zero tillage (0 = no, 1= yes)	
	Coef.	Std. error	Coef.	Std. error	Coef.	Std. error
Log likelihood					–1,144.88	
Rho	0.130	0.121	–0.113	0.142		
Sigma	–1.303	(0.026)*	–0.891	(0.018)*		

The adoption of improved varieties has a positive and significant effect on net wheat income. After controlling for all the above confounding factors, our results show that by adopting improved varieties of wheat, the typical Moroccan wheat farmer who adopted them earned about MAD 1,324 (USD 154) more per ha than they would have if they had not. This figure is much less than the increase in gross revenue of MAD 1,518 presented in the last paragraph on page 159. This shows that adoption of improved varieties and, hence, obtaining additional yields, can only be achieved at an additional cost. However, the value of the gain in yields more than offsets the additional cost needed for the adoption of improved varieties – leading to about 49% higher net margins. Given the average area under improved varieties per family of 1.6 ha, a typical adopter family may earn MAD 2,118 (USD 245) more net wheat income each year.

Effect on consumption

PSM estimates of treatment effects are presented in Table 5.37. The results show that adoption of varieties under 20 years old (the majority of which are 15–20 years old) provide a 25.4 kg/capita/year (54%) gain in wheat consumption for adopters. If non-adopters were to adopt the improved

Table 5.36: Average expected treatment and heterogeneity effects on net income from the ESR model (MAD/ha)

	Decision stage		
Sub-samples effects	To adopt	Not to adopt	Treatment
Farm households that adopted	4,049.6	2,725.6	1,324.1***
Farm households that did not adopt	3,566	2,507	1,059***
Heterogeneity effects	483.7	218.6	265.1

Table 5.37: Treatment effects on wheat consumption, PSM model, (kg/capita/year)

Group	Treatment group	Control group	Difference	Std. error	t-statistic
Unmatched	86.7	51.1	35.6	1.2	28.7*
ATT	72.6	47.2	25.4	3.4	7.5*
ATU	50.7	59.3	8.5		
ATE			11.5		

* and ** show significance at 0.01 and 0.05 levels, respectively.

varieties, they would have consumed 8.5 kg/capita/year (14%) more wheat. This shows that the benefit to those who have already adopted is higher, which may provide part of the explanation for why most farmers did not adopt the improved wheat varieties.

The estimates of the ESR are provided in Table 5.38. As the main objective of this section is to measure the effect of adoption of improved wheat varieties, only a brief discussion of the regression estimates is provided here. Total wheat area and whether the plot is irrigated seem to have positive and significant effects on wheat consumption among both adopters and non-adopters. All other variables, including quantities of inputs (nitrogen, DAP fertilizers, and seeds) are found to have differential effects on wheat consumption between adopters and non-adopters.

Estimates of the treatment effects from the ESR are provided in Table 5.39. The results show that adopters of varieties 20 years old or less, on average, consume about 29.6 kg/capita/year (60%) more wheat than the counterfactual (i.e., what they would have consumed if they had not adopted). If non-adopters were to adopt the improved varieties, they would have consumed 6.5 kg/capita/year (15%) more wheat. This shows that the benefit to those who have already adopted is much higher – a possible explanation for why most farmers have not adopted the improved wheat varieties yet.

Given that ESR is good at correcting for biases, both from observable and unobservable factors, the 6% higher consumption effects from the ESR relative to the PSM shows that unobservable factors are important in explaining the differences in consumption effects. In the case of consumption, the unobservable factors lead to an underestimation of the yield impacts. PSM failed to correct this, while ESR did correct it. During the survey, farmers were

Table 5.38: Full information maximum likelihood estimates of the ESR model for wheat consumption (kg/capita/year)

Independent variables	Yield equation for adopter		Yield equation for non-adopter		Adoption of zero tillage (no = 0, yes = 1)	
	Coef.	Std. error	Coef.	Std. error	Coef.	Std. error
Age (years)	−0.006	0.042	−0.018	0.022	0.623	(0.280)**
Sex (0 = male, 1 = female)	−0.022	0.033	0.024	0.032	0.502	(0.305)***
Number of years of education	0.014	0.038	0.037	(0.018)**	3.965	(0.394)*
Number of family members working on own farm (person days/ha)	−0.164	(0.025)*	−0.160	0.011	0.358	(0.137)*
Obtained credit from a bank (1 = yes, 0 = no)	0.108	(0.029)*	−0.005	0.011	0.381	(0.133)*
Off-farm employment (1 = yes, 0 = no)	0.026	0.028	0.015	0.014	−0.216	0.183
Irrigated (1 = yes, 0 = no)	0.473	(0.037)*	0.587	(0.019)*	−0.081	0.246
Wheat area (ha)	0.297	(0.019)*	0.577	(0.010)*	−0.870	(0.141)*
Total cropped area (ha)	0.002	0.004	−0.002	0.002	−0.028	0.029
Walking distance from seed sources (km)	−0.158	(0.014)*	0.017	0.011	−1.491	(0.113)*
Hosted wheat demonstration/PVS trials (1 = yes, 0 = no)	–				0.949	(0.136)*
Visited demonstration fields/ attended field days (1 = yes, 0 = no)	–				0.509	(0.181)*
Used certified seed (1 = yes, 0 = no)	0.169	(0.025)*	0.091	(0.011)*	−0.275	(0.134)**
Seed from seed company (1 = yes, 0 = no)	−0.027	0.023	−0.005	0.017	0.175	0.185
Seed from agro-dealers/agro-vets (1 = yes, 0 = no)}	−0.030	0.020	−0.022	(0.011)**	0.653	(0.197)*
Price of seed	0.004	0.027	−0.002	0.015	−0.013	0.085
Farm in favorable zone (1 = yes, 0 = no)	0.047	0.038	−0.014	0.015	−0.058	0.082
Farm in intermediate zone (1 = yes, 0 = no)	0.030	0.041	0.018	0.012	0.067	0.202
Quantity of nitrogen fertilizer used (kg/ha)	−0.012	0.011	−0.033	(0.005)*	1.564	(0.186)*
Quantity of DAP fertilizer used (kg/ha)	−0.027	(0.011)*	0.009	(0.005)c	1.652	(0.561)*
Amount of seed used (kg/ha)	0.082	(0.029)*	−0.001	0.015	0.606	0.510
Constant	3.679	(0.236)*	3.191	(0.126)*	−3.263	(1.589)**
Log likelihood					69.838	
Rho	0.346	(0.130)*	0.422	(0.199)**		
Sigma	−1.363	(0.019)*	−1.636	(0.019)*		

asked about the effects of improved wheat varieties (Table 5.40). The results are consistent with the empirical evidence in that the improved varieties have led, among other things, to higher farm incomes and consumption.

5.6.7 National impacts at current adoption levels

The total wheat area in the 21 provinces covered by the survey is 2.151 million ha, of which 42% (903,609 ha) is under improved varieties of wheat 20 years old or younger. Given the average yield gain of 482 kg/ha, the introduction of the improved wheat varieties has so far led to an additional 0.43 million tonnes of wheat in the 21 provinces. This represents about 17% higher annual production. Assuming that, on average, the adoption levels and yield impacts in the other wheat growing areas that were not covered by the survey are also the same, Morocco has been producing a total of 0.58 million tonnes more wheat because of the adoption of improved varieties. This level of increase in total national food production is high. Even at the current 42% level of adoption it is making a sizeable contribution to national food security and Morocco's aim to become self-sufficient in food.

Likewise, the total net income gains arising from a 42% adoption of improved varieties in the 21 provinces surveyed is about MAD 6.8 billion (USD 0.78 billion). This represents an additional gain of 20% in total net income from wheat production. Assuming the average adoption levels and yield impacts in the other wheat growing areas not covered by the survey are, on average, the same as those of the 21 provinces, Morocco is earning a net wheat income gain of about MAD 9.1 billion (USD 1.1 billion) per year. The total population of Morocco in 2012 was about 33 million. Assuming the average per capita consumption from our survey of 57.63 kg, the additional 0.58 million tonnes of wheat produced because of the adoption of improved wheat varieties translates

Table 5.39: Average expected treatment and heterogeneity effects on wheat consumption from the ESR (kg/capita/year)

	Decision stage		
Sub-samples effects	To adopt	Not to adopt	Treatment
Farm households that adopted	78.9	49.3	29.6***
Farm households that did not adopt	49.1	42.6	6.5***
Heterogeneity effects	29.8	6.7	23.1

Table 5.40: Stated effects of using improved wheat varieties (percentage of farmers)

Change in	Decreased	No change	Increased
Availability of wheat for food at home	3.1	29.8	67.2
Availability of other food items	3.5	43.3	53.2
Cash income from selling wheat	3.6	30.8	65.5
Investment in children's education	2.5	63.8	33.7
Investment in health of the family	2	65.1	32.9
Investment in livestock husbandry	7.9	37.8	54.3
Investment in clothing and footwear for family	1.9	69.1	28.9
Investment in household utensils	1.9	75	23.1
Investment in residential house (size and quality)	2.7	74.1	23.2
Investment in communication (phone, TV, etc.)	3.5	74.8	21.7
Investment in transport (bicycle, horse, mule, etc.)	3.5	80.2	16.3
Investment in fertilizer use for crop production	5.7	54.9	39.4
Investment in social activities	3.2	82.6	14.2
More time for leisure	3.5	78.5	18

to about 17 kg/capita/year of extra wheat available for consumption. This calculation, however, assumes differences in terms of access and entitlement to the produced wheat, which is a very unrealistic assumption.

Potential national impact

While current adoption levels are low, the gain in total production and, hence, contribution to national food security and food self-sufficiency documented above is sizeable; not to mention that newly released improved varieties might lead to even higher yields. Assuming the current yield gains per unit area, then if adoption of improved varieties were to increase to higher levels, Morocco would benefit even more (Table 5.41).

This shows that any effort to enhance the adoption of improved varieties currently in the Moroccan wheat production system is worthwhile. What is more, varieties which have been released more recently might have higher yield potentials and, hence, the country, in general, and individual farmers, in particular, could expect even higher benefits than are being realized now or those hypothesized in Table 5.42. Tables 5.42 and 5.43 provide data from the survey that show how grain yields vary based on the age of varieties, agro-

Table 5.41: Potential effect of improved wheat varieties with different levels of assumed adoption levels

Assumed adoption level	Realized/potential gain		
	Production (million tonnes)	Net income (MAD billion)	Net income (USD billion)
Current level (42%)	0.58	9.15	1.06
50%	0.70	10.90	1.26
60%	0.84	13.08	1.52
70%	0.98	15.26	1.77
80%	1.12	17.44	2.02
90%	1.26	19.62	2.28
100%	1.40	21.80	2.53

ecologies, and the varieties used and how net margins decrease with the age of the variety.

5.6.8 Seed demand analysis

Farmer perceptions and opinions about wheat seed issues

Survey results show that 49% of farmers believe they are still growing local wheat varieties. With a few exceptions, no local wheat varieties exist in the regions covered by the survey. When asked about the certainty of the origin and purity of the seeds of the varieties which they call local, only 24% of the farmers responded that they are very sure while the remaining 76% are either unsure or have doubts. One possible explanation for this high figure for local varieties is that some farmers may consider all uncertified seed which they buy from local markets as local varieties or consider “obsolete improved” varieties used for long periods of time as local varieties.

To a question about the use of improved varieties, 88.5% of farm households responded that they are using improved varieties. Along with the figures shown in the previous paragraph for local varieties, this figure shows that sizeable number of farmers believe that they are cultivating both the local and improved varieties, more probably on multiple plots. As is often the case, the farmers do not make any distinction between more recent and old varieties. Provincial adoption levels for bread wheat varieties generally follow similar patterns to those for total wheat (regardless of species) reported in

Table 5.42: Yields and gross margins by year of release and agro-ecology

Release date	Irrigated		Rainfed	
	Yield (kg/ha)	Gross margins (MAD/ha)	Yield (kg/ha)	Gross margins (MAD/ha)
1921	2,775	8,299	647	1,376
1982	3,375	11,702	797	1,954
1984	3,705	12,627	820	2,007
1985	3,559	13,196	838	2,356
1988	4,024	13,154	984	2,535
1991			848	2,424
1993	4,024	12,853	971	2,526
1994	3,800	14,172	781	2,504
1995	3,625	14,093	844	2,296
1996	3,987	13,253	997	2,673
1997	4,525	14,720		

Table 5.13. The adoption level of all improved varieties, regardless of their release date, is above 98%. This shows that about 10% farmers who cultivate improved varieties think that they are cultivating local varieties.

The farmers in the sample were also asked if they always get the amount of seed they need and 76% responded "Yes". This is a high percentage, but as it does not specify the type of seed (improved/local or certified/uncertified) and the type of the previous year (good/bad rainfall) this figure may not necessarily be too high. For those who answered "No", only an average of 58% of their annual seed demand was met, regardless of their sources. The main reasons for this are unavailability of seeds in the market (76.5%) and very high prices (18.3%).

Estimation of quantity of seed used

Amount of seed used by geographic and agro-ecological zones

The typical farmer in the sample is using about 176 kg/ha of wheat seed (250 kg/ha for irrigated and 157 kg/ha for rainfed). Applying the area weights to the individual provinces, the total amount of seed that is being used in the 21 provinces is estimated at 3.852 million quintals/year. Therefore, assuming the same seeding rate for the provinces that are not covered by our sample and based on the five-year average total national wheat area of 2.91 million ha, the

Table 5.43: Yields and gross margins by variety and agro-ecology

Variety	Irrigated		Rainfed	
	Yield (kg/ha)	Gross margin (MAD/ha)	Yield (kg/ha)	Gross margin (MAD/ha)
Achtar	4,024.1	13,153.5	987.2	2,542.1
Salama	4,717.9	14,005.0	1,079.6	2,735.9
Arrehane	4,015	12,829.4	988.2	2,572.1
Aguilal	4,075	15,377.5	1,016.3	3,547.2
Radia	5,058.3	15,060.7	1,113.0	3,263.9
Raja			914.1	2,294.4
Amal	4,025.6	12,819.3	988.4	2,553.8
Tigre	3,875	13,251.4	1,053.3	2,656.6
Merchouch	3,725	11,736.0	892.5	2,070.9
Karim	3,559.2	13,196.1	838.1	2,356.2
Crioca	5,091.7	17,819.9	940.3	3,354.8
Oum Rabia			720	2,379.275
Marzak	3,683.9	13,611.4	728.0	1,924.3
Viton	3,925	13,611.4	859.2	2,527.3
Vitrico			965	3,539.9
Saidi	3,800	14,172.4	780.9	2,504.4
Cocorit			752.5	2,063.8
Beldi	2,775	8,299.2	679	1,619.6
Mazrouba			675	1,809.14
Mehdia			975	3,249.575
Anouar			781.7	2,038.7
Ouissane			600	1,749.4
Krifla Kahla			575	1,061
Wissam			844.3	2,295.5
Jouda			725	2,267.825
Nessma	3,375	11,701.5	829.9	1,874.1
Massira			915	1,992.8
Manal			1,126.3	3,294.8
Blé Tendre Local			651.4	1,303.3
Faiza			1,225	3,121.3
Durum wheat (local)			570	1,172.3
Amjad			1,225	3,675.3
Irride			1,225	4,095.7

	Irrigated		Rainfed	
	Yield (kg/ha)	Gross margin (MAD/ha)	Yield (kg/ha)	Gross margin (MAD /ha)
Prosse Pero			1,005	3,835.5
El Wafia			1,128.3	2,580.5
El Manar			575	1,221.6
Baida			847.9	2,423.6
Kenz			780	1,599.0
Tomouh	4,525	14,720.45		
Ourgh	3,625	14,092.8		
Total	**3,994.16**	**13,302.64**	**896.64**	**2,390.63**

total national amount of wheat seed used is estimated at 5.12 million quintals/year. Of this 5.12 million quintals/year, about 43% was used in the favorable zones and 33% in the intermediate ones (Table 5.44).

The provincial distribution seems to follow the geographic size of the provinces. Sidi Kacem used 0.35 million quintals, Settat 0.33 million quintals, Safi 0.32 million quintals, and Beni Mellal 0.32 million quintals of wheat seed in the 2011/12 cropping season (Table 5.45).

Amount of seed used by variety and by source

Achtar, Amal, Karim, Radia, and Merchouch are the five varieties with the highest seed use in Morocco. Secondary data sources show that the total amount of certified seed produced and distributed in the country follows similar patterns (Table 5.46). These results are consistent with the degree of adoption by variety reported in Table 5.20, but in a slightly different order. These same varieties occupy the largest areas relative to other varieties. Estimates of the total amount of seed used by variety and by province are presented in Annex II.

Analysis of the actual amounts and sources of seeds used for the 2011/12 cropping season show that 22% of the seed originated from SONACOS (17.81% acquired from the local government extension service units and 4.21% from SONACOS' own seed distribution points). Another 13.3% of seed used was purchased from local informal seed traders in the villages who sell uncertified seed. A further 13.39% comes from seed traders from outside the villages (Table 5.47). The biggest share, 51.19%, is reported to have come from non-official sources – all sources other than the known government and

Table 5.44: Seed use by agro-ecological zone

Seed by agro-ecological zone	Total for 21 sample provinces (million quintals)	Estimated total national use (million quintals)	Proportion of total national use (%)
Favorable	1.670	2.218	43
Intermediate	1.273	1.693	33
Unfavorable south	0.444	0.592	12
Mountain	0.465	0.618	12
Total	**3.852**	**5.120**	**100**

Table 5.45: Seed use by the 21 sample provinces

Province	Total (million quintals)	Province	Total (million quintals)
Sidi Kacem	0.350	Berrechid	0.148
Settat	0.333	Khenifra	0.143
Safi	0.323	Meknes	0.139
Beni Mellal	0.322	Taza	0.123
Taounate	0.287	El Kelâa	0.121
Rehamna	0.259	Benslimane	0.107
Khemisset	0.258	El Hajeb	0.092
Sidi Bennour	0.204	Sidi Slimane	0.059
Kénitra	0.199	Guercif	0.033
El Jadida	0.179	Fez	0.024
My Yacoub	0.150		
Total (21 provinces)			**3.852**

private seed distribution points/shops/businesses. It would include own-saved seed and farmer-to-farmer exchanges. This shows that the sources for a large quantity of seed are own-saved seed, local grain producers, local grain markets, and from seed exchanges between farmers.

Among the farmers who said they save their own seed, only 27% said they treat their seed. The remaining 73% said they do not. In terms of storage

Table 5.46: Total seed use and certified seed production by variety (21 sample provinces)

Total national seed use (million quintals)			Total amount of certified seed produced in 2012 (million quintals)		
Rank	Variety	Amount used in 2012	Rank	Variety	Amount produced in 2012
1	Achtar	0.732	1	Achtar	0.099
2	Amal	0.517	2	Amal	0.178
3	Karim	0.480	3	Radia	0.214
4	Radia	0.445	4	Salama	0.098
5	Merchouch	0.430	5	Arrehane	0.080
6	Marzak	0.358	6	Rajae	0.058
7	Arrehane	0.318	7	Tigre	0.022
8	Crioca	0.121	8	Wissam	0.058
9	Wissam	0.083	9	Marchouch	0.012
10	Salama	0.074	10	Manal	0.017
11	Saidi	0.073	11	Mehdia	0.010
12	Tigre	0.036	12	El Wafia	0.046
13	Bread wheat (local)	0.032	13	Massira	0.015
14	Raja	0.027	14	Nassim	0.010
15	Nessma	0.022	15	Kanz	0.001
16	Viton	0.015	16	Faiza	0.013
17	Baida	0.015	17	Najia	0.012
18	El Wafia	0.013	18	Samia	0.009
19	Cocorit	0.011	19	Fadela	0.008
20	Aguilal	0.009	20	Resulton	0.003
21	Beldi	0.005	21	Zanzibar	0.003
22	Prosse pero	0.004	22	Gades	0.002
23	Oum rabia	0.003	23	Siena	0.002
24	Blé dur local	0.003	24	Aguilal	0.000
25	Kenz	0.003	25	Bandera	0.001
26	Tomouh	0.003	26	Saragola	0.000
27	Irride	0.003			
28	Massira	0.002			
29	Mehdia	0.002			
30	Manal	0.002			
31	Amjad	0.002			

Total national seed use (million quintals)			Total amount of certified seed produced in 2012 (million quintals)		
Rank	Variety	Amount used in 2012	Rank	Variety	Amount produced in 2012
32	Faiza	0.002			
33	El Manar	0.002			
34	Anouar	0.001			
35	Ouissane	0.001			
36	Krifla Kahla	0.001			
37	Mazrouba	0.001			
38	Vitrico	0.001			
39	Ourgh	0.001			
40	Jouda	0.000			
Total		**3.852**	**Total**		**0.970**

however, the majority (55%) said they store their own-saved seed separately (Table 5.48). Most of the farmers (86%) store their seed in jute bags kept inside the house and another 11% in polypropylene bags kept in the house (Table 5.49). Weevils and Bruchids (for legumes) are the main storage problems for 71% and 15% of farmers, respectively.

Only 1.3% of the famers in the sample said that they have plots exclusively for seed production.

Table 5.47: Seed amount by source

Source	Total amount of seed (million quintals)	Share of total seed used (%)
State	0.686	17.81
Seed company	0.162	4.21
Non-official sources (own-saved seed, farmer to farmer exchange)	1.972	51.19
Local seed trader	0.512	13.30
Trader outside the village	0.516	13.39
Cooperatives	0.004	0.10
Total	**3.852**	**100.00**

Amount of seed used by type and analysis of farmers' seed choices

Of the total seed used in the 2011/12 cropping season, the farmers reported that 18.5% was certified and the remaining 81.5% was uncertified. The average seed replacement rate is 2.1 years with some farmers replacing every year and others not replacing for more than 10 years. The reported 10-year average wheat seed sale price was MAD 359/quintal (USD 42.2/quintal) and the wheat grain sale price was MAD 268/quintal (USD 31.5/quintal). When asked about the names of their most preferred varieties, which they know or have heard about, Achtar (32.7%), Merchouch (26.1%), Amal (13.1%), Radia (9.2%), and Arrehane (6.3%) were the top five bread wheat varieties mentioned. Similarly, Karim (57.9%), Marzak (30.1%), Carioca (6.9%), and Vitron (1.3%) were the top four favorite durum wheat varieties. Apart from Radia and Carioca, which were both released less than 10 years ago and both of which are non-INRA varieties, the other seven farmer-preferred varieties are from the INRA/CGIAR collaborative work but are more than 20 years old. This raises several important questions. Are there new improved INRA/CGIAR varieties that are superior to these old varieties? Are there new and better varieties from INRA/CGIAR that the farmers are not aware of or which are not reaching them? Are these old varieties performing as well as or performing

Table 5.48: Management of own-saved seed by farmers

	If farm saved, did you treat your seed? (%)	Did you store seed separate from other grains? (%)
Yes	26.7	54.7
No	73.3	45.3
Total	**100**	**100**

Table 5.49: Mode of storage for own-saved seed

Where do you store the seed?	Proportion of farmers using this approach (%)
In jute bags kept in the house	86.4
In polypropylene bags kept in the house	11.1
In jute bags kept in a storage area outside the house	0.1
Traditional stores	2.3
Total	**100**

better than the more recent INRA/CGIAR varieties and hence farmers prefer them?

To shed light on some of these questions, farmers were asked if they cultivate their favorite varieties. The results show that 77.4% of farmers responded "Yes" when referring to bread wheat, and 57% said "Yes" for durum wheat. For those who responded "No", the main reason given in 75.7% of the cases was that insufficient quantities were available in the market for many reasons. These included: lack of adequate rain or irrigation water in the previous cropping season, followed by high prices (21.6%). When asked whether they have heard about the new INRA Hessian fly resistant durum wheat variety, Faraj, that was released in 2007 and is hailed by breeders as one of the best available varieties, almost 96% of the farmers responded "No" and 4% said "Yes". Among those who responded "Yes", 75.5% said they liked the variety and hence wanted to plant it. But 95.5% said they could not get the seed in the market. This confirms that lack of information about and availability of the seeds of the most recent varieties in the market provides part or all the explanation for the dominance of the old wheat varieties in Morocco.

Farmers were also asked what they think would be the best way to solve the current seed-related problems. The main solutions proposed by farmers included:

- Seed companies should know better what farmers want and produce enough quantities of those varieties (29.5%)
- Government should intervene and solve these problems (28%)
- Purchasing the varieties from the local market (24.5%). We interpret this to mean that farmers think that the informal sector needs to be strengthened to fill the gap
- Creating better access to credit facilities for seed purchase and seed production under irrigation (15.5%).

The average minimum price per quintal (100 kg) farmers were expecting to pay for the seed of their favorite variety was MAD 200 (USD 23.5) and the maximum price per quintal they were prepared to pay was MAD 284 (USD 33.4), while the actual average price per quintal of seed was MAD 600 (USD 70.6). Therefore, the average price the farmers were willing to pay per quintal for seed was almost equivalent to the actual average harvest-time wheat grain price. These results are consistent with the traditional way of thinking among most farmers who believe that seed prices and grain prices should be the same.

In response to a question about the main problems or issues related to the use of certified seeds, the high price of certified seeds was the main issue for 60% of the farmers. While seed is highly subsidized in the country, the fact that most farmers feel that the price is still high could provide a good explanation for the low level of use of certified seeds. The lack of availability of certified seeds, in general, and the certified seeds of preferred varieties, in particular, were important issues for 14.1% and 4.7% of the farmers, respectively. About 8% of the farmers said that the long distance to the certified seed distribution centers was an important factor in their decision to use certified seed while 6% said it was lack of access to credit facilities.

Regarding the quality of certified seeds, about 80% of the farmers said they were happy with the genetic purity and 77% said they were satisfied with the physical purity of certified seeds sold in the market. These responses were based on their personal experiences, information from other farmers, or what they thought. The germination ability and health of the certified seeds were also both good in the opinions of about 79% of the respondent farmers. A few farmers (11%) said they occasionally engage in exchange of seeds with other farmers, while a sizeable number (44%) said that they save seed from their own wheat grain production of the previous cropping season.

Comparison of net margins between wheat grain and wheat seed production

Production of seed requires more attention, skill, intensive management, and extra activities and efforts than producing grains. Moreover, seed production carries a higher risk because failing to meet the minimum quality requirements might lead to financial loss, as what was produced as seed might need to be sold as grain. In the face of a substantial gap between the total national seed demand and the national supply of certified seeds, one wonders if there is a role for village-based seed enterprises to play. This may have many political, legal, and operational implications and create a conflict of interest for some actors in the seed sector. But a first step for studying its feasibility is to undertake a profitability analysis. This needs to determine if there are enough economic incentives for the ordinary grain producing farmer or group of farmers to be attracted to the production of seeds. To this effect, we developed crop budgets for the typical wheat grain producer, the typical commercial wheat seed producer, and a typical local (informal) wheat seed producer who sells the seed to farmers in his/her neighborhood. We used these to make profitability comparisons. As profits will depend on the ecology of production (irrigated

vs. rainfed), species (durum vs. bread), and variety (as yields and perhaps input costs might differ across varieties), we selected a total of six varieties. We chose three bread wheat varieties (Table 5.50) and three durum wheat ones (Table 5.51) for comparison.

Survey results show that, except for Achtar produced by local seed growers under rainfed conditions and Crioca produced by commercial seed growers also under rainfed conditions, the rest of the cases for which data was available show that seed production indeed leads to higher net margins. However, there is no clear pattern in terms of which mode of seed production (commercial or local) leads to the highest net margins as this seems to vary by variety and agro-ecology. We do not have a good explanation for this. Therefore, a more focused and more rigorous study is needed to identify factors which affect the profitability of seed production and explain the sources of differences in profitability across ecological zones, wheat species, varieties, and mode of production. From the results we have, there is a clear indication that with proper training and institutional support, local seed growers can be made profitable. Given the high risk involved, the introduction of crop insurance might also make local seed production more attractive to both large and smallholder grain producers alike.

5.7 Summary and concluding remarks

After the introduction of durum wheat by the Arabs from the Arabian Peninsula around the seventh century AD and bread wheat by the French at the turn of the 20th century, both crops have been expanding rapidly in Morocco. Between 2008 and 2012 production reached an average of 2.04 million tonnes on 0.94 million ha. Around 2010, wheat, in general, occupied about 59% of the total cereals area and bread wheat, in particular, occupied about 40%. These figures show the growing importance of wheat in Moroccan agriculture. During the 1960s and 1970s, wheat yields at the national level remained low at about 0.9 t/ha. This started to increase after the arrival of new and improved bread wheat varieties in the 1980s. After a decade, average yields reached about 1.21 t/ha for durum wheat and 1.3 t/ha for bread wheat. With the introduction of many newly improved varieties in subsequent years, significant increases in wheat yields were observed in Morocco.

However, even though the yield increases over the years are commendable, current Moroccan yield levels of about 1.5 t/ha remain far behind both the global average of over 3 t/ha and the African average of 2.3 t/ha. Given the availability of new varieties with yields reaching 4–5 t/ha, the current yield

Table 5.50: Comparison of crop budgets for grain producers, commercial seed producers, and local seed producers, bread wheat

Variety	Ecology	Type of producer	Cost (MAD/ha)						Cost (MAD/ha)			Revenue components (MAD)					Share of gain relative to grain producers (%)
			Seed	N	DAP	Tillage	Pesticide	Herbicide	Harvest	Transport	Total cost	Yield (kg/ha)	Grain or seed price	Value of residue (MAD/ha)	Total revenue	Net margin	
Achtar	Irrigated	Grain producers	490	2,983	1,106	400	147	79	571	362	6,139	4,024	2.83	7,872	19,279	13,141	
		Commercial seed producers	751	2,801	1,238	600	210	113	849	402	6,964	4,467	3.30	7,983	22,723	15,759	19.9
		Local seed producers	None in the sample						None in the sample								
Achtar	Rainfed	Grain producers	526	477	282	400	154	83	138	89	2,147	987	2.79	1,939	4,695	2,548	
		Commercial seed producers	452	828	401	400	81	44	193	91	2,491	1,016	3.30	2,078	5,431	2,940	15.4
		Local seed producers	458	1,350	375	400	105	57	191	90	3,026	1,005	3.30	2,103	5,419	2,393	–6.1
Radia	Irrigated	Grain producers	607	3,670	1,436	400	118	63	719	455	7,469	5,058	2.84	8,142	22,529	15,061	
		Commercial seed producers	725	2,574	1,706	600	228	123	1,148	544	7,647	6,042	3.29	8,598	28,475	20,828	38.3
		Local seed producers	628	2,484	1,500	600	158	85	1,131	536	7,121	5,950	3.29	9,235	28,810	21,689	44.0
Radia	Rainfed	Grain producers	502	583	313	400	82	44	155	100	2,180	1,113	2.77	2,339	5,444	3,264	
		Commercial seed producers	452	936	498	400	91	49	229	108	2,764	1,203	3.29	2,182	6,141	3,377	3.5
		Local seed producers	481	912	544	400	105	57	229	109	2,836	1,208	3.29	2,216	6,189	3,353	2.7
Amal	Irrigated	Grain producers	487	3,161	1,127	400	130	70	566	362	6,302	4,026	2.81	7,807	19,122	12,819	
		Commercial seed producers	670	2,693	1,323	600	210	113	851	403	6,864	4,479	3.27	8,277	22,923	16,059	25.3
		Local seed producers	638	2,889	1,245	600	200	108	868	411	6,958	4,570	3.27	8,342	23,286	16,328	27.4
Amal	Rainfed	Grain producers	472	479	314	400	126	68	135	89	2,084	988	2.75	1,929	4,638	2,554	
		Commercial seed producers	437	1,125	225	400	105	57	214	101	2,664	1,125	3.27	2,196	5,875	3,211	25.7
		Local seed producers	483	630	461	400	131	71	200	95	2,470	1,050	3.27	2,207	5,640	3,170	24.1

levels are rather depressing. Thus, the importance of understanding the major reasons behind these low yields and developing mitigation strategies is critical. Low adoption levels of improved varieties are often cited as one of the major constraints. This itself is a function of many other variables, including an ineffective seed-delivery system. Using a nationally representative sample of 1,230 farm households from 21 provinces distributed across 56 districts and 292 villages, this study attempted to provide accurate estimates of current national and provincial adoption levels of improved varieties. Special attention was paid to their release dates. Analyses of the factors influencing adoption of improved wheat varieties and an estimation of farm, provincial, and national

Table 5.51: Comparison of crop budgets for grain producers, commercial seed producers, and local seed producers, durum wheat

Variety	Ecology	Type of producer	Cost (MAD/ha)						Cost (MAD/ha)			Revenue components (MAD)					Share of gain relative to grain producers (%)
			Seed	N	DAP	Tillage	Pesticide	Herbicide	Harvest	Transport	Total cost	Yield (kg/ha)	Grain or seed price	Value of residue (MAD/ha)	Total revenue	Net margin	
Karim	Irrigated	Grain producers	486	3,115	1,192	400	119	64	599	320	6,295	3,559	3.37	7,506	19,499	13,204	
		Commercial seed producers	727	2,624	1,287	600	212	114	802	380	6,747	4,222	3.82	5,796	21,925	15,178	15.0
		Local seed producers	596	2,822	1,400	600	210	113	717	340	6,799	3,773	3.82	5,925	20,339	13,540	2.5
Karim	Rainfed	Grain producers	492	394	284	400	126	68	139	75	1,977	838	3.31	1,557	4330	2,353	
		Commercial seed producers	488	931	596	400	73	39	191	90	2,808	1,003	3.82	1,549	5,381	2,573	9.3
		Local seed producers	462	831	356	400	118	64	194	92	2,517	1,019	3.82	1,580	5,471	2,955	25.5
Marzak	Irrigated	Grain producers	516	2,912	1,085	400	75	40	605	332	5,963	3684	3.28	7,484	19,575	13,611	
		Commercial seed producers	None in the sample						None in the sample								
		Local seed producers	619	2,504	1,125	600	210	113	732	347	6,249	3,850	3.74	6,031	20,430	14,181	4.2
Marzak	Rainfed	Grain producers	501	435	260	400	121	65	118	66	1,966	728	3.24	1,533	3,890	1,924	
		Commercial seed producers	546	1,028	475	400	123	66	192	91	2,920	1,008	3.74	1,661	5,432	2,511	30.5
		Local seed producers					None in the sample		None in the sample								
Crioca	Irrigated	Grain producers	691	3,627	1,593	400	96	52	873	458	7,790	5,092	3.43	8,150	25,610	17,820	
		Commercial seed producers	751	2,592	1,500	600	210	113	1093	518	7,376	5,750	3.74	5,945	27,450	20,074	12.6
		Local seed producers					None in the sample		None in the sample								
Crioca	Rainfed	Grain producers	511	491	224	400	56	30	149	85	1,946	940	3.19	2,312	5,300	3,355	
		Commercial seed producers	440	930	721	400	90	49	235	111	2,976	1,236	3.74	1,631	6,253	3,277	−2.3
		Local seed producers					None in the sample		None in the sample								

level seed demands have been conducted. The study also attempted to measure the effects of the adoption of improved varieties on the livelihoods of households.

During the survey, 40 wheat varieties were found in farmers' hands (19 bread wheat, 15 durum wheat, and 6 unidentified). Of the 34 identified varieties, 10 of them are old (over 20 years of age). The breeding programs of 27 varieties were identified and 18 of them came from the INRA breeding program. Except for one variety, the other 17 varieties released by INRA came from the joint INRA/ICARDA/CIMMYT program, showing strong collaboration between INRA and CGIAR. All these varieties are over 10 years old and are

being cultivated by 81.8% of the wheat growers in the country – an indication that they are still the favorite varieties among Moroccan farmers. None of the INRA/CGIAR varieties released in the last 10 years have found their way into farmers' hands. Generally, the top 10 varieties are being cultivated by more than 91% of wheat growers on 92% of the total wheat area. Among the top 10 varieties, four are at least 24 years old and cover 56% of the total wheat area – the old varieties still dominate in Moroccan wheat fields. Karim and Achtar (both of which come from the INRA/CGIAR program) are the top two varieties being cultivated by 38.1% of Moroccan farmers.

The national adoption rates for more recent varieties, generally, stand at very low levels. Just 16% of Moroccan wheat growers cultivate varieties that were released 10 or less years ago, while 48% of the farmers cultivate varieties which are 20 years old or less on 41% of the total wheat area. With an area-weighted national average varietal replacement rate of 22 years, very old varieties still dominate the Moroccan farmers' portfolio. More than 58% of the growers are still cultivating varieties that were released more than 20 years ago. This raises several important questions. Are there new improved INRA/CGIAR varieties that are superior to these old varieties? Are there new and better varieties from INRA/CGIAR which farmers are not aware of or that are not reaching them? Are these old varieties performing as well as or better than more recent INRA/CGIAR varieties and is this why farmers prefer them?

Survey results showed that farmers are not up-to-date in terms of new varieties and when they are, the seeds of these new varieties are often not available. This confirms that lack of information and the non-availability of the seeds of the most recent varieties in the market account for part or all the explanation for the dominance of old wheat varieties in Morocco. The availability of seed has a significant effect on adoption. However, this effect is not high enough to justify blaming the seed availability for the poor adoption levels, as is often the case with breeders, development practitioners, policy makers, and donors alike. Instead, farmer characteristics (age, gender, education, access to credit, off-farm employment, and whether the farmer hosted demonstration trials) were found to be the most important explanatory variables. These accounted for 45% of the total variation and were followed by farm characteristics, which explained 19% of it.

To develop a deeper understanding on the role of gender on varietal adoption, a separate qualitative analysis was carried out. This generated new

insights that would have otherwise been overlooked if only quantitative data were used. This shows that the collection of sex-disaggregated data is essential in generating information that can influence policy and development and enable women to participate more effectively in wheat systems. Through data collected in a sex-disaggregated fashion from women and men individually and in groups, findings from Saïs reveal that women's participation in demonstration events and activities such as farmer field schools, individual farms, and extension programs is limited. This restricts their ability to learn from these activities. It is important to improve access to information for women as this may increase productivity and contribute to food security. This is especially so given male outmigration. It is also important for the involvement of both men and women in adoption decisions related to wheat varieties. A thorough understanding of men's and women's roles, needs, and aspirations can inform extension program design and breeding objectives. This will help achieve better yields and gender equity in the targeting of beneficiary farmers.

To realize that, and given the cultural norms, it is important to hire women extension staff to deliver information to and collect it from women. Increasing women's involvement in voicing their preferences for varietal traits needs to be part of the feedback to breeding objectives and varietal selection. This is a necessary initial step towards enabling women to benefit equitably with men from improved seed varieties and improved agronomic practices. Involving women extension agents in culturally appropriate ways (such as place and timing of the training venues) is important to successfully recruiting women participants. These considerations are important for the development of varieties which are responsive to both female and male needs and preferences, and which, in turn, could increase adoption rates more broadly.

The adoption of improved wheat varieties leads to improvements in livelihoods' indicators. These would include a 482 kg/ha (49%) increase in yields, MAD 1,324/ha (48%) higher net incomes, and a 29.6 kg/capita/year (60%) increase in wheat consumption. Given an average area per farm household under the improved wheat varieties of 1.6 ha, the typical adopter farm households are obtaining 771 kg extra wheat production and MAD 2,118 (USD 246) additional net income. These data clearly show that the improved varieties are contributing to livelihood improvements. Nationally, the adoption of the improved varieties has led to 17% higher annual production, net annual wheat income gains of about MAD 9.1 billion (USD 1.1 billion), and about 17 kg/capita/year of extra wheat availability for consumption from domestic production.

The average seeding rate for wheat in Morocco is 176 kg/ha (250 kg/ha for irrigated and 157 kg/ha for rainfed lands). This translates to a national seed use rate of 5.12 million quintals per year. Of the total seed used, 43% is planted in the favorable zones and 33% in the intermediate. The remaining 24% is used in the unfavorable and mountainous zones. Achtar, Amal, Karim, Radia, and Merchouch are the top five varieties with the highest seed use in Morocco, but except for Karim, certified seed is not produced. These results are consistent with the total amount of certified seed produced and distributed in the country.

Of the total wheat seed used nationally in the 2011/12 cropping season, 22% originated from SONACOS (17.81% acquired from the local government extension service units, and 4.21% from SONACOS' own seed distribution points). The remaining 78% was from other sources, including local seed dealers, seed dealers in neighboring villages, farmer-to-farmer exchanges, and own-saved seed. The average seed replacement rate is 2.1 years, with some farmers replacing every year and others not replacing for more than 10 years. Farmers stated that the lack of availability of the desired seeds and high seed prices are the most important problems.

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Chapter 6: Wheat sector perspectives

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6 Wheat sector perspectives

6.1 Executive summary

With a consumption of more than 250 kg of wheat per person per year, Morocco has one of the highest per capita wheat consumptions in the world. Such a high consumption is in part the result of the subsidies that Morocco has been providing to the wheat sector to make wheat byproducts (bread, pasta, etc.) affordable. Keeping wheat prices low has traditionally been a popular policy in Morocco. Yet, following independence, the total supply of wheat has become more reliant on imported wheat, and less on domestically produced wheat. While this is not necessarily bad, the Moroccan government has been determined to increase domestic wheat production to become fundamentally self-sufficient. To this end, since the 1980s, wheat imports have been subject to high tariffs (even more than 100% ad valorem). This has provided protection to domestic wheat producers. Yet, Morocco's trade agreements with the EU, the USA, and other countries have been pushing and will eventually achieve complete elimination of the import tariffs. Aware of this situation, the Moroccan government has been allocating resources to improve wheat productivity, to make the sector more competitive. This section focuses on understanding how a hypothetical elimination of tariffs on imported wheat will affect domestic wheat supply. This simulation was complemented with a productivity shock that simulated technological improvement leading to a productivity increase in the Moroccan wheat sector.

The methodology used the Global Trade Analysis Project (GTAP) model to rigorously estimate possible outcomes emerging from technological changes and the elimination of import tariff protection. The results indicate that domestic wheat production would increase because of improvements in capital and unskilled labor productivity and would decrease as result of the elimination of tariff protection for domestic wheat. Results suggest that the Moroccan wheat sector strongly depends on import tariffs to keep the wheat

sector protected from more competitive wheat produced abroad. The results also suggest that increased wheat productivity and production will not be enough to reduce wheat imports. Morocco has been and will continue to be a net wheat-importing country. Yet, Morocco does not need to be self-sufficient to increase the per capita supply of wheat. Importing wheat from countries well-endowed with water can be an interesting option to Morocco, allowing it to specialize in the agricultural production of commodities that are less water intensive.

6.2 Introduction

Over time the Government of Morocco has provided significant subsidies to the agricultural sector, in particular for wheat production. As a result of the subsidies, ordinary people in Morocco pay as low as USD 0.2 per loaf of bread (about 500 g). Over time, the wheat subsidy has driven patterns of consumption to be intensively based on cereal consumption, to the point that Morocco has become one of the highest wheat-consuming countries in the world (more than 250 kg/year/per capita). Decades of subsidies and investments to improve wheat productivity, coupled with high import tariffs to protect domestic wheat production from more competitive imports, have not prevented the relative decline in total domestic wheat production in comparison to wheat imports.

In the frame of the WTO negotiations, countries have been encouraged to eliminate import tariffs to experience welfare gains from international trade. What if Morocco decides to liberalize its wheat market? Will per capita consumption of wheat decrease? Will the domestic wheat supply increase? Will improvements in wheat productivity be enough to compensate for a reduction in or elimination of import tariffs? Shedding light on these questions can provide policy makers with key information to analyze the trade-offs that emerge from protecting the wheat sector in the context of subsidies that sustain a large production.

To analyze the implications emerging from wheat liberalization, we simulated changes in tariff protection. To test the effect of policies designed to improve productivity, we simulated technological changes that improve wheat productivity. By analyzing policies for trade liberalization of wheat, we assessed the dependence of domestic wheat production on tariff protection. By testing policies for improved factor productivity, we analyzed the effect in terms of production, imports, self-sufficiency, changes in prices, and overall welfare.

The next part of this chapter presents the methodology used to estimate changes in productivity and the protection tariffs for the wheat sector. This part briefly presents the theory behind the GTAP model that has been used to estimate the macro-effects of increased capital and unskilled labor productivity and import tariff elimination on the overall domestic wheat supply. Then, the results of the simulation scenarios are presented. The effects of increased wheat productivity (resulting from technological change) and import liberalization on the development of the wheat sector, including macro-indicators, such as gross domestic product (GDP), welfare, imports, terms of trade, and shares of domestic production are discussed. How feasible the results obtained might be is the next part discussed. This discussion analyzes the wheat sector in Morocco, focusing on production, imports, and value from the 1960s onwards. It includes reference to the importance of wheat in the Moroccan diet as well as the level of dependence of the country on imported cereals. Water productivity was compared, considering that it is not only cereals that compete for water resources, but other commodity groups, such as vegetables, fruits, and pulses. The purpose of this comparison was to understand from a macro-perspective the trend in agricultural production, not only from an economic viewpoint, but also considering the restrictions that limited water resources can impose in the overall aggregate of commodities that are produced in the country. Finally, conclusions emerging from this study are presented.

6.3 Methodology

Growth and development of the wheat sector is important for food security in Morocco. The extent to which subsidies and tariff protection contribute to improved performance in this sector is analyzed here using the GTAP model (Hertel 1997). This model, widely discussed and described in many economic policy articles, is a standard, static, multi-region, multi-sector computable general equilibrium (CGE) model. It explicitly includes the treatment of international trade and transport margins, global savings and investment, and price and income responsiveness across countries. It assumes perfect competition, constant returns to scale, and an Armington specification for bilateral trade flows that differentiates trade by origin.[1] It also assumes fixed factor endowment and full factor use.

[1] The GTAP model adopts Armington's (1969) treatment for commodity substitution. That is, even in regions producing the same commodity, the elasticity of substitution between the two regions is not infinite, meaning that the "low of one price" does not hold.

In this exercise, the GTAP database Version 8.0 (addressing 129 regions or countries and 57 sectors or commodity groups) was used. It represents a snapshot of the world economy for 2007. The results of this model for all variables are expressed as relative changes from the original GTAP database. That is, the scenario results are percentage changes from the base case scenario. The GTAP model is basically expressed in equations contained in the code of the model, which represents the fundamental theory behind the GTAP model. Given the large number of components included in this code, this simulation focuses on the behavioral equations needed to understand the effects of changes in technology and in tariff protection. It describes the interactions of the various agents of the model, the way goods and services are exchanged, the distribution of production factors, and the way prices are built-up as a result of the shocks.

The GTAP model assumes that agents (e.g. farmers) combine five endowment inputs (land, skilled labor, unskilled labor, capital, and natural resources) with intermediate inputs (fertilizers, seeds, pesticides, or any other input that has already been subject to some level of transformation process) to produce agricultural commodities for final consumption. Farmers' behavior is modelled through the 'production tree' (Figure 6.1). At the top of this figure is the percentage change in the final output (*qo*), which is produced from the percentage change in value added[2] (*qva*) and from the percentage changes in intermediate inputs (*qf*). Also, at the top level, there is a constant elasticity of substitution (*ESUBT*), indicating that if it is non-zero it is possible to substitute value added by intermediate inputs and vice-versa. For example, if *ESUBT* is a positive number, then intermediate inputs could be substituted by employing more labor, land, or capital if the prices of intermediate inputs increase. The farms' production functions use nested constant elasticities of substitution (CES) functions that represent the form in which farms demand endowment and intermediate inputs. At the bottom of the tree, farms purchase the endowment inputs (*qfe*) as well as some domestic (*qfd*) goods.

There is also an elasticity of substitution among the components of value added, namely *ESUBVA* that is also a constant in the model (i.e. *ESUBVA* is a CES function). The *ESUBVA* indicates the degree to which it is possible to increase output by using one or more inputs. For example, agricultural output on a given amount of land can be increased by employing more labor and capital.

[2] In GTAP lexicon, changes in value added refer to changes in production factors – skilled labor, unskilled labor, capital, land, and natural resources.

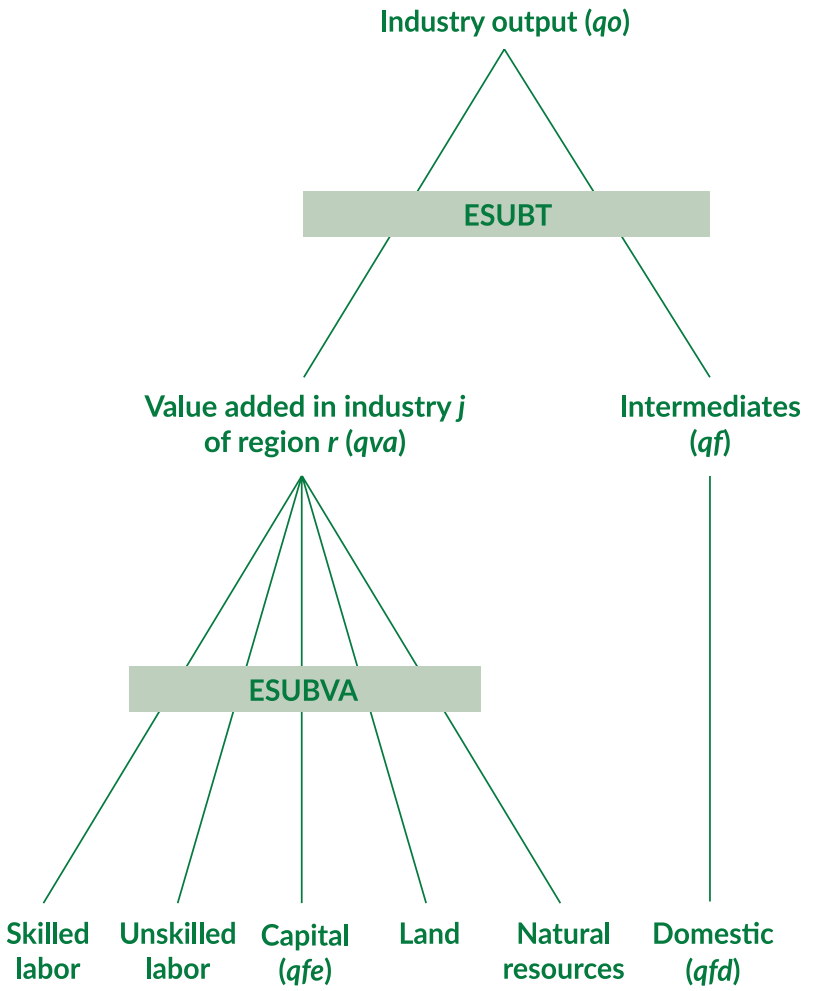

Figure 6.1: Farmer behavior in the "production tree"

Source: Hertel and Tsigas 1997.

The key assumption in the production tree is the separability of the primary factors from the intermediate inputs. Separability permits the nesting of value-added primary factors together (Hertel 1997). The separability assumption of the primary factors from intermediate inputs has two implications:

- The optimal mix of land, labor, and capital (value-added primary factors) is invariant to the price of intermediates

- The elasticity of substitution between any primary factor and intermediates is the same.[3]

The mathematical form of the CES function focuses on the value-added nest. The value-added production function (*QVA*) is produced by assembling inputs or endowments (*QFE*) which, formally, is the amount of endowment *e* used in sector *p* (Equation 1).[4] These endowments are weighted by a distributive parameter (δ) indicating its relative importance in production and raised to a power (σ) that governs the elasticity of substitution between endowments.

$$QVA_p = \left\{ \left(\sum_e \delta_{e,p} QFE_{e,p} \right)^{\frac{\sigma_p - 1}{\sigma_p}} \right\}^{\frac{\sigma_p}{\sigma_p - 1}} \quad (1)$$

On the one hand, if there is a high degree of substitutability among inputs (i.e. high σ), the reduction in one input can be offset by increasing other inputs. On the other hand, if σ is very small (zero in the limit), then a case of the Leontief production function appears, where factors of production are used in fixed proportions as there is no substitutability between them. The implication is that an increase in any production factor will lead to no increase in output. The derived demand equation for inputs that follows this production function is shown as the derived demand for endowment (*QFE*) *e* in sector *p* (Equation 2). This is a function of the overall level of production of value added (*QVA*), the share of input *e* in total value added in sector *p* (*SVA*), and the relative prices of endowments and value added.

$$QFE_{e,p} = QVA_p . SVA_{e,p} . \left\{ \frac{PFE_{e,p}}{PVA_p} \right\}^{-\sigma_p} \quad (2)$$

[3] Hertel (1997) recognizes that the separability assumption might be restrictive for certain applications (e.g. the energy-labor substitution is not equal to energy-capital substitution); however, he claims that this assumption can be relaxed in the GTAP standard model if a full matrix of substitution elasticities is known.

[4] The GTAP model uses linearized equations for general equilibrium. When the intermediate demand shown in Equation 1 is linearized, changes in the value-added production function (*QVA*) become a percentage change in value added (*qva*). It is a function of the percentage change in output (*qo*) and of the relative prices weighted by the elasticity of substitution amongst the intermediates in value added – *ESUBT* (which determines the substitution effect among intermediate inputs and the value-added primary factors).

$qva_j = qo_j - ESUBT_j * [pva_j - ps_j]$ as per the GTAP convention; lower case variables represent percentage changes.

For example, if *QVA* goes up by 1%, then *QFE* also increases by 1% – assuming that relative prices do not change. Underlying this is the assumption of constant returns to scale. Notice that this price ratio is raised to a negative value of the elasticity of substitution (σ). This means that if the price of a given input (*PFE*) rises relative to the average price or cost of all inputs (*PVA*), then the demand for that particular input (*QFE*) will fall given that the relative prices are raised to a negative value of elasticity of substitution. The price index of value added (*PVA*), in the right-hand side in Equation 2, is determined by the sum of the share-weighted prices of the endowments.

In the GTAP model, technological change refers to the variations farms might experience as a result of the technology improvements used in the production of agricultural commodities. In this study, the focus is on technological changes occurring when primary factors (i.e. capital and unskilled labor) augment wheat production in Morocco. To analyze how these technological changes work in the model, let us assume that if technological change in capital (*AFE*) increases, three effects are generated:

- If capital becomes more productive, then less capital is used for a given amount of output and constant prices
- If capital becomes more productive and returns to capital do not change, then the effective price of capital is reduced, encouraging the substitution of other inputs for capital (i.e. more capital demanded)
- More productive capital also lowers the cost of production, facilitating output expansion.

These effects are explained in Equation 3, which is equivalent to Equation 2, but expressed in GTAP code notation. On the left-hand side, an increase in *AFE* (e.g. higher capital productivity) for a constant level of output of value added (*QVA*) and constant relative prices (*PFE* and *PVA*), implies that less capital is needed (*QFE*). On the right-hand side, an increase in capital productivity (*AFE*) lowers the effective price of capital (*PFE*), thus encouraging substitution of capital for other inputs.

$$QFE_{e,p}.\,AFE_{e,p} = QVA_{p}.SVA_{e,p}.\left[\frac{PFE_{e,p}}{PVA_{p}.\,AFE_{e,p}}\right]^{-ESUBVA_{p}} \quad (3)$$

In the CES price equation, an increase in capital productivity (*AFE*) lowers cost, and with a lower price of capital, encourages expansion in the output of the sector (Equation 4):

$$PVA_p = \left\{ \sum_e SVA_{e,p} \cdot \left[\frac{PFE_{e,p}}{AFE_{e,p}} \right]^{1-ESUBVA_p} \right\}^{\frac{1}{1-ESUBVA_p}} \quad (4)$$

Commodity prices in the model are assumed to change as a function of the tariffs on imports (*tm*). These are a source-generic change in tax on imports of the commodity *i* into country *s*, plus supplier import tariffs (*tms*), that is a bilateral import protection measure, and plus the cost, insurance, and freight world price of commodity *i* supplied from country *r* to country *s* (*pcif*). This commodity price formation process in linearized form is shown in Equation 5:

$$pms(i,r,s) = tm(i,s) + tms(i,r,s) + pcif(i,r,s) \quad (5)$$

6.3.1 Sectoral and regional aggregation

The GTAP database is huge, containing input-outputs matrices for 129 regions (countries or groups of countries) and 57 sectors (commodity groups). These are available in Version 8.0. Given this size, the amount of computational resources needed to calculate the data is usually unbearable. Therefore, for the simulations to be solvable, data aggregation is needed (Hertel et al. 2004). Thus, this database was aggregated into 11 regions and 12 sectors, where the criterion for regional aggregation consisted of choosing countries that are important trade partners for Morocco. The criteria for the commodity groups consisted of sectors that are important contributors to Moroccan GDP (Table 6.1).

6.3.2 Simulation scenarios

To assess the technological changes improving wheat productivity and the liberalization of the domestic wheat market, the following three scenarios were defined:

- **Scenario 1**: 20% productivity increase in capital used in wheat production in Morocco
- **Scenario 2**: Scenario 1 plus 20% productivity increase in unskilled labor used in wheat production in Morocco
- **Scenario 3**: Scenario 2 plus full liberalization of import tariffs on wheat imported into Morocco.

Table 6.1: Regional and sectoral aggregation based on GTAP database, Version 8.0

No	Region	Description
1	Mar	Morocco
2	Oceania	Oceania: Australia, New Zealand, rest of Oceania
3	East Asia	East Asia: China, Hong Kong, Japan, Korea, Mongolia, Taiwan, rest of the East Asian countries
4	SEAsia	South East Asia: Cambodia, Indonesia, Lao People's Democratic Republic, Malaysia, Philippines, Singapore, Thailand, Viet Nam
5	SouthAsia	South Asia: Bangladesh, India, Nepal, Pakistan, Sri Lanka
6	N. America	North America: United States, Canada, Mexico
7	LatinAmer	Latin America: Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Paraguay, Peru, Uruguay, Venezuela, Costa Rica, Guatemala, Honduras, Nicaragua, Panama, El Salvador, Caribbean, rest of the Latin American and Caribbean countries
8	EU25	European Union 25: Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, and UK
9	MENA	Middle East and North Africa: Egypt, Tunisia, rest of the MENA countries
10	SSA	Sub-Sahara Africa: Cameroon, Côte d'Ivoire, Ghana, Nigeria, Senegal, Ethiopia, Kenya, Madagascar, Malawi, Mauritius, Mozambique, Tanzania, Uganda, Zambia, Zimbabwe, Botswana, Namibia, South Africa, rest of the African countries
11	ROW	Rest of the world
No	**Sector**	**Description**
1	Wheat	Wheat
2	Cerealgran	Cereal grains not elsewhere classified (nec)
3	GrainCrops	Paddy rice, vegetables, fruit, nuts, oil seeds, sugar cane, sugar beet, plant-based fibers, crops nec, processed rice
4	MeatLstk	Bovine cattle, sheep and goats, horses, animal products nec, raw milk, wool, silk-worm cocoons, bovine meat products, meat products nec
5	Extraction	Forestry, fishing, coal, oil, gas, minerals nec
6	ProcFood	Vegetable oils and fats, dairy products, sugar, food products nec, beverages, tobacco products
7	TextWapp	Textiles, wearing apparel
8	LightMnfc	Leather products, wood products, paper products, publishing, metal products, motor vehicles and parts, transport equipment nec, manufactures nec
9	HeavyMnfc	Petroleum, coal products, chemical, rubber, plastic products, mineral products nec, ferrous metals, metals nec, electronic equipment, machinery and equipment nec
10	Util_Cons	Electricity, gas manufacture, distribution, water, construction
11	TransComm	Trade, transport nec, water transport, air transport, communication
12	OthServices	Financial services nec, insurance, business services nec, recreational and other services, public administration, defense, education, health, dwellings

Source: Own classification based on GTAP 8.0 Database.

These scenarios test the effects on wheat production in Morocco if improved technology, in the form of more productive capital (improved mechanization, improved irrigation, seeds, fertilizers, etc.), is used in the production processes applied to wheat (Scenario 1). Also, wheat production could be changed if it is assumed that unskilled labor becomes more productive through training and capacity building (Scenario 2). Finally, using the previous scenarios, we tested how unilateral elimination of import tariffs on imported wheat affects domestic wheat production (Scenario 3).

6.4 Results

The results presented in this section focus on the most important variables relevant to evaluating how technological (improving factor productivity) and trade reforms affect the wheat sector in Morocco. Presentation of the results starts with macro-economic changes in terms of GDP, welfare, and terms of trade. Then the results are reported in terms of changes in demand for production factors, changes in wheat production, changes in domestic prices, and changes in the international trade in wheat.

6.4.1 Aggregate welfare outcomes

Moroccan GDP would marginally increase by 0.09% per year under Scenario 1 and 0.49% per year under Scenario 2 and would decrease by 0.83% per year under Scenario 3. These minor results in terms of GDP change were expected, given that wheat is a relatively minor sector in comparison with the whole Moroccan economy (Table 6.2).

In terms of welfare, Scenario 1 would represent a net positive welfare gain of USD 130 million/year for Morocco. Scenario 2, which adds increased productivity in unskilled labor, results in welfare increases of USD 429 million/year. Scenario 3, which adds the unilateral trade liberalization on wheat, augments net welfare by USD 495 million/year. Understanding welfare changes is one of the most important results in the GTAP model as it provides a general overview of changes emerging from policy adjustments. In the GTAP model, such changes come from four main sources: a) improved (or deteriorated) efficiency, b) improved (or deteriorated) technology, c) improved (or deteriorated) terms of trade (which refers to changes in the relative prices of exports and imports), and d) more (or less) investment. All these factors together provide decomposition of welfare changes as shown in Table 6.3.

Table 6.2: Aggregated welfare changes for Morocco

Economic variable	Scenario 1	Scenario 2 (Scenario 1 + 20%)	Scenario 3 (Scenario 2 + full tariff liberalization)
Value GDP (%)	0.09	0.49	–0.83
Welfare (USD million/year)	130	429	495
Terms of trade (%)	0.04	0.26	–0.64

Source: Own elaboration based on results from GTAP Version 8.0 simulations.

Table 6.3: Welfare decomposition for Morocco (USD million)

Sources of welfare	Scenario 1	Scenario 2 (Scenario 1 + 20%)	Scenario 3 (Scenario 2 + full tariff liberalization)
Allocative efficiency effect	–51	–125	209
Technical change effect	167	463	463
Terms of trade effect	9	60	–149
Investment savings effect	5	31	–27
Total	**130**	**429**	**496**

Source: Own elaboration based on results from GTAP Version 8.0 simulations.

Allocative efficiency is negative under Scenarios 1 and 2 indicating losses to the economy as a result of a less efficient allocation of production resources between sectors. Allocative efficiency under Scenario 3 was projected to be positive (USD 209 million). This is explained by the removal of the import tariff. That is, when a commodity is subject to a protective tariff, it implies that this commodity is under-using resources compared to what it would use under free market conditions (conversely, subsidies lead to the over-use of resources, which in turn leads to over-production relative to free market conditions). The technical change effect is positive in all three scenarios, which is just because of the simulations. In all, it is simulated that the productivity of capital and unskilled labor is improved.

Under Scenarios 1 and 2 the terms of trade (ToT) (expressed in USD million) increased, while under Scenario 3 it decreased. From Morocco's perspective, changes in ToT measure the price of products exported from Morocco relative to the price of products imported into Morocco. ToT increased under the first

two scenarios because the price index of exported commodities increased faster than the price index of imported ones. This means that Moroccan exports became more competitive abroad (appreciation of the ToT). Negative ToT, as in Scenario 3, indicates that the price index of imported commodities grew faster because the elimination of import tariffs on wheat resulted in depreciation of the ToT. The positive values of the investment savings effect reflect increases in national savings arising from the improved productivity of capital and labor. The negative value of the investment saving effect under Scenario 3 denotes a reduction in national savings resulting from trade policy changes. Thus, welfare changes in Morocco came predominantly from the technical change effect.

6.4.2 Aggregated production

This section addresses changes in aggregated production in Morocco. Changes in production are captured by the production function (Equation 1). Aggregated production would increase in some commodity sectors and decrease in others (Table 6.4). Under Scenarios 1 and 2, the model projected that the production of wheat would increase, while the production of other commodities (which includes domestically consumed and exported goods) would experience minor changes. These would be less than 1% in cereal grains, meats and livestock, and other commodities. Under Scenario 3, wheat production would decrease, while the production of cereal grains, grain crops, processed foods, and textiles would increase in the range 0.1–4.5%. The most noticeable result is observed in the domestic production of wheat, which would increase by 16.37% under Scenario 2 and would decrease by 13.72% under Scenario 3. These results are explained by the way in which the GTAP models change in aggregate output. That is, as a result of the shocks, aggregate output changes as a result of changes in domestic sales, changes in exportable production, and a slack variable in the market clearing condition. This is exogenous to the model and, therefore, is zero as no changes are produced in this variable.

Changes in production are an important result in terms of understanding the general equilibrium demand response (Equation 1). Decomposing changes in wheat (Table 6.5) shows that under Scenarios 1 and 2 the driving force behind the increases in total domestic wheat production was increased demand for domestically produced wheat. In Scenario 3 domestic wheat production decreased mainly because of lowered demand for domestically produced wheat. Despite increased capital and unskilled labor productivity, in Scenario 3 demand switches to imported wheat. In other words, the effect of liberalization

Table 6.4: Changes in the Moroccan production of tradable commodities (%)

Commodity	Production in Moroccan sectors		
	Scenario 1	Scenario 2 (Scenario 1 + 20%)	Scenario 3 (Scenario 2 + full tariff liberalization)
Wheat	5.99	16.37	–13.72
Cereal grain	0.11	0.25	2.13
Grain crops	–0.23	–0.75	2.22
Meat livestock	0.16	0.40	1.83
Extraction	–0.09	–0.59	0.66
Processed food	0.55	1.35	4.32
Textiles, wearing apparel	–0.24	–1.17	3.40
Light manufacturing	–0.13	–0.36	1.28
Heavy manufacturing	–0.1	–0.39	1.00
Utilities, construction	–0.17	0.39	0.16
Transport, communication	0.13	0.31	1.04

Source: Own elaboration based on results from GTAP Version 8.0 simulations.

Table 6.5: Changes in Moroccan wheat production (%)

Aggregated wheat production	Scenario 1	Scenario 2 (Scenario 1 + 20%)	Scenario 3 (Scenario 2 + full tariff liberalization)
Domestic sales	5.63	15.41	–15.08
Export sales	0.35	0.96	1.36
Slack variables	0	0	0
Total	**5.98**	**16.37**	**–13.72**

Source: Own elaboration based on results from GTAP Version 8.0 simulations.

in the wheat sector overcomes the increases in factor productivity, suggesting that the Moroccan wheat sector strongly depends on import tariffs to keep the wheat sector protected from more competitive (i.e. cheaper and possible higher quality) wheat produced abroad.

When wheat production changes, there are also changes in the demand for the factors of production. Changes in the demand for these factors are given by Equations 2 and 3, which in a linearized form is expressed as:

$$qfe(i,j,r) = -afe(i,j,r) + qva(j,r) - ESUBVA(j) * [pfe(i,j,r) - afe(i,j,r) - pva(j,r)]$$

GTAP captures the changes in the demand for production factors through changes in productivity, in the prices of production factors, and in the elasticity of substitution among production factors. The above equation shows technical change in capital and unskilled labor are reflected through the variable *afe*. This has a negative sign meaning that if technical change makes capital and unskilled labor more productive (as in Scenarios 1, 2, and 3), then agricultural farms would need less labor and less capital if production remains unchanged. Yet, *afe* also appears within the last bracket, which refers to the prices of the production factors. When capital and unskilled labor become more productive, the retributions of those production factors increase. Farmers have an incentive to substitute capital and unskilled labor for other inputs that are comparatively less productive. The level of replacement depends on the elasticity of substitution (*ESUBVA*) among the production factors. Quantifying Equation 3, the variable *afe* represents the technical change, and its values are zero. This means that it is an exogenous variable that has not been shocked in the model, except in the cases of capital and unskilled labor that were shocked by the 20% increased productivity. GTAP uses general equilibrium closure and, as a result, the direct effect of the productivity simulation is to lower the demand for capital and unskilled labor used in the Moroccan wheat sector by 20% (Table 6.6).

The value of *qva* is constant across production factors meaning that the wheat sector in Morocco would expand by 5.99% under Scenario 1 and 16.37% under Scenario 2 as a result of productivity increases. Under Scenario 3 it would shrink by 13.72% as result of full liberalization in the wheat sector. In general, under Scenarios 1 and 2 there is an overall increase in the demand for the production factors, which leads to an increase in wheat production in Morocco. Under Scenario 3 the model projected an overall reduction in the demand for production factors, which leads to a reduction in the production of wheat in Morocco.

Under Scenario 1, the demand for land, unskilled labor, and skilled labor used in the production of wheat would increase in percentages that vary from 2.91% to 4.56% (Table 6.6). Changes in demand for the natural resources used in wheat production are almost zero across all simulation scenarios. This result arises because the GTAP model considers natural resources (such as mines, aquifers, forests, and natural gas) as sluggish production factors, meaning that the amounts of natural resources are almost fixed, and, therefore, the supply

Table 6.6: Changes in demand for the factors of production and the associated changes in the production of wheat in Morocco (%)

Production factor	Scenario 1				Scenario 2 (Scenario 1 + 20%)				Scenario 3 (Scenario 2 + full tariff liberalization)			
	afe	*qva*	*ESUBVA*	*Total*	*afe*	*qva*	*ESUBVA*	*Total*	*afe*	*qva*	*ESUBVA*	*Total*
Land	0		−3.08	2.91	0		−8.41	7.96	0		0.84	−12.43
Unskilled labor	0		−1.46	4.53	−20		1.08	−2.55	−20		−0.04	−33.31
Skilled labor	0	5.99	−1.42	4.57	0	16.37	−3.98	12.39	0	−13.27	−5.3	−18.57
Capital	−20		3.66	−10.35	−20		1.06	−2.57	−20		−0.13	−33.40
Natural resources	0		−5.97	0.02	0		−16.32	0.05	0		13.65	−0.38

Source: Own elaboration based on results from GTAP Version 8.0 simulations.

curve is almost perfectly inelastic leaving very little room for mobility among sectors.

Under Scenario 2, the demand for land and skilled labor used in wheat production would vary between 7.96% and 12.39%. Demand for unskilled labor and capital would decrease by about 2.5%. This is a direct effect of the productivity simulation (that consists of increasing productivity by 20% which lowers the demand for capital and unskilled labor used in Moroccan wheat production – GTAP's general equilibrium closure). Under Scenario 3, the demand for all production factors used in wheat production would reduce by percentages ranging from 33.86% to 12.88%. These reductions are explained by the lower demand for domestically produced wheat, which is the direct effect of eliminating the wheat tariff.

In terms of commodity prices, GTAP assumes that changes in supplier prices are transmitted to consumers as a function of the production costs and are reflected in prices and taxes (Equation 5). As expected, wheat prices in all scenarios would decrease (Table 6.7). In Scenario 1 the price of domestic wheat supplies would decrease by 3.94%, while in Scenario 2 prices would fall by 10.78%. The largest wheat price reduction is projected in Scenario 3 (−15.08%), because of the elimination of the import tariff. Under Scenario 1, the price of wheat would fall because the overall wheat supply in the country (both domestic and imported) would increase as a result of greater domestic production. In Scenario 2, the domestic price of wheat would decline further because of the greater domestic wheat production. In Scenario 3 (wheat trade

Table 6.7: Changes in Moroccan domestic prices (%)

Commodity group	Scenario 1	Scenario 2 (Scenario 1 + 20%)	Scenario 3 (Scenario 2 +full tariff liberalization)
Wheat	–3.94	–10.78	–15.08
Cereal grain	0.36	1.01	–1.03
Grain crops	0.31	0.99	–1.04
Meat livestock	0.13	0.53	–1.22
Extraction	0.01	0.11	–0.03
Processed food	–0.35	–0.78	–3.02
Textiles, wearing apparel	0.06	0.27	–0.58
Light manufacturing	0.08	0.32	–0.32
Heavy manufacturing	0.04	0.26	–0.22
Utilities, construction	0.05	0.37	–0.28
Transport, communication	0.1	0.44	–0.36

Source: Own elaboration based on results from GTAP Version 8.0 simulations.

liberalization), the price of wheat decreases most (–15.08%). This is concomitant with the drop in import tariffs and technological change accompanying improvements in capital and unskilled labor productivity. As expected, the changes in the prices of other commodities were very small (most of them less than 1%). Almost no change occurs in the prices of other commodities (other than wheat) indicating that, as a result of the shocks, the model produced very small reallocations of the factor of production among the sectors, thus the production level in each one would not change significantly.

6.4.3 Changes in imports

Morocco has historically been a net importer of wheat. This situation does not change in the three scenarios simulated, meaning that Morocco would not become a net exporter of wheat. Under the first two scenarios, the first consequence emerging from an increase in Moroccan productivity of capital and unskilled labor is the reduced imports of wheat at the expense of increased domestic wheat production. The first two scenarios estimate a reduction in wheat imports of 11.39% and 31.14%, which would take place because Morocco would produce more wheat, and, therefore, can afford to reduce imports (Table 6.8). In Scenario 3, wheat imports substantially increase by 44.29%, because

Table 6.8: Changes in Moroccan imports (%)

Commodity group	Scenario 1	Scenario 2 (Scenario 1 + 20%)	Scenario 3 (Scenario 2 + full tariff liberalization)
Wheat	–11.39	–31.14	44.29
Cereal grain	0.52	1.56	0.32
Grain crops	0.85	2.63	–1.15
Meat livestock	0.59	2.25	–2.49
Extraction	–0.09	–0.09	0.84
Processed food	–0.37	–0.63	–3.91
Textiles, wearing apparel	0.07	0.18	1.02
Light manufacturing	0.11	0.87	0.04
Heavy manufacturing	0.09	0.87	0.11
Utilities, construction	0.24	1.17	0.22
Transport, communication	0.34	1.32	0.27

Source: Own elaboration based on results from GTAP Version 8.0 simulations.

eliminating the wheat import tariffs makes it more attractive to import wheat rather than produce it domestically. In this scenario imported wheat displaces domestically produced wheat.

According to the model, the effect of tariff elimination overcomes improvements in productivity, suggesting that to maintain domestic wheat production in Morocco protection measures are needed. In the first two scenarios, Moroccan importers (firms, households, and government) would find a greater supply of domestic wheat sold at relatively cheaper prices than imported wheat, which would lead to a reduction in Moroccan imports of wheat. In the third scenario, Moroccan dealers find imported wheat cheaper (because of tariff elimination), this displaces domestic production, provoking an increase in wheat imports.

6.5 Discussion

How feasible are these results? Or put another way, how feasible is it that wheat production in Morocco would increase under the technological change scenarios and decrease under a trade liberalization scenario? How feasible is it that imports of wheat would decrease in Morocco under the two first

scenarios and would increase under the third one? It is not straightforward to discuss the credibility of CGE projections, given the difficulty in appraising predictions. When changes in production are forecasted, it could be argued that many variables must be considered, such as production costs, commodity demand, import tariffs, labor market conditions, and others. Additionally, it could be argued that the results also depend on the type of economic model being used (e.g. partial or general equilibrium), the level of the national currency (appreciation, stability, or devaluation), the economic situation (recession/expansion and economic cycles), and environmental and physical variables, among others.

In this study, the GTAP model has been chosen to analyze the Moroccan wheat sector under three specific scenarios. The GTAP model has many components, where the most important ones are the assumptions, the inputs parameter values, and the output values. Analyzing the feasibility of prediction can target any of these components and, as a result, the analysis may focus on different parts of the model. In practice, it becomes difficult to achieve a full assessment of the model, especially if the system being modelled includes informal sectors, as is the case for the Moroccan wheat sector. In such sectors the transactions being made are neither taxed nor monitored by the government. Thus they are unlikely to be included in national accounts, such as GDP. The feasibility of the results was analyzed focusing on the outputs of the model. Broadly speaking, this analysis is a combination of expert consultation and analysis of secondary data. The discussion elements have focused on an analysis of the historical production value data of wheat and other commodities, the domestic and imported supplies of wheat, water productivity in Morocco, and the expansion of the Moroccan export sector relative to the world market.

A key finding of this study in relation to the first two scenarios is that as a response to technological change, assuming no change in the other variables, the production of wheat in Morocco would increase by 5.99% under Scenario 1 and by 16.37% under Scenario 2. These results are feasible considering several measures the government has been taking in recent years. Since the launch of the Green Morocco Plan (GMP 2014), Morocco has increased its investments in labor training and physical capital accumulation, reaching figures between 5.4% and 6% of GDP (World Bank 2010; UNESCO 2014). This is almost twice the average for Middle East and North African countries (3.8%), (AMCML 2014). These investments have been mainly given in the form of subsidies to the wheat sector. For example, in 2016 the government set seed subsidies for

durum wheat, common wheat, and barley, which covered from 40% to 60% of the seed costs (USDA 2017). In calendar year 2017 the volume of subsidized common wheat flour, known as "National Flour", was 650,000 tonnes (USDA 2017). This was given by the government to support low-income consumers. The Moroccan government in 2012 allocated about USD 28 million to lower the price of certified wheat seeds (USDA 2013). This subsidy targeted about 70% common or bread wheat, 29% durum wheat, and 1% barley (USDA 2013). Subsidies for seeds are not the only instruments the government has been using to foster wheat production and productivity. Other subsidies include a 30% to 70% subsidy for the purchase of modern machinery and irrigation facilities.

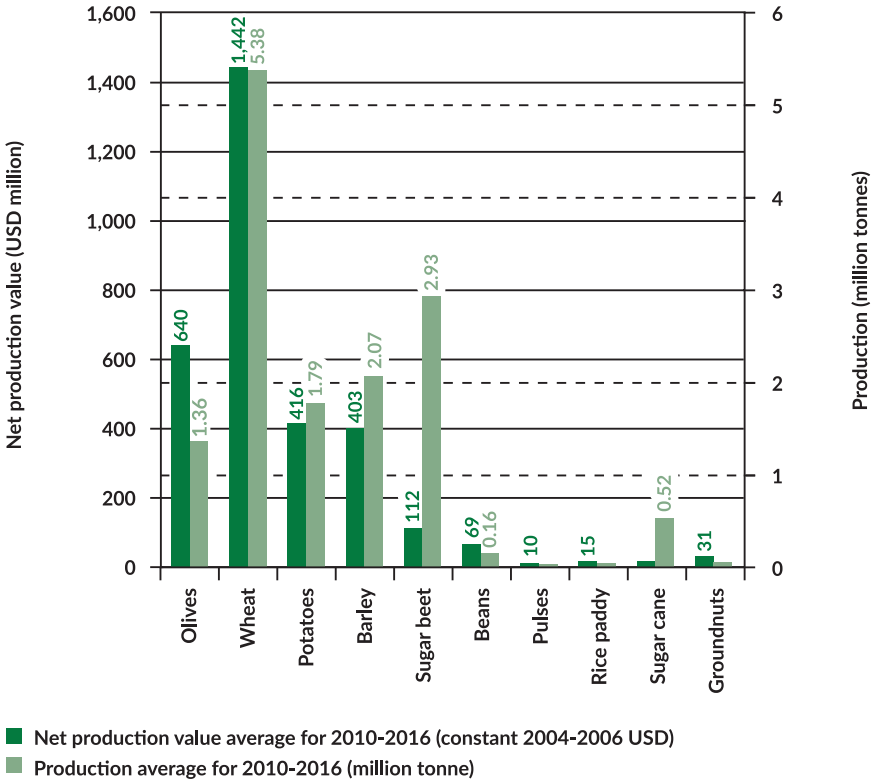

Figure 6.2: Top 10 commodities in Moroccan agriculture, in production and value, average for 2010–2016

Source: Own elaboration based on production and value data extracted from FAOSTAT online database (2018).

In 2011, the Moroccan government implemented a crop insurance program to reduce the biotic (such as insects and pests) and abiotic (such as droughts, floods, and storms) risks associated with the production of cereals. This insurance program targeted 500,000 ha representing about 10% of the Moroccan area planted to cereal (USDA 2013). The purpose of the program was to absorb between 50% and 90% of the financial losses if farmers experienced unfavorable conditions. Thus, wheat in Morocco has become by far the main crop in terms of quantities produced (5.4 million tonnes produced, on average, in the period 2010–2016). It is also most important in terms of production value (USD 1,142 million, on average, for the same period) (Figure 6.2).

Despite years of support, the country has been unable to be self-sufficient in wheat production. In fact, Morocco has, over time, become more and more dependent on wheat imports. In the 1960s, Morocco had an average population of 13 million inhabitants and was largely self-sufficient, producing 81% of total wheat supply (Figure 6.3). By the 1970s domestic wheat production dropped to 62% of total supply, while imports increased from 19% in 1960s to 38% in the 1970s. This trend continued over the 1980s and 1990s. By 2000–2016

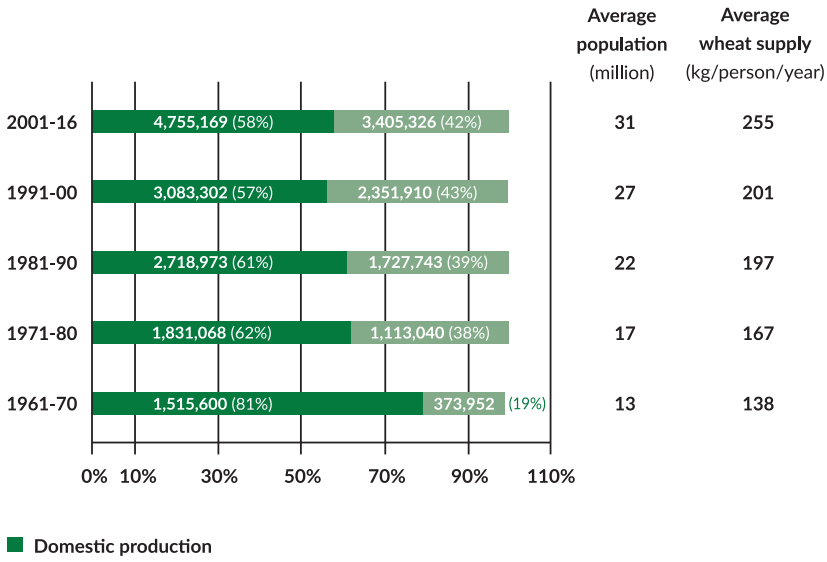

Figure 6.3: Moroccan total domestic wheat supply (000 tonnes)

Source: Own elaboration based on production, population, wheat supply, and agricultural population data extracted from FAOSTAT online database (2018).

Morocco produced 58% of domestic supply, while 42% was imported, mainly from France, Canada, Ukraine, and United States. Morocco's population more than doubled after the 1960s, reaching more than 35 million by 2016. Along with that population growth the per capita wheat supply increased from 138 kg/person in the 1960s to 255 kg/person, on average, for the period 2001–2016.

This historical trend shows that as a population increases domestic wheat demand also increases. Morocco depends on imports to satisfy this domestic demand. The projections of the GTAP model seem to be acceptable under the first two scenarios. That is, production would increase because of technological changes, but those increases would be small, and hence significant wheat imports will still be needed. Even if imports are somehow reduced, technological changes that increase productivity will not be enough to replace the wheat imports. Morocco has been and, according to its historical trend and our projections, will continue to be a net wheat-importing country.

The third scenario, eliminating wheat import tariffs, forecasts an increase in imports of wheat and a reduction in domestic wheat production. These results arise from the lowered imported wheat prices which will displace some of the domestic wheat production. The tariff protection that Morocco currently applies to imported wheat is complex and varies according to the source (Table 6.9). In 2015, durum wheat imports were subject to a 75% ad valorem tariff when imported from the United States, and 170% when coming from the European Union. In 2017 a tariff of 70% was applied to bread wheat imports from the United States and one of 30% was applied on imports from the European Union (WTO 2017; USDA 2017). In 2015, the Moroccan import tariff for cereal products ranged from 59.4% to 195% (WTO et al. 2016). Such tariffs suggest high protection for the Moroccan wheat sector. Our simulations suggested that removing them could significantly lower imported wheat prices, which in turn would increase wheat imports and displace some domestic production. Tariffs applied to other countries that Morocco has trade agreements with, such as the United Arab Emirates, Mauritania, Algeria, Iraq, and Libya, are all zero (Table 6.9). However, these countries (like Morocco) are net wheat importers and, therefore, no wheat trade takes place between them.

The Government of Morocco is aware of the importance of tariffs in protecting the domestic production of wheat. In turn, this production creates agricultural and agro-industrial employment and provides livelihoods for thousands of families in the country. Yet, despite the high wheat tariffs, which

Table 6.9: Tariff structure applied to wheat by region

Tariff Regimes Granted by Reporter (Excluding MFN)	Original Nomenclature		Duty Free TL (%)	Maximum duty (%)	HS subheading 6-digit description
	HS version	HS subhdg			
FTA-DR for United Arab Emirates	HS02	100110	100	0.0	Durum wheat
FTA-DR for the Arab League Member Countries	HS02	100110	100	0.0	Durum wheat
FTA-DR for Mauritania	HS02	100110	100	0.0	Durum wheat
FTA-DR for United States of America	HS02	100110	0	75.0	Durum wheat
FTA-DR for Arab Mediterranean Countries (Agadir)	HS02	100110	100	0.0	Durum wheat
FTA-DR for the European Communities	HS02	100110	0	170.0	Durum wheat
FTA-DR for Algeria	HS02	100110	100	0.0	Durum wheat
FTA-DR for Iraq	HS02	100110	100	0.0	Durum wheat
FTA-DR for Libya	HS02	100110	100	0.0	Durum wheat
FTA-DR for United Arab Emirates	HS02	100190	100	0.0	Bread wheat
FTA-DR for the Arab League Member Countries	HS02	100190	100	0.0	Bread wheat
FTA-DR for Mauritania	HS02	100190	100	0.0	Bread wheat
FTA-DR for United States of America	HS02	100190	0	30-70	Bread wheat
FTA-DR for Arab Mediterranean Countries (Agadir)	HS02	100190	100	0.0	Bread wheat
FTA-DR for the European Communities	HS02	100190	0	30.0	Bread wheat
FTA-DR for Algeria	HS02	100190	100	0.0	Bread wheat
FTA-DR for Iraq	HS02	100190	100	0.0	Bread wheat
FTA-DR for Libya	HS02	100190	100	0.0	Bread wheat

MFN – Most Favored Nation
HS – Harmonized System
TL – Tariff Line
FTA-DR – Free-Trade Agreement Duty Rate
Source: Own elaboration based on WTO online database 2017, Tariff Download Facility
USDA 2017. Global Agricultural Information Network. Report: MO1703.

increase imported wheat prices, wheat imports into Morocco are still the most important (in both quantitative and value terms) of all agricultural imports (Figure 6.4).

In 2016, Morocco imported almost 6.3 million tonnes of wheat, valued at USD 1.3 billion (at an average cost of USD 207/tonne). Wheat is one of the

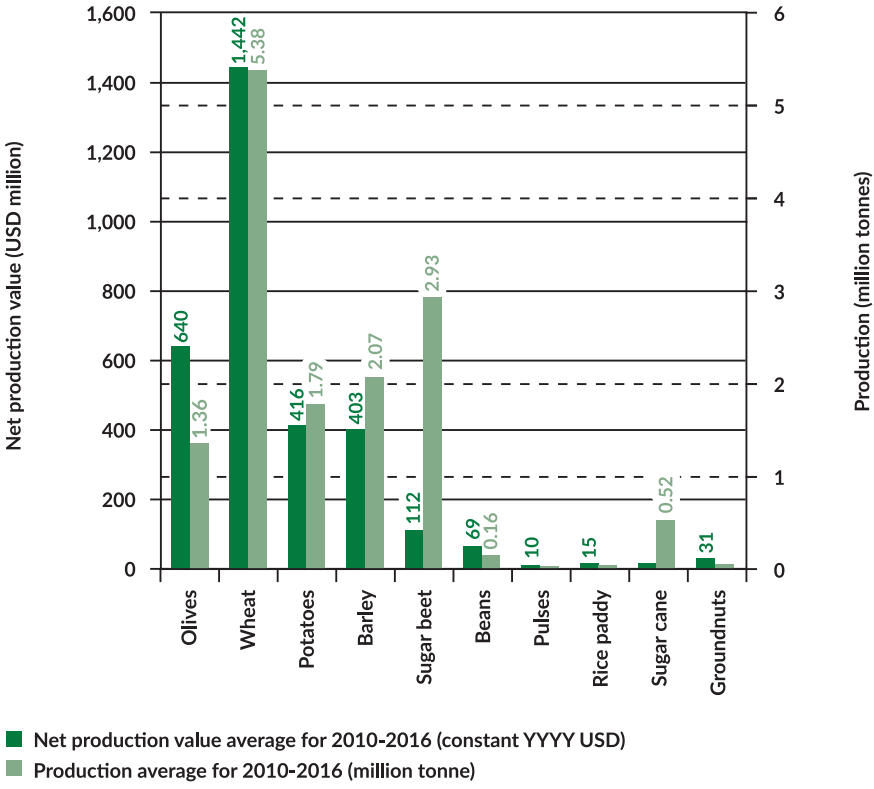

Figure 6.4: Top 10 imported commodities in Morocco, 2013

Source: Own elaboration based on import data extracted from FAOSTAT online database (2018).

most important foodstuffs in the Moroccan diet. The USDA estimated that per capita consumption of wheat in 2013 was 258 kg/year, while our estimate is 255 kg/year. Either case would place Morocco among the highest per capita wheat-consuming countries in the world. High consumption of cereals is explained by the government policy to keep bread prices at affordable levels for all segments of the population.

Keeping bread prices low has political and social benefits and has been a popular policy not only in Morocco, but also in many other Arab countries. Rapid population growth in most Arab countries has prompted governments

to make sure that a basic foodstuff will be available to every household in the country. Even in countries like Jordan, which only produces about 3% of the total wheat consumed domestically, the price of bread can be as low as USD 0.2/kg. Similarly, in Egypt or Syria (before the conflict), the price of bread products responded to government policies that kept them to less than USD 0.25/kg. The Moroccan government has only subsidized imports of bread wheat suitable for bread production and has managed to keep domestic bread prices at about USD 0.5 per loaf (Morocco has not been subsidizing imports of durum wheat). Low prices of bread in countries that are net importers of wheat contrast with the high prices in countries that are net exporters of wheat, such as Argentina, where bread products can cost as much as USD 2/kg.

Relatively less production of domestic cereals is not necessarily harmful to the Moroccan society or economy. As previously shown in Figure 6.3, wheat supply per capita has shown a significant increase since the 1960s onwards. While the average wheat supply/person/year was 138 kg in the 1960s, it increased to 167 kg/person/year in the 1970s and rose as high as 255 kg/person/year, on average, in the period 2001–2016. This suggests that a country does not need to be self-sufficient to increase the wheat supply per person, even in the face of rapid population growth. The international market has large cereal producers, such as Argentina, the United States, Canada, Ukraine, Australia, the European Union, and Russia. These countries can supply large volumes of wheat at cheaper prices than it would be possible to produce it domestically.

The fact that Morocco is a net cereal-importing country could be interpreted as efficient and rational in terms of water productivity and virtual water use. Wheat consumes more water per kg of output produced than many other cultivars. Data for Morocco (Figure 6.5) show that cereals in general (barley, maize, and durum and bread wheat) use between 2,400 and 3,600 m^3/tonne, which is substantially more water than required for vegetables or fruits. These consume between 40 and 500 m^3/tonnes. Pulses (lentils, chickpeas, and soya beans), olives, and dates consume higher quantities of water (more than 1,700 m^3/tonne) when compared with vegetables (garlic, potatoes, onions, carrots, lettuce, tomatoes, and cucumbers) and most fruits (apples, lemons, oranges, mandarins, and bananas) that use less than 500 m^3/tonne.

From a water productivity perspective, it seems that importing cereals from countries well-endowed with water, such as France, Ukraine, US, Russia, and Canada would bring savings in water that can be used for other cultivars that are

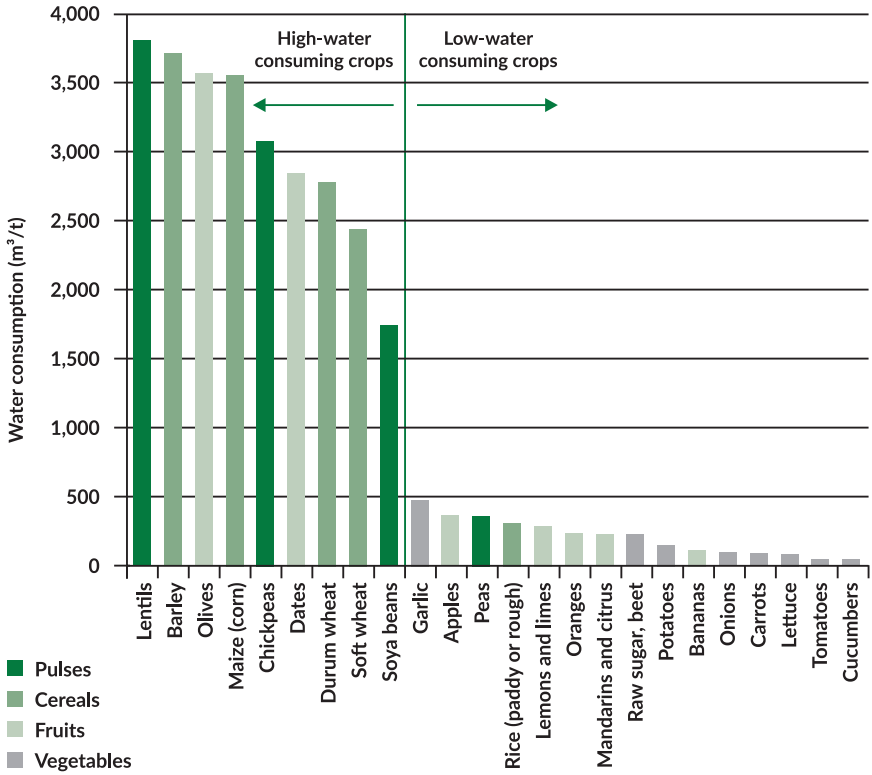

Figure 6.5: Water productivity in Morocco, 2010

Source: Own elaboration based on data from Mekonnen and Hoekstra 2010. The green, blue, and grey water footprints of crops and derived crop products. Value of Water Research Report Series No. 47. UNESCO-IHE, Delft, Netherlands. http://www.waterfootprint.org/Reports/Report47-WaterFootprintCrops-Vol1.pdf.

Note: Data in this figure corresponds to national Moroccan averages, where the "green water footprint" indicator has been used to estimate water productivity. Green water footprint is the volume of rainwater consumed during the production process. This is particularly relevant for agricultural and forestry products (products based on crops or wood), where it refers to the total rainwater evapotranspiration (from fields and plantations) plus the water incorporated into the harvested crop or wood.

less water intensive, while still having high international and domestic demand. In this context, it seems rational that since the 1960s Moroccan farmers have been reducing wheat cultivars and, instead, intensifying their farming systems with fruit and vegetable production that uses relatively less water. In fact, Morocco since the 1960s has become self-sufficient in fruit and vegetable production (Figure 6.6). It has even become a net exporter, although the share of exports in relation to total domestic production has reduced over time.

In the 1960s, Morocco used to export more than 0.5 million tonnes of fruits, which slightly increased to almost 0.57 million tonnes in 2000–07. The increase in fruit exports has not been substantial as most of the domestic production goes to satisfy the growing domestic demand, which has more than doubled from the 1960s to the period 2000–07 (1.2 million tonnes in the 1960s to 2.6 million tonnes in 2000–07). The increase in vegetable exports has almost doubled from 0.2 million tonnes in the 1960s to 0.39 million tonnes in 2000–07, and the country is completely self-sufficient in vegetables (remarkably, the supply grew from 0.8 million tonnes in the 1960s to 4.5 million tonnes in 2000–07).

Morocco's agriculture has recently consolidated the trend towards exporting vegetables and fruits. In Figure 6.7 the vertical axis measures the average growth in Moroccan exports (2008–11), while the horizontal axis measures the average annual growth of world exports (also 2008–11). This latter can be understood as the rate of world market expansion. In this figure, Morocco has gained market share in chilies and peppers, strawberries, vegetable oils, animal and vegetable oils, tangerines, tomatoes, and raw materials. All of these have increased at more than 10% per year between 2008 and 2011. The most important crop for Morocco, in terms of exports, has been olive oil, which has increased 243% per year between 2008 and 2011 (not shown in Figure 6.7 because of scale issue).

Other agricultural commodities, such as dairy products, cheese, milk, oranges, olives, coffee, tea, and prepared fruits have lost export share at a rate of between 1% and 20% per year between 2008 and 2011. As expected, wheat is not included in this figure as Morocco does not export any wheat.

6.6 Conclusion

In view of international trade agreements already signed by Morocco, permanent trade liberalization on wheat is a reform that the Government of Morocco will have to consider undertaking. Therefore, shedding light on these issues provides policy makers with key information with which to analyze the

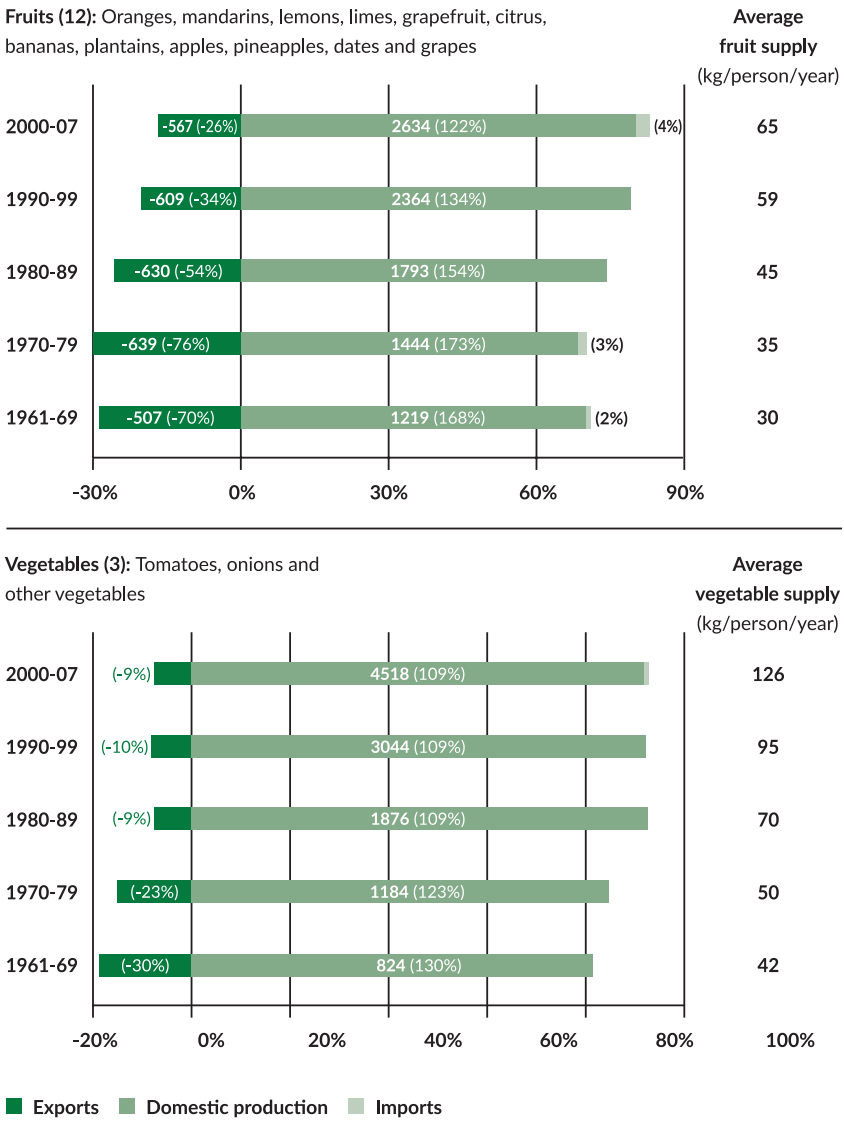

Figure 6.6: Morocco: Total domestic food supply (000 tonnes)

Source: Own elaboration based on data from the World Development Indicators (2017) online database for Prevalence of undernourished; Prevalence of underweight in children; and Poverty headcount. All other variables (production, population, cereal supply, and agricultural population) were extracted from FAOSTAT online database (2018).

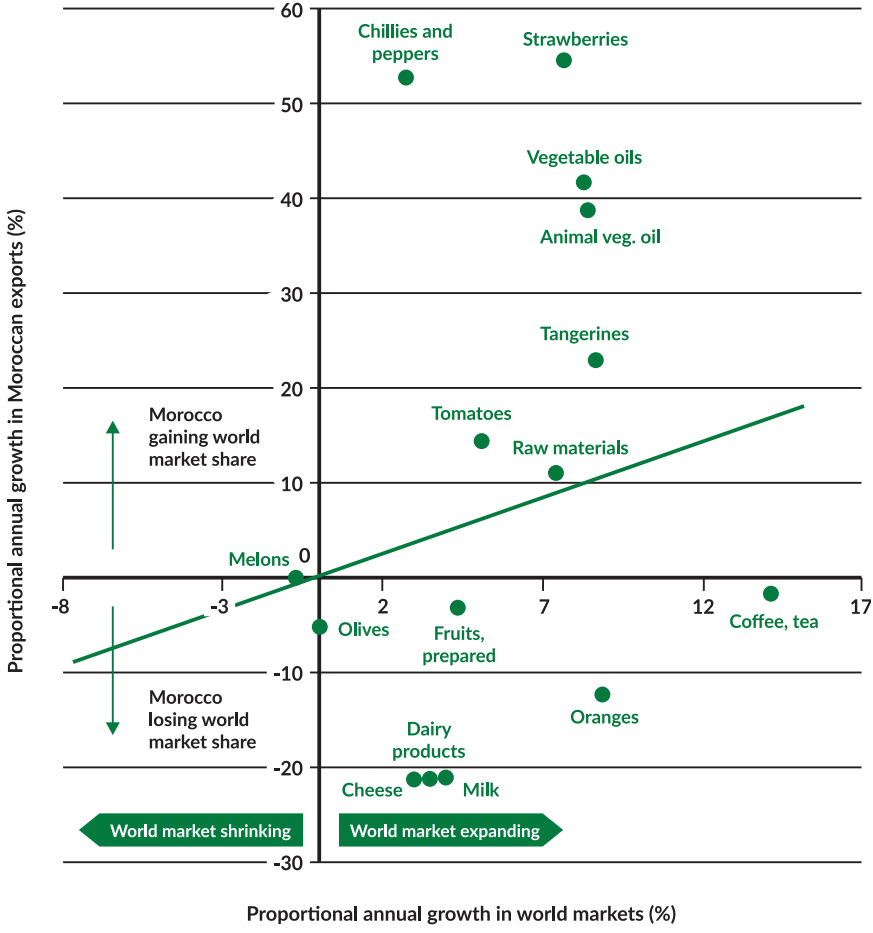

Figure 6.7: Proportional changes in export growth of the main Moroccan product lines relative to proportional changes in world market growth (average for 2008–11) (%)

Note: The percentages are averages for the period 2008–11. Data reported correspond to the most important product categories in Morocco.

Source: Own elaboration based on data extracted from FAOSTAT online database (2018); Trade, Crops and Livestock products data.

trade-offs emerging from maintaining protection of the wheat sector or liberalizing it given trade agreements and current trends.

Overall, the GTAP results show that productivity improvements in the factors of production could increase production levels in Morocco. Yet, historical data shows that such increases will not be enough to reduce wheat imports. Morocco has been and will continue to be a net wheat-importing country. Wheat production would increase because of technological changes, but those increases would be small and, hence, significant wheat imports will still be needed as projected under the first two scenarios.

Results suggest that import tariffs are important in keeping a share of domestic wheat production. That is, import tariffs provide protection to domestic wheat producers and without these tariffs national wheat production would drop drastically. In fact, both import tariffs and domestic subsidies provide a framework for the production of domestic wheat in a way that competes with cheaper wheat imports from foreign counties (mainly France, Ukraine, Canada, and the United States), which are produced using high-yielding technologies, frequently subsidized, and under rainfed conditions.

Being a net wheat-importing country is not necessarily negative. From a water use perspective, wheat consumes more water/kg of output produced than vegetables and fruits and, therefore, importing wheat from countries well-endowed with water would bring water savings. These could then be used for other cultivars that demand less water, but still have high international and domestic value.

However, our analysis also shows that without tariffs local wheat production would drop drastically. Tariffs contribute by keeping a relatively large wheat sector generating significant agricultural value added and, more importantly, to maintaining thousands of jobs in the wheat chain sector. Removing them would be a challenging trade policy as thousands of families that directly depend on wheat for their livelihoods can be affected in the short and medium terms. The Moroccan government has a difficult duty ahead. It consists of maintaining wheat-associated agricultural employment given the shrinking water resources for agriculture, while dealing with international pressures that are asking for liberalization of the wheat sector. The future of wheat production in the country will depend, therefore, on the trade-offs between the potential cost savings from the substitution of domestically produced wheat with imports, on the one hand, and the contribution of wheat to GDP and employment opportunities with their social and political benefits, on the other.

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Chapter 7: The wheat sector in Morocco: seed systems, varietal adoption, and impacts – a synthesis

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7 The wheat sector in Morocco: seed systems, varietal adoption, and impacts – a synthesis

7.1 Introduction

Agriculture in general and wheat production in particular play an important role in the Moroccan economy. With a total harvested area of 3 million ha and production of 5.4 million tonnes in the period 2010–2016, wheat is the dominant crop in the country (GMP 2014). In 2013, total cereal production[1] accounted for 47% of the agricultural value added. Wheat production alone was worth about USD 850 million, making it the second most important crop after olives (FAOSTAT 2018; GMP 2014). In the 1960s, Morocco was largely self-sufficient, producing more than 80% of domestic wheat consumption. After a decade, the share of domestic wheat production dropped sharply to 62% while imports increased from 20% to 38%. The situation remained the same until the end of the 1990s with some exceptions. In the first decade of the new millennium, domestic wheat production met, on average, only 60% of the total domestic demand (FAOSTAT 2018). The Moroccan population has more than doubled since the 1960s, reaching about 36 million in 2018. The per capita supply of wheat increased impressively from 138 kg/person in the 1960s to an average of 255 kg/person for the period 2001–2016 (FAOSTAT 2018). Considering the population increase and shifts in consumption habits, wheat and particularly bread consumption became an even bigger component of food security.

Wheat yields in Morocco remained low at about 0.9 t/ha until the 1970s. With the introduction of improved wheat varieties in the 1980s, significant increases in yields were observed. After the new millennium these reached a 10-year average of about 1.5 t/ha for durum wheat and 1.6 t/ha for bread wheat (ICARDA 2014). However, these yield levels are far below both the global average of over 3 t/ha and the African average of 2.3 t/ha (FAOSTAT 2018).

[1] No estimation for wheat only was found.

Consequently, Morocco has not exported any wheat in the last half century. Rather, it has imported large volumes, making wheat the most important (in both volume and value terms) of all agricultural imports.

In 2016, Morocco imported almost 6.3 million tonnes of wheat (FAOSTAT 2018), at a cost of over USD 1.3 billion. Despite the high dependency on imports, wheat remains one of the most important food staples in the Moroccan diet (CIHEAM 2006). Traditionally, keeping prices low for bread and other wheat-based food items has been a socially and politically popular policy not only in Morocco, but also in other Arab countries (Mahfouz et al. 2014), including Egypt, Jordan, and Lebanon. To contribute to household food security, the Moroccan government has made bread available to everyone at the subsidized prices of USD 0.25/kg. Because of this policy, import subsidies are provided only for bread wheat for bread making while durum wheat imports are not eligible.

Wheat production contributes to the creation of agricultural and agro-industrial employment for men and women and provides livelihoods for many families along the wheat commodity chain (i.e. agricultural research, seed production and use, grain production, value addition, and marketing). GMP (2014) estimated that 75% of rural employment is generated by the cereal sector. Although outdated, the latest agricultural census in Morocco, conducted in 1996, estimated that 1.45 million Moroccan farmers were engaged in cereal production (MADR 1996). Figures on population growth and wheat production show that Morocco has, over time, become dependent on wheat imports – a situation which is not expected to change soon. As a result, one can argue that Morocco does not need to be self-sufficient to increase the per capita supply of wheat. Large cereal producers, such as the United States, Russia, France, and Canada, can supply the desired amount of wheat at a cheaper price relative to the cost of domestic production. However, wheat production in Morocco not only contributes substantially to gross domestic product (GDP), but also creates massive employment opportunities in the country, especially in the rural areas. The future of wheat production in the country will, therefore, depend on the trade-offs between the potential cost savings from the substitution of domestic production of wheat with imports, on the one hand, and the contribution of wheat to GDP and employment opportunities with its social and political benefits, on the other.

One of the most important results from public investment in agricultural research is the development of new crop varieties and the associated

technologies. The Government of Morocco and its international research and development partners have made substantial investments in agricultural innovation. However, developing new crop varieties is not enough. To have a real impact crop development should be coupled with an efficient and effective seed-delivery system that will push technologies out to farmers' fields. Within this context, there are several actors in the Moroccan seed sector. These include the National Agricultural Research System, public and private seed companies with networks of seed dealers, associations of seed growers and seed traders, and regulatory agencies. Their individual or collective strengths and weaknesses influence and affect the performance of the national seed sector in Morocco.

7.2 Objectives

Under the Green Morocco Plan (GMP), improving the performance of the seed sector is one of the priorities in the agricultural transformation agenda of the country. Given this priority and the long history of national and international agricultural research, this study was undertaken for an in-depth review and analysis of the functioning of the wheat seed sector with the following main objectives:

- Understanding the performance of the wheat seed sector in Morocco to draw important lessons for adaptation in other countries
- Identifying opportunities for the Moroccan seed sector to overcome systemic bottlenecks (if any) that are detrimental to ensuring food security and improving the livelihoods of men and women farmers.

7.3 Methods

To analyze the supply and demand sides of the Moroccan wheat seed sector we used a variety of methods for data collection and analysis. For a supply side analysis of both the wheat seed and grain sectors, secondary data was collected from national and international sources, including government reports, scientific reports from universities, unpublished documents, official national laws and regulations, and wheat policy documents from the Government of Morocco. We also solicited expert opinion through a series of meetings with the staff of several Moroccan institutions that are important players in the wheat sector. These institutions included the Ministère de l'Agriculture et de la Pêche Maritime (MAPM), the Institut National de la Recherche Agronomique

(INRA), the Société Nationale de Commercialisation des Semences (SONACOS), the Office National de Sécurité Sanitaire des Produits Alimentaires (ONSSA), the Association Marocaine des Multiplicateurs de Semences (AMMS), the Association Marocaine des Semences et Plants (AMSP), and the Confédération Marocaine de l'Agriculture et de Développement Rural (COMADER). All the information collected was carefully studied and analyzed to develop a good understanding of the wheat sector, in general, and the wheat seed system, in particular. Special in-depth attention was given to the regulatory framework on varieties and seeds where institutional arrangements and technical requirements were investigated. The achievements and challenges for variety release, protection and licensing, seed production and commercialization, and seed quality assurance and certification were also investigated.

For seed demand, adoption, and impact analysis, we surveyed the top 21 wheat producing provinces in Morocco, which contribute 78% of the total national wheat production using 73% of the total wheat area in the country. During the inception workshop for this study, a panel of experts from Morocco, including breeders and extension personnel, estimated the national adoption level of improved wheat varieties to be 53%. Then, power analysis was used to determine the minimum sample size that ensures 95% confidence and 3% precision levels for capturing improved wheat variety adoption levels of up to 53%. Accordingly, we determined that the minimum sample size required was 1,061 households. To account for possible absences or the reluctance of farmers to participate in the survey, the sample was increased by 15%. Thus the final sample size was set at 1,230 households. A stratified sampling approach was used to draw the 1,230 households from 292 villages, situated in 56 districts that were randomly drawn from the 21 provinces. This survey identified the roles of men and women in wheat production, as well as their decision-making roles in varietal adoption. The survey was conducted between November 2012 and March 2013.

For analysis, descriptive statistics were used to summarize the survey data, including a seed use estimation. The Heckman selection model (Heckman 1979) was used for determining the factors affecting the decision and intensity of adoption. The propensity score matching method (Rosenbaum and Rubin 1983; Heckman et al. 1998) and the endogenous switching regression method (Maddala and Nelson 1975) were used to provide estimates of the impacts on livelihoods of the adoption of improved wheat varieties. The empirical data for gender analysis was collected through a survey of 400 agricultural laborers (200

women and 200 men) in Saïs province, Morocco in December 2014. The analysis in this study was based on three case studies carried out in 2014 and 2015 that involved sex-disaggregated key informant interviews with community leaders, wheat farmer innovators, and gender-segregated focus group discussions with poor and middle-class farmers. We used maximum variation sampling to select participants (elite, middle class, and poor class) for the case studies (Patton 2002). The multiple methods used in this research allowed for a cross-checking of the information needed in qualitative research (Bernard 2006).

The initial findings of the study were validated during a five-day ICARDA-INRA-SONACOS-ONSSA wheat sector experts consultation meeting in Dubai, 6–10 April 2014. Discussion elements focused on analysis of the main actors, policy and regulatory frameworks, institutional arrangements, technical procedures, and the status of the wheat seed sectors as well as the historical perspective in the production and value of domestic and imported wheat in Morocco. Details of all the data, information, policies, regulations, institutional settings, and procedures, and data analysis conducted under the title "Analysis of the Moroccan Wheat Sector" are documented in six separate reports (Najjar et al. 2015; Yigezu et al. 2015; Sabik et al. 2014; Tahiri et al. 2014a; Tahiri et al. 2014b; Telleria 2014). The comprehensive study adopted a holistic approach covering the whole spectrum of wheat-grain and wheat-seed policies – variety development, evaluation and release; seed production and commercialization; seed quality control and certification; varietal adoption and the results; seed demand and supply analysis; and gender equity in wheat production. This chapter provides a synthesis of the facts and findings of the above studies, paying special attention to synergies, complementarities, and ways forward.

7.4 Wheat sector policies and regulations

In the early 1970s, the Government of Morocco set up several public institutions that currently are the main actors in the seed sector. The government also established a regulatory framework for the seed sector with laws, regulations, and strategies to provide an enabling environment for both state and private seed companies to achieve high quality seed production. Currently the GMP provides the operational framework for all actors in the seed sector. The GMP is the official strategy of the Government of Morocco to meet the challenges of food security, competitiveness, and sustainable management of natural resources.

The GMP is built on two pillars:

- Accelerating the development of modern and competitive agriculture, through the realization of high added-value agro-food production
- Supporting aggregation of smallholder agriculture for promoting and enhancing productivity and sustainability at the farm level.

Issues such as climate change, employment, gender, institutions, and markets apply to both pillars. The wheat seed sector is key within both pillars not only because it provides high quality seeds to achieve high productivity, but also because it makes specific segments of the wheat sector (i.e. research, production, certification, and marketing) more dynamic. The seed policy within the GMP is not restricted to wheat, but also intends to improve seed systems across all agricultural (other cereal and legume) and horticultural (vegetable and fruit) crops.

Historically the Agricultural Development Fund (FDA), operational since 1986, has been the key instrument in implementing government policy in the agricultural sector. Implementation of policies was carried out through investments, targeted subsidies, technical assistance granted to activities that permitted better exploitation of agricultural potential, and leverage of funding. In the GMP, agricultural subsidies have been granted according to pre-established investment contracts agreed between farmers' organizations and government agencies (regional or national). Contracts are collective rather than individual, showing a clear intention of the government to promote farmer aggregation in the form of cooperatives or farmers' associations. The FDA subsidizes land improvement, irrigation facilities, farm equipment, certified seed and planting materials, export promotions, genetic improvement, agro-processing units, and farmer aggregation.

7.4.1 The seed sector

Morocco has introduced laws that provide a legal framework for the seed sector in line with international norms and standards for seed certification established by the Organisation for Economic Co-operation and Development (OECD) and the European Union. It introduced plant variety protection based on the International Convention on the Protection of New Varieties (UPOV) and adapted the rules, procedures, and methods for seed testing developed by the International Seed Testing Association (ISTA). The key legislative frameworks include:

- The Seed Law (Dahir) No. 1-69-169 of 25 July 1969, amended and supplemented by Dahir No. 1-76-472 of 19 September 1977, which regulates the production and marketing of seeds and planting materials. A set of regulations was introduced for the implementation of this law, including:
    - Requirements to register crop varieties in the official variety catalogue
    - Technical regulations (15 in all) defining the production, control, packaging, and certification of seeds and planting materials produced locally or imported
    - Requirements for granting licenses to companies for the marketing of seeds and planting materials
    - Regulations to grant licenses to import and market seeds and planting materials.
- Law 9-94 on Plant Variety Protection is an intellectual property statute that gives plant breeders legal rights over plant varieties they have developed. The implementation of this law is based on two regulations
    - The first provides legal instruments that allow Moroccan breeders to protect their property rights related to variety development
    - The second enables foreign breeders to introduce new technologies in Morocco that allow local farmers to benefit from new crop varieties developed abroad but adapted to local climatic conditions.

Since the launch of the GMP in 2009, the government has been supporting domestic wheat seed production through several policy measures. In 2012, the Moroccan government allocated about USD 28 million to lower the price of certified wheat seeds (USDA 2013). This subsidy targeted about 70% of bread wheats and 29% of durum wheats (USDA 2013). Subsidies for seeds have not been the only instrument the government has been using to foster wheat production and productivity. Other subsidies included 30% to 70% subsidies for the purchase of capital (modern machinery and irrigation facilities) and the training of farmers. The Moroccan government also implemented a crop insurance program in 2011 to reduce the risks associated with the production of cereals, such as an outbreak of disease, an infestation of insects, droughts, floods, and storms. This insurance program targeted 500,000 ha representing about 10% of the total area under cereals (USDA 2013). The purpose of

the program was to absorb 50% to 90% of the financial losses if farmers experienced unfavorable conditions.

The Moroccan government provides direct price subsidies to farmers. In 2014, the average subsidy was MAD 170/quintal (USD 20/quintal) for bread wheat and MAD 180/quintal (USD 21.2/quintal) for durum wheat[2]. For example, a typical subsidy structure for bread wheat included a base price/quintal of MAD 325 (USD 38.2) and a subsidy/quintal of MAD 170 (35%), leading to a seed price/quintal of MAD 495 (USD 58.2). The production cost for rainfed bread wheat has been estimated at MAD 4,000/ha (USD 470/ha) and MAD 6,000/ha (USD 706/ha) for irrigated production. Thus, the subsidy represents 4–6% of the total production cost. This subsidy has directly contributed to increasing the use of certified cereal seeds among farmers. This has almost doubled from 68,000 tonnes before 2008 to 128,000 tonnes in 2013, an increase of almost 88% in just five years. The certified seed use rate for bread wheat has increased from 18% before 2009 to almost 35% in 2013. The Government of Morocco provides a yearly subsidy of about 120,000 tonnes of certified seed ready for marketing and about 22,000 tonnes of carry-over seed stock from all seed companies.

For the protection of domestic wheat seed producers, Morocco applies differentiated import tariffs on wheat seed and on wheat grain. Pre-basic (G3) and basic (G4) seeds have always been tariff-free. By exempting seed imports from tariffs, the government has been encouraging the import of source seeds of foreign varieties that can in turn be used to achieve higher yields in wheat production. The government has also been providing subsidies/quintal of MAD 500 (USD 59) for imported pre-basic cereal seed and MAD 400 (USD 47) for imported basic cereal seed. The subsidy considers the cost of seed production abroad. The government has encouraged foreign private seed companies to establish partnerships with Moroccan counterparts (including producers) through special concessions. These concessions comprise providing government land to foreign seed companies on the condition of partnering with local entrepreneurs (so far, 11 partnerships have been established). Liberalizing the cereal seed sector and introducing import subsidies has increased varietal diversification, which is exhibited by an ever-increasing presence of foreign improved varieties in the Moroccan Catalogue. Currently, more than 90% of

[2] One quintal (q) = 100 kg.
The exchange rate in 2014 was: 1USD = 8.5 MAD.

all the varieties listed in the catalogue are imported through seed companies. These benefit equally from the domestic plant protection laws.

7.4.2 The grain sector

In contrast to wheat seed, wheat grain is subject to a complex tariff structure that protects domestic production from imports. In 2015, durum wheat imports were subject to a 75% ad valorem tariff when imported from the United States and a 170% tariff when coming from the European Union. Likewise, in 2017 tariffs of 70% and 30% were applied when bread wheat was imported from the United States and European Union respectively (WTO 2017; USDA 2017). Such tariff levels suggest high protection for the Moroccan wheat-grain sector. Morocco's trade agreements with Algeria, Iraq, Libya, Mauritania, and the United Arab Emirates grant duty-free import to these partner countries. However, these countries are net wheat importers themselves and hence no trade in wheat takes place with them. No records of wheat re-exports have been found for Morocco.

Import tariffs protect Moroccan farmers from cheaper wheat imported from abroad. The average cost of wheat production in Morocco is estimated at USD 580/tonne (Bentaleb 2012), which is much higher than the wheat production costs in France (USD 267/tonne), Germany (USD 245/tonne), the United States (USD 238/tonne), and Argentina (USD 334/tonne) (Saubanov et al. 2014) – the major wheat suppliers to Morocco. These estimates suggest that producing one tonne of wheat in Morocco would cost between 74% and 144% more relative to France, Germany, United States, and Argentina. The cheaper cost of production abroad arises from many factors. These include substantial domestic support provided to cereal farmers by developed economies, and/or better land and climate conditions for wheat production. For example, the United States, under the US Farm Bill, provides domestic support measures for (in order of financial importance): yield and revenue protection insurance, conservation, direct payments, agricultural research services, disaster aid payments, countercyclical payments, and marketing loans (Rupp 2014). The structure of European subsidies, provided through the Common Agricultural Policy (CAP), is like that of the US Farm Bill, except that CAP does not generally subsidize crop insurance programs.

Schnepf (2014) estimated that in the United States the average farmer's income was USD 108,844 in 2013. This was about 53% higher than the average income of a typical United States household. The average income of a principal

farm operator for 2008–12 was 27% higher than the average United States household income (IFPRI 2014). Matthews (2012) estimated that, on average, the total subsidy received by a typical French farmer in 2012 was EUR 32,204, while it was EUR 33,974 for German farmers, and EUR 44,824 for British ones. For Morocco, in 2013, the average income of farmers producing wheat in rainfed areas was USD 5,160 and in irrigated areas was USD 8,940. These large differences in domestic support and farm incomes provide grounds for the Moroccan government to apply tariffs that protect domestic farmers who must compete with supported wheat production from developed economies.

7.5 Wheat seed sector institutions and performance

There are several key institutions in the seed sector in Morocco: INRA for agricultural research; Société de Gestion des Terres Agricoles and Société de Développement Agricole for seed growers; SONACOS for certified seed production and marketing; and ONSSA for seed quality assurance and certification. This organizational set-up was mainly oriented to cereal crops, or lower margin crops, such as wheat. The government also established a regulatory framework for the seed sector with laws, regulations, and strategies that provided an enabling environment for both state and private seed companies to undertake seed production and supply.

7.5.1 Variety development, release, and licensing

Modern varieties are the backbone of an organized seed sector. However, the development of new crop varieties and their associated technologies passes through rigorous evaluation and validation before they are released for commercial purposes.

Variety development

In Morocco, the crop breeding program (variety development) has gone through several structural and organizational changes since the establishment of Direction de la Recherche Agronomique[3] under the Ministry of Agriculture (MoA) in the early 1920s. INRA was reorganized and established in its current structure in 1981. The breeding program also gradually shifted from selection

[3] The institutions for variety development went through several organizational changes from the Official Service for Agricultural Research established in 1914. It was renamed INRA (1962) and Directorate of Agronomic Research (DAR) within the Ministry of Agriculture (1966) before it was finally re-established in its present structure as INRA (1981).

using local germplasm to hybridization to improve grain yield and quality. To date, yield, grain quality and tolerance to abiotic stresses (early maturity, and drought and heat tolerance) and biotic stresses (resistance to diseases and pests) are the major objectives and thrusts for variety development, considering the overarching effects of climate change affecting wheat production.

In Morocco, both the public and private sectors are responsible for variety development. Currently, INRA is the sole public sector organization responsible for variety development of major field crops, such as wheat. The variety development strategy combines the national crossing program and the introduction of international nurseries from International Agricultural Research Centers (IARCs) or bilateral projects. This is followed by the subsequent evaluations carried out in a network of the agricultural research stations of INRA located in irrigated, high rainfall, mountainous, semi-arid, and arid areas representing the different agro-ecological zones for wheat production. Collaboration with the International Wheat and Maize Improvement Center (CIMMYT) and ICARDA consolidated the breeding program and permitted the development of several high-yielding and disease (rust and Septoria) and pest (Hessian fly) resistant durum and bread wheat varieties (Jlibene 2005; Nasserlhaq et al. 2006).

The private sector primarily introduces varieties from overseas through partnership agreements with foreign seed companies for direct registration or evaluation for adaptation prior to their submission for registration. The private sector also introduces advanced lines and carries out on-station or on-farm evaluations for making strategic decisions on whether to register and commercialize the variety in the country or not.

Variety release

Systematic variety release procedures are the defining features of the formal seed sector in which new genotypes, originating from breeding programs, are transferred ultimately to seed companies for commercialization. Moroccan regulation stipulates that the registration of a new variety is compulsory prior to seed certification and the import of seed or planting material into the country.

ONSSA is a public organization created in 2010 bringing together all the sanitary and phytosanitary services of the MoA. It is responsible for varietal release. This involves conducting registration (distinctness, uniformity and stability [DUS]) and performance (value for cultivation use [VCU]) trials, preparing ministerial decrees for variety release, publishing the variety catalogue, and granting rights to plant breeders. The DUS and VCU trials are

conducted based on the experimental protocols adopted by the Committee on National Security Systems Policy. The trials are conducted in locations defined by its various technical committees composed of multidisciplinary teams. Variety registration is valid for 10 years, which can be extended at the request of the breeder for another five years.

The partnership of INRA with IARCs (e.g. CIMMYT and ICARDA) and particularly with the private sector, which deals with the foreign seed companies, provided opportunities to have access to a wide range of germplasm from international sources. It has led to the release of a diverse set of wheat varieties in the country. Since 1982, a total of 88 bread (69% foreign) and 83 durum (58% foreign) wheat varieties have been registered in the national catalogue i.e. about six varieties per year. A significant increase in the number of foreign varieties has been observed over the years, particularly during the last two decades. Of a total of 60 bread and durum wheat varieties released between 2001 and 2012, only nine (seven bread wheat and two durum wheat) varieties (15%) are from INRA while the rest are foreign varieties introduced by the private sector.

Variety protection and licensing

With Morocco's membership in UPOV in 2006, the plant variety protection (PVP) is officially operational in the country. The purpose of PVP is fourfold:

- To give the plant breeders the legal rights to protect their varieties
- To encourage foreign breeders to introduce new varieties to the domestic seed market
- To promote the development of the seed sector
- To fulfill the legal requirements for joining the World Trade Organization and UPOV.

As the institution responsible for examining for granting PVP, ONSSA received PVP applications for 23 durum (14 from INRA) and 18 bread (6 from INRA) wheat varieties during 2006–13. About 19 durum (14 from INRA) and 15 bread (6 from INRA) wheat varieties were granted protection by the Commission Consultative de la Protection des Obtention Végétale (CCPOV). When the approval for PVP is completed, it is registered in the 'Plant Variety Protection Bulletin' published by ONSSA. Breeders have the full right to enforce the protection of their varieties using a licensing mechanism and/or they can seek an effective mechanism to oversee PVP enforcement and royalty collection.

Variety licensing is a tool for plant breeding companies and institutions to commercialize their varieties and to transfer technology to farmers efficiently (Nilsson 2007). Initially SONACOS was established in 1975 as the sole national parastatal body to produce and market seeds of INRA varieties on a concessional basis with a 2.5% royalty on the sale of certified seed. Accordingly, about 35 INRA wheat varieties were conceded to SONACOS. Among these were three bread wheat (Achtar, Marchouch and Kenz) and two durum wheat (Karim and Marzak) varieties, that are still under seed production. In response to economic liberalization, access to INRA varieties and the seed market was opened to the private sector in 1990. In 1992, one significant innovation in the seed sector was the decision to offer all new INRA varieties through an open tender system (Appelle d'offre) open to both the public and the private sectors and governed by an agreement called "Contrat de concession des obtentions végétales" (Concession contract for plant varieties). The license is granted based on the highest combined offer of royalty paid on the amount of certified seed sold to farmers and the concessional (licensing) fee paid at the time of signing the contract.

To date, about 82 bread and durum wheat varieties from INRA have been conceded to public and private seed companies (54 to SONACOS and the remaining 28 to 4 private seed companies – Marosem [9], Deltasem [3], Agrin Maroc [5] and Nabat Chaouia [11]). Under the licensing agreement, only seven bread wheat and eight durum wheat varieties are licensed to SONACOS, whereas two each were licensed to the private sector. Among these, the bread (Rajah, Amal, Mehdia, and Aguilal), and durum (Yassmine, Amjad, Tarek, Ourgh, Marjana, and Tomouh) wheats are licensed to SONACOS while the bread (Massira and Tilila) and durum (Anouar and Jaouhar) wheats are licensed to the private sector. Since 2002, despite calls for open competitive bidding arrangements, no INRA variety was licensed to either public or private seed companies. The flaw in the licensing contracts provides absolute exclusivity to the recipient seed company for the exploitation of licensed varieties but does not stipulate any obligation for commercialization of these varieties. This privilege allowed the seed companies not to multiply some of these varieties. This has resulted not only in a monetary loss to INRA, but also the waste of several years of research and technological progress.

SONACOS and the private seed companies also enter licensing agreements with foreign seed companies to introduce pre-basic and/or basic seed from which to produce and market certified seed (R1 and R2) in Morocco. Under

this agreement, the royalty rates and payment mechanisms are specified. The arrangement permitted the introduction and use of foreign varieties taking advantages of new technologies developed elsewhere. Access to foreign varieties provided an opportunity to have a choice of varieties for Moroccan farmers. In 2013, for example, bread wheat varieties licensed from foreign companies represented about 44% of certified seed production while for durum wheat, foreign varieties represented 48% of the certified seed.

7.5.2 Seed production and commercialization

Licensing of seed producers

About 94 public and private seed companies are involved in commercialization of seed and planting materials covering a wide range of crop species. Licensing of seed companies to engage in seed production and marketing is the responsibility of ONSSA. There are specific criteria for qualification, such as access to source seed of their own or licensed varieties, facilities for processing and storage, their own land or contractual agreements with seed growers, and qualified technical staff.

Seed production, processing, and storage

Historically, formal seed sector operations started in 1920. However, large-scale certified seed production and commercialization started with the establishment of SONACOS in 1975. In Moroccco, as elsewhere, the public and private sectors have distinct seed and commodity interests. The formal seed sector is dominated by the public sector and focuses on a few cereal crops. Currently, of 94 seed companies, only five, comprising one public (SONACOS) and four private (Deltasem, Marosem, Agrin Maroc, and Aphysem) seed companies are involved in low-margin crops (cereals and legumes). The other companies work on high-margin crops (vegetables, potato, sugar beet, sunflower, and legumes). This demonstrates that high-margin crops are the focus of the private sector. SONACOS handles 91% of total national wheat seed production and marketing while the remaining 9% is the share of four private seed companies. This gives SONACOS an edge over the relatively younger private seed companies in exploiting the economies of scale essential in the seed business, particularly those working with low-profit-margin crops. This affects overall seed system performance and calls for innovative reforms in policy and regulatory frameworks to promote seed system diversification, resilience, and greater economic sustainability.

In addition to public and private seed companies, there are professional associations for seed growers that are active players in the seed sector and are also involved in the development and implementation of seed sector strategies and policies. These are the AMMS with a membership of more than 1200 seed growers and the AMSP grouping of about 140 accredited commercial operators. These are engaged in seed distribution through public and private networks – about 500 selling points – covering all the agricultural areas of the country.

Seed classes

In Morocco, generations for seed production include: G0 (nucleus material), G1 and G2 (breeder seed), G3 and G4 (basic seed), R1 (certified seed 1) and R2 (certified seed 2). For the publicly bred varieties, maintenance and breeder seed production is the responsibility of INRA while pre-basic, basic, and certified seed production is the responsibility of the public or private seed companies based on the respective varieties.

The amount of G1 wheat seed delivered by INRA in the last five years (2009–13) averaged about 9–10 tonnes. Based on requests from the seed companies, INRA planned to resume the production of G2 seed starting in 2014. For the foreign varieties, breeder and pre-basic seed are imported by the seed companies for further multiplication through contracts with the seed growers. The proportions of seed production areas in a typical season are estimated at 600 ha (G3), 5,500 ha (G4), 51,000 ha (R1), and 12,000 ha (R2).

The estimated average area covered in a typical season for cereal seed production is estimated at 70,066 ha. Of this, bread and durum wheats occupy 77%. Among the 69 varieties under commercial seed production in 2012–13, only 27 varieties (14 bread and 13 durum wheat) were multiplied, covering 90% of the total certified seed production area. In 2013, a total of 200,000 tonnes of certified seed was produced. Of this, 160,000 tonnes were for sale and 40,000 tonnes were for carry-over stock. Of the total certified seed produced, wheat accounted for 99% of the total, with 154,000 tonnes of bread wheat and 44,000 tonnes of durum wheat. About 43% of the certified seed was produced under irrigation and 57% under rainfed conditions.

During 2007–12, an average of 154,000 tonnes of certified seed of bread wheat was produced nationally. Of this, six varieties (Achtar, Amal, Radia, Salama, Arrehane, and Rajae) constituted more than 77%. The average share of each of these varieties was Achtar 23%, Amal 14%, Radia 13%, Salma 9%, Arrehane 9%, and Rajae 7%. Achtar, which is more than 20 years old, occupies

about 23%. Amal, Arrehane, and Rajae, each more than 15 years old, covered 30%. Radia and Salma, both less than 10 years old, constituted the remaining 22% of the certified bread wheat seed production. The total average seed production of the remaining 20 varieties was 23%, with each one contributing less than 5%.

The area covered by certified wheat seed is still far below the 40% goal set by the GMP. In 2013, the average certified seed use rate for wheat was 19% of the total national seed requirement. Of this, 33% was bread wheat and 16% was durum wheat. The informal seed sector dominates the cereal sector with shares of 67% for bread wheat and 84% for durum wheat. Around 60% of the total average annual sales of certified seed (120,000 tonnes) occurs in three regions, Chaouia, Saïs, and Doukala-Abda.

Forecasting seed demand is based on four key elements:

- Historical statistical data on domestic seed sales
- The varietal development plans of seed companies
- Adjustments made based on information from regional networks involved in commercialization
- Adjustments during the sale season based on carry-over stock.

The five seed companies in Morocco collectively produce 180,000 tonnes of wheat covering 19% of the estimated average national annual seed requirement of about 950,000 tonnes.

The national seed processing facilities consist of 36 seed processing plants of which 25 belong to SONACOS, four to private companies and seven to private seed growers. SONACOS currently has 82% of the total national seed storage capacity estimated at 170,000 tonnes.

Seed marketing and distribution

The national seed distribution network consists of 500 distribution centers belonging to SONACOS and the private seed companies. There are also 70 retail points for the seed growers acting on behalf of commercial seed companies.

Seed price structure

The purchase price of approved certified seed (R2) from seed growers is calculated based on the prevalent grain market price plus a maximum allowable difference between seed and grain prices fixed by the MoA. This maximum allowable difference, for example was MAD 45/quintal (USD 5.3/quintal) in 2013. The purchase prices per quintal of the certified (R1), basic, and pre-basic

seed categories are then calculated by adding incremental premiums of MAD 15 (USD 1.8), MAD 30 (USD 3.5) and MAD 130 (USD 15.3), respectively, to the net R2 seed price. For example, in 2013, the declared price for one quintal for bread wheat grain was MAD 280 (USD 32.9) and the net price per quintal for approved certified seed (R2) of bread wheat was MAD 375 (USD 44.1). These figures were obtained by assuming that a proportion of the seed was wasted. The price per quintal was, therefore, MAD 15 (USD 1.5) plus the value of wasted grain – MAD 21 (USD 2.5) i.e. a maximum allowable price per quintal difference between grain and seed was MAD 45 (USD 5.3) (a 15% premium on the declared grain price being added). The cost per quintal for processing was MAD 17 (USD 2). The cost of processing on the net weight was MAD 20/quintal (USD 2.4/quintal). Accordingly, the purchase prices per quintal of seeds are calculated by adding incremental premium rates of MAD 15 (USD 1.5) for R1, MAD 30 (USD 3.5) for G4, and MAD 130 (USD 15.3) for G3 to the MAD 375 (USD 44.1) to the established price of R2. In 2013, the prices per quintal of bread wheat seed were, therefore, MAD 505 (USD 59.4) for pre-basic, MAD 405 (USD 47.6) for basic, MAD 390 (USD 45.9) for R1, and MAD 375 (USD 44.1) for R2. The prices per quintal for the same categories of seed of durum wheat were MAD 560 (USD 65.9) (pre-basic), MAD 460 (USD 51.8) (basic), MAD 445 (USD 52.4) (R1), and MAD 430 (USD 50.6) (R2).

Seed purchasing and selling follow the same pricing procedures and modalities. The seed growers and grain producers buy the net approved seed of different categories from the seed companies at a price set by adding the prevalent grain market prices and the maximum allowable price differences between seed and grain set at 45 MAD/quintal. The government absorbs:

- The seed production premium per quintal set at MAD 15 (USD 1.5) (pre-basic), MAD 30 (USD 3.5) (basic) and MAD 130 (USD 15.3) (certified seed R1)
- The seed processing cost per quintal set at MAD 17 (USD 2)
- The storage cost per quintal for carry-over stock set at MAD 45 (USD 5.3)
- The cost of transportation as direct subsidies.

The per quintal subsidies for certified R2 constitute 34% of the calculated selling price of MAD 170 (USD 20)/MAD 495 (USD 58.2).

Subsidies are also applied to imported pre-basic (G3) and basic (G4) seed of wheat in such a way that the sale price will match the corresponding domestically produced classes of certified seed. The subsidy rates per quintal

given to imported seed are MAD 500 (USD 58.8) for G3 and MAD 400 (USD 47.1) for G4.

Direct subsidy

A ministerial decree designed to maximize the use of certified seed over a period of five years has been instituted and applied since 2010/11. In addition to the indirect subsidies to seed producers through low/free seed certification, the state provides direct subsidies to the seed price and seed security carry-over stocks. Previously, subsidies were variable components of seed pricing. The intervention of the state, through subsidies, depended on the scarcity/availability of grain and the seed harvest as well as international grain prices. The old subsidy rates per quintal for bread wheat increased from MAD 100 (USD 11.8) in 2005/06 to MAD 150 (USD 17.6) in 2009/10 while for durum wheat the increase per quintal was from MAD 80 (USD 9.4) to MAD 135 (USD 15.9) over the same period.

7.5.3 Seed quality assurance and certification

ONSSA is responsible for implementation of the relevant decrees and regulations for seed certification. In Morocco, only varieties registered in the official catalogue are eligible for seed certification and only seeds meeting field and seed standards can be labeled as 'certified seed'. This allows them to be multiplied further or marketed to farmers, alluding to both compulsory variety registration and seed certification. Field inspection is carried out according to OECD seed schemes while sampling and testing of seed lots is conducted according to the rules, methods, and procedures of ISTA.

Annually about 1200 seed growers, who are members of AMMS, are involved in contractual seed production with SONACOS and private seed companies. During the seven-year period 2006/7 to 2012/13, an analysis of the data supplied by ONSSA shows a progressive increase in the area used for production and the quantity of certified wheat seed produced to meet the national demand. During this seven-year period, the bread wheat seed production area increased from 30,025 ha to 56,598 ha, an increase of 89%. The average rejection rate was 5.6%. Likewise, the production area for durum wheat seed increased from 9,331 ha to 16,795 ha, an 80% increase. The average rejection rate was 8%. The average total area dedicated to produce certified seeds, during the seven-year period, was 59,203 ha, of which 46,642 ha was for bread wheat and 12,561 ha was for durum wheat.

Like the area for seed production, production of certified seed increased substantially during the seven-year period. For bread wheat, the quantity of certified seed controlled for seed quality increased from 39,716 tonnes (from 1,778 seed lots) to 127,440 tonnes (from 5,453 seed lots), a 220% increase. The average rejection rate was 8% (303 seed lots). For durum wheat, the quantity of certified seed tested increased from 12,253 tonnes (from 577 seed lots) to 44,611 tonnes (from 1,276 seed lots), a 264% increase. The rejection rate was 25.2% (321 seed lots). The average total annual certified seed production during the last seven years was 112,046 tonnes, of which 85,035 tonnes were bread wheat and 27,011 tonnes were durum wheat.

The rejection levels, both during field inspection and seed testing, are within the acceptable range given the high national field and seed standards. However, for durum wheat seed lots the average rejection level of 26.2% was substantially higher than that of bread wheat (8%) during this period. A previous study has shown a high rejection rate of certified seed of durum wheat primarily because of poor germination arising particularly from mechanical damage during harvesting (Grass and Tourkmani 1999).

Meeting the GMP targets of producing 280,000 tonnes of certified seed of cereals and the increase in the rate of certified seed use to 40% by 2020 warrants an expansion of the current capacity for seed certification in terms of physical, financial and human resources. A new reference seed testing laboratory for ONSSA is under construction. Also, four regional private sector laboratories, under the supervision of ONSSA, are planned for the coming years.

The increase in the number of seed testing laboratories is required to cope with the substantial expansion in the certified seed production program. The envisaged training plan would also solve the capacity problem but may not ensure the economic sustainability of the seed certification scheme through government support alone. Accreditation of seed companies to undertake certain responsibilities of field inspection and seed testing is of paramount importance and should be accelerated as envisaged in the plan.

In 2009, a contract was signed between the Moroccan government and Fédération Nationale Interprofessionelle des Semences et Plants (FNIS), stipulating, among other things, the gradual transfer of certain tasks of seed certification, like field inspection and laboratory seed testing. FNIS will be accredited to undertake these activities, under the supervision of ONSSA, based on international experience with the OECD and the European Union.

The accreditation system will be established gradually between 2013 and 2017. Procedures defining the tasks of each party will be elaborated and adopted. A training program will be organized to strengthen the capacities of the staff.

7.6 Seed use, varietal adoption, and impacts

7.6.1 Wheat seed use and sources

Analysis of wheat seed use among farmers, based on a national household survey, revealed that the typical Moroccan farmer is using, on average, 176 kg/ha of wheat seed (250 kg/ha for irrigated and 157 kg/ha for rainfed). Based on the five-year average total national wheat area of 2.91 million ha, this translates into a total national wheat seed use rate of about 512,000 t/year. Of this, 43% was used in the favorable zones, 33% in the intermediate zones, and the rest in the marginal areas[4]. Achtar, Amal, Karim, Radia, and Merchouch are the top five varieties with the highest seed use in Morocco. These results are consistent with the degree of adoption, as these same varieties occupy the largest area relative to other varieties. The same varieties also occupy the highest share of certified seed production. This shows that seed availability is important for adoption and that seed companies can play an important role in influencing the varietal adoption landscape.

Survey results also show that, nationally, 22% of the total seed used by farmers in 2011/12 was from SONACOS (18% acquired through local government extension units and 4% from SONACOS' own seed distribution points). The remaining 78% was attributed mainly to informal sources, including own-saved seed, local seed traders, local grain markets, and seed exchanges with other farmers. This confirms the importance of the informal seed sector in Morocco. For example, about 40% of farmers mentioned that they save their own seed. However, the majority mentioned purchasing seed frequently, leading to a seed replacement rate of two years, with some farmers replacing every year and others not replacing for more than 10 years. The average seed replacement rate among the very few farmers sampled who are local seed producers is 3.6 years, while that of the ordinary grain producers is 2.1 years.

[4] The favorable zones of Morocco include the provinces of Benslimane, El Hajeb, Fez, Kenitra, Khemisset, Meknes, Sidi Kacem, Taounate, and Taza. They represent about 44% of the total wheat area in the country. The intermediate zones include the provinces of El-Jadida and Setat and constitute 24% of the total national wheat area. The remaining 19% and 13% of the wheat area are found in the unfavorable south and the mountainous zones, respectively.

Farmers are aware of seed quality and may replace seed frequently, but do not necessarily buy certified seed from the formal public or private sectors. Over 75% of farmers reported that they use only one seed source, while 22% reported they use two, and 3% reported they use more than two seed sources.

The 10-year average wheat seed (certified and uncertified) and wheat grain sales prices/quintal reported by farmers were MAD 359 (USD 42.2) and MAD 268 (USD 31.5), respectively. This shows 31% higher prices for seeds relative to grain – a premium well above the minimum acceptable level of 20%. However, given the higher costs associated with seed production, the net margins obtained by seed growers – though still higher than the grain producers – are much less, standing at an average 12% (13% for commercial seed growers and 11% for local seed producers). As local production of seeds by smallholders could provide a solution to the low level of certified seed use in the country, answering the question, "Are these net gains high enough to encourage grain growers to become seed growers?", is important. The answer is, "It depends on individual farmers' perceptions and risk behaviors." Some farmers might not find it any riskier than grain production and, hence, be willing to become seed producers if they get the opportunity. Others could be more skeptical and, hence, would not want to shift into the production of seeds. Therefore, if the country adopts a strategy of encouraging local seed production by smallholders, there may be enough grain farmers who will be happy to convert to seed production, provided they have the market and some level of training on quality management.

Adoption of improved varieties

Results from the national survey showed that currently 40 wheat varieties are in the hands of Moroccan farmers. The results also clearly showed that the top 10 varieties alone cover about 93% of the total wheat area in the country and are planted by 91% of farmers. A total of 17 varieties, which were released from the collaborative breeding program of INRA, CIMMYT, and ICARDA, are being cultivated by 82% of the wheat growers on 79% of the total wheat area. However, four old improved varieties, Achtar, Merchouch, Amal, and Karim, which are more than 20 years old, cover about 60% of the total wheat area. Varieties less than 10 years old cover 19% of the wheat area. This shows that the older varieties currently dominate in Moroccan wheat fields.

All wheat varieties aged between 10 to 20 years come from INRA while other sources (the private sector) are covering the remaining 21% of the total wheat area. The area-weighted national average age of varieties is 22 years.

These figures show a generally low level of varietal replacement, hence low adoption of more recent improved varieties in the country. During our survey, none of the varieties from the joint INRA/CGIAR program released in the last 10 years were found in Moroccan wheat fields.

Among the farm households surveyed, 88% responded that they were using improved varieties. This corresponds to a national adoption level for varieties, including those which are up to 30 years old. The fact that old improved varieties, such as Achtar (released in 1987) and Karim (1986) are still being produced and sold in the commercial seed market reflects farmers' statements about the use of improved varieties.

However, establishing specific categories, such as "old or new" improved varieties based on specific cutoff time periods, might help to clarify some of these ambiguities. This calls for some form of consensus between seed sector stakeholders and more understanding of the life span of improved varieties. It also calls for their withdrawal from the national catalogue, particularly if they have lost their original attributes, such as disease resistance.

Farmers were asked to name their preferred variety. Among the list of 10 top-ranking farmer-preferred varieties, only two (both of which are from private companies) were less than 10 years old. The remaining eight (all of which are from the INRA/CGIAR collaborative work) were more than 20 years old. This raises some important questions:

- Are the new improved INRA/CGIAR varieties superior to these old varieties?
- If there are new and better varieties from INRA/CGIAR, why are farmers not aware of them and using them?
- Could these older varieties be preferred by farmers because they are still performing equally as well as or better than the more recent INRA/CGIAR varieties?

To shed light on some of these questions, farmers were asked if they cultivated their favorite varieties. The results show that 77% of farmers responded "Yes" to the cultivation of their favorite bread wheat varieties and 57% responded affirmatively about the durum wheat varieties. From among the 23% who responded "No" for bread wheat, the main reason is the non-availability of seed in sufficient quantities in the market. There are many reasons for this, including a poor previous year's harvest (76%) and high seed prices (22%).

To assess the level of farmers' access to information about new varieties, they were asked what they knew about the new varieties. To this effect, Faraj, the new Hessian fly resistant durum wheat variety released in 2007, was selected as an example. When farmers were asked if they have heard about Faraj, almost 96% of them responded "No". This shows the serious lack of information about or farmers' knowledge of the new varieties. However, among the 4% (49 farmers) who responded "Yes", 37 (76%) liked the variety and hence wanted to plant it, but they could not get the seed in the market.

Farmers were also asked what they thought would be the best way to solve the current seed-related problems. The main solutions proposed by farmers were:

- Seed companies should know better what farmers want and produce enough seed of those varieties (30%)
- The government should intervene and solve problems relating to the non-availability of information and affordable certified seed (28%)
- Strengthening the informal sector to fill the gap between the demand and supply of certified seed (26%)
- Creating better access to credit facilities for seed purchase and seed production under irrigation (16%).

Among all provinces covered in the survey, Berechid, in the intermediate zone, led in terms of the adoption of varieties which are 10 years old or older These varieties account for 63% of the total in Berechid. It was followed by Safi (41%) and Settat (40%). Several factors have been identified as being important determinants for the adoption of improved varieties of wheat. A Heckman selection model fitted to the survey data showed that 79% of the total variation in adoption decisions is explained by all the variables included in the model, while the remaining 21% is explained by other variables, such as farmers' attitudes to risk.

The variables included farmer characteristics (age, sex, education, access to credit, off-farm employment, and hosting demonstration trials). These, in general, were found to be the most important explanatory variables, accounting for 45% of the total variation. These were followed by farm characteristics (wheat area, access to irrigation, agro-ecological zone, and distance from residence to the farm). All together, these explained 19% of the variation. Variables that examine access to seeds (distance to seed source, availability of adequate quantity and quality of seeds at the desired time, the choice to

buy certified seed, the seed source, and seed price) explained the remaining 15% of the total variation. While 15% is high, it does not alone account for the poor varietal adoption levels, as is often heard among breeders, development practitioners, policy makers, and donors.

There is an important role for the extension program in popularizing high potential varieties and for seed companies to make certified seeds of these varieties available to farmers. The ideal situation would be for farmers to have access to certified seeds from a menu of diverse varieties and for them to have adequate information about the merits of each variety.

Market imperfections, such as the dominance of one seed company with monopoly control, exist. There is, therefore, a need for government intervention to reconcile and regulate the conflicts of interest between variety developers, seed companies, farmers, and the national interest.

Impact of improved varieties

Results from propensity score matching and endogenous switching regression show that wheat varieties under 20 years of age (the majority are 15–20 years old) provide, on average, a yield gain of 482 kg/ha (49%), and result in a per capita wheat consumption of 29.6 kg/year (60%) more than varieties that are older than 20 years. Moreover, adoption of these varieties leads to a gain in net margin/ha of MAD 1,324 (USD 154). Given that the average area per family under improved varieties is 1.6 ha, a typical adopter family currently earns MAD 2,118 (USD 245), which represents 49% additional net wheat income from the adoption of improved wheat varieties. The adoption of improved wheat varieties, indeed, leads to very high gains in important livelihood indicators. However, in the face of such huge gains, the low adoption levels remain a puzzle.

The current national practice of planting 41% of the total wheat area with varieties less than 20 years old has helped Morocco to produce 0.58 million tonnes more wheat than it would if it were to use only varieties which are more than 20 years old. The additional production resulting from the adoption of improved varieties represents a 17% increase in annual production. This translates into a net national income gain of MAD 9.1 billion (USD 1.1 billion) per year which, by any standards, is not small.

In fact, if the barriers are removed and adoption of improved varieties is somehow enhanced to as high as, say, 80%, the country has the potential to increase the gain in national wheat production to 1.1 million tonnes. This would result in an additional annual net wheat income of MAD 17.44 billion (USD 2.02 billion). Further analysis of all the 40 varieties in farmers' hands

shows that yields and net income gains are higher with more recent varieties. Therefore, the popularization of more recent varieties might enhance adoption and, hence, increase the national supply of wheat and the country's wheat income even further.

7.7 Gender roles in varietal adoption

It is important to consider gender issues when looking to enhance wheat production for two main reasons:

- First, it is important to ensure that both men and women benefit from the resulting interventions
- Second, it is important that the distribution of the costs and benefits of the interventions are not worsening gender inequalities.

Findings from Gambia, for example, showed that introducing an irrigation scheme along with improved rice varieties only to men had numerous negative consequences for gender. It displaced women from their land, discounted their knowledge, increased their workloads, and negatively affected nutrition, especially in female-headed households (Kerr 2012). For a variety and seed technology to provide equitable benefits to women and men, their respective needs, roles, constraints, and opportunities need to be considered.

Gender matters in adopting agricultural innovations. It determines access to land and other agricultural inputs as well as preferences of output. These, in turn, affect the willingness and ability to adopt innovations (Doss 2001). In Ghana, for example, gender-linked differences in the adoption of modern maize varieties and chemical fertilizers resulted from gender-linked differences in access to complementary inputs (Doss and Morris 2000). In Morocco, women own less than 2% of agricultural land (Dr. Hassan Serghini, personal communication 2014). In 2006, state-led land distribution efforts in Saïs provided mostly men with land and did not alter the existing gender imbalance. The few women that did own land did so on the basis that they were heads of households or because they inherited land upon the death of their husbands (Bossenbroek and Zwarteveen 2015).

Landowners, mostly men, are often targeted for extension support and varietal demonstrations. Women in Saïs were largely marginalized from extension support and participation. The focus group discussions revealed that women are often excluded from extension support. Men reported mainly learning and accessing information about new varieties and agronomic practices

from farmer field schools, on-farm variety trials, and extension services. Women, in contrast, learned about new varieties and innovative practices from neighbors, family, and friends. Among all the respondents in Saïs, women lacked knowledge about ongoing variety demonstration trials and innovations related to wheat, such as conservation agriculture and wheat-legume rotations.

Yet our study shows that both women and men are involved in wheat production, as both paid and unpaid labor for land preparation, weeding, and threshing. And women spent as much time as men – about 21 days per ha. Paid wheat-related activities are found, for the most part, in the informal sector where the gender wage gap is particularly pronounced. The labor survey in Saïs revealed that women earn 25% less than their male counterparts in activities related to wheat production. While men earn MAD 80, women earn MAD 60. Our findings have revealed that higher-paid machine-intensive tasks tend to be assigned to men while women are more likely to find themselves performing the lower-paid labor-intensive manual tasks related to wheat and other crops.

Land privatization in neighboring provinces has resulted in the loss of pasture lands and has provoked drought that has fueled migration to Saïs, particularly of women. This is a more resource-endowed province (with water and a thriving fruit and olive production sector). This has led to a surge in female agricultural laborers, resulting in women becoming the main workforce in the region. The abundance of female labor has reduced their bargaining power. To make matters harder, the pay equity law (Moroccan Labor Law of 2003, Article 346) is not being enforced. These conditions have made life very difficult for these female migrant workers, who are considered “losers” and receive little respect from the wider community.

In addition to their participation in paid and unpaid labor in wheat production, women are involved in decision making related to varietal adoption. Focus group discussions and interviews with women in Saïs and the national household survey revealed that both men and women make joint decisions on varietal adoption. Results from the national survey show that in 90% of the cases, women are involved in varietal adoption decisions i.e. jointly with men in 89% of the households and independently in 1% of households – these latter are all women-headed households (WHHs). In Saïs, women are the main decision makers on varietal adoption for bread wheat grown for home consumption. Varietal choices have implications for adoption and it is strategic to involve both men and women in varietal demonstrations, varietal attributes, and related extension advice.

Gender also proved to be important in trait preferences for wheat varieties. In Saïs, strong gender differences in varietal trait preferences emerged. Men have shown greater interest in wheat varietal attributes like yield, disease resistance, and drought tolerance, while women expressed more interest in dough quality. Women's concerns are linked to their prominent role in preparing food for their families. Results from the national survey with 52 WHHs and 1,178 men-headed households (MHHs) also revealed differences between men's and women's preferences regarding wheat varieties for adoption. Women were keen to reduce post-harvest losses and improve storability. Like men, they ranked grain yield and grain color highly, but they also ranked shattering tolerance, and storability as top priorities in selecting wheat varieties. Men, in contrast, were largely focused on yield – ranking grain yield, grain yield stability, grain color, and guaranteed minimum yield as their most preferred traits for wheat variety adoption.

From the national survey, a comparison between WHHs and MHHs revealed that WHHs are more likely to adopt improved varieties than MHHs. Our findings from a survey conducted with 52 WHHs in Saïs reveal that 64% of WHHs are adopters of the improved wheat varieties, and among the adopters, the WHHs get higher yields and higher net income than the MHHs. This suggests that WHHs are more readily adopting new wheat varieties and realizing better benefits. These findings contradict a global trend in disparities in access to innovations for women, as women generally have less access to productive resources (such as land, fertilizers, pesticides, financial capital, certified seed, machinery, and labor) as well as information (Doss 2001; Doss and Morris 2000). A closer study to understand the unique performance by the Moroccan WHHs will be needed to shed more light on why this is the case.

It is worthwhile mentioning that the national survey also revealed that women's involvement in seed production is very limited. Of the sample of 1,230 farmers, only 16 farmers produce seed for local sale and just 2 of them (12%) are women. Moreover, of a random sample of 83 seed growers selected from the 1,300 AMMS members, just 2 (a little under 2%) were women.

It is important to invest in women's involvement in seed production not only for increasing income generation opportunities for women who have access to land (owned, rented, or managed), but also to benefit other women who either control or jointly cultivate land. As women, they can more readily disseminate information to other women both formally, by hosting demonstration trials, and informally, through regular interactions to learn about new wheat varieties and

relevant agronomic practices. This strategy constitutes one of the approaches the extension system can adopt to increase the participation of women in varietal selection. Greater participation of women would help raise crop yields and income. This approach can also nurture leadership skills in women by granting them opportunities for public speaking, networking, and increased public involvement (Alkire et al. 2013).

7.8 Conclusions

The Moroccan wheat sector involves several actors interrelated in many ways; and each has specific interests and aspirations. Any attempt to improve the performance of the wheat sector in the country requires an approach that simultaneously addresses prevalent bottlenecks through a multifaceted intervention involving policy, and institutional and technological changes.

The success of such interventions will depend on many factors: how best they target the major aspects of varietal development, evaluation, release, protection and licensing, seed production and commercialization, seed quality and certification, wheat production and marketing, and access to certified seed and new varieties.

A regulatory framework for the Moroccan seed sector, which includes laws, regulations, and strategies, has been established to create an enabling environment for both public and private seed companies to produce and commercialize high quality seed in the country. Under the GMP, this framework has managed to increase the use of certified seeds from 68,000 tonnes before 2008 to 128,000 tonnes in 2013 (an 88% increase in just five years). This represents an increase in the use of certified bread wheat from 18% before 2009 to almost 35% in 2013.

Under this regulatory framework, the government has been providing domestic support for wheat seed production and tariff protection to wheat grain. These are complementary policy measures to widen domestic wheat production, by, among other things, developing internally improved crop varieties. The rationale behind this approach is clear. Wheat is a massive generator of direct and indirect employment. The country is also heavily dependent on imports. Hence it becomes a priority to ensure better livelihoods and improved food security. Without this regulatory framework it would be difficult for Moroccan farmers to compete with the cheaper wheat produced in other counties (France, United States, and Germany), which use high-yielding varieties and are comprehensively subsidized.

Variety development is a long-term process. It requires huge investment to attract highly qualified personnel and to build well-equipped infrastructure. These are needed to address the challenges of agricultural research under the prevailing climate change. Morocco has already experienced problems associated with climate change, such as frequent droughts, extreme temperatures, and emerging diseases and pests. These conditions have a significant potential effect on wheat production. This calls for a review of INRA's breeding program strategies and breeding objectives to ensure its responsiveness to the emerging challenges. It is evident that the departure of several senior research staff at the beginning of the new millennium has left a significant gap in agricultural research and variety development in the public sector. Currently, most of the released crop varieties are from foreign-based private companies creating dependency at the expense of the national breeding program. Attempts by INRA to reinforce the national breeding programs are commendable. They demonstrate the government's commitment to invest in the development of research capacity (physical, and human and financial resources) that will affect variety development and release in the coming years. Such a commitment must continue if the wheat research program is to provide varietal sovereignty and have a significant effect in transforming the agricultural sector within the vision of GMP.

In the last three decades (since the 1980s), two emerging trends can be observed in bread and durum wheat variety development, registration, and release in Morocco. First there is a continuous decline in INRA varieties (most of which were developed through joint efforts with CIMMYT and ICARDA) and an increase in private sector varieties in the national catalogue. Bread and durum wheat varieties from the private sector, on average, constitute about 64% of all releases. Bread wheat releases from the private sector alone increased from 21% in the early 1980s to 93% in the 2010s. Likewise, the proportion of durum wheat varieties increased from 0% to 77% during the same period.

Second, the public varieties submitted for varietal release are often characterized by lack of uniformity or poor agronomic performance during registration and performance trials. This has led to a high level (86%) of rejection by the national varietal release committee compared to that of the private sector (37%). This shows a gap in the national public breeding program and the competitiveness of foreign varieties under the existing agro-climatic conditions in the country. There is low commercial attractiveness for wheat seed for the private sector. This has limited its contribution to just 9% of the total national certified seed market and diversity of the farming systems. It

is uncertain if dependence on foreign varieties at the expense of a national breeding program would bring the desired changes and results for the long-term sustainability of the wheat sector. Therefore, it is important to have public sector investment in wheat breeding.

The INRA breeding program, in partnership with CIMMYT and ICARDA, develops varieties, adapted across the country, in a network of research stations and farmers' fields. A fundamental dilemma is that multi-locational trials in a range of environments naturally favor varieties that have wide adaptation, even though they may not be the best varieties in specific locations. In countries like Morocco, which have a very diverse agro-ecology, it might be beneficial to exploit the potential of niche varieties with extraordinary performance in targeted agro-ecologies. There is a philosophical debate among scientists about how to handle such critical issues of fundamental importance in a national breeding program. Given these circumstances, there needs to be a debate about whether the current variety release system should be modified to accommodate regional releases (with specific adaptations). And if so, this debate should assess the implications of such a regional dimension on the variety release system in the interests of the different stakeholders. Additionally, it would need to consider how any new variety release system would affect the country's food security and development goals.

The current variety licensing arrangement of INRA with the public and private sectors appears dysfunctional; it is undermining the investments made in agricultural research and the development of new varieties in Morocco. Most of the blame for this is placed on the poorly developed contractual agreement. INRA is currently developing a new contractual agreement to overcome past shortcomings to ensure wider adoption and dissemination of new varieties. The new contract obligates recipient seed companies to engage in pre-basic seed multiplication and pay royalties on certified seed production (R1 or R2) to recover money invested in research. However, given the previous poor experience, it is not clear how this new licensing agreement could be enforced within the existing legal framework and how any risks that may arise with the new arrangement can be mitigated.

Variety maintenance and early generation seed production are common constraints in national seed programs, because public breeders do not have the resources or incentives to undertake this routine technical work. However, variety release should be coupled with commercialization to create awareness of new varieties and stimulate demand for seed. Availability of and access

to early generation seed remain major constraints for INRA varieties. Until 2015, INRA had well-established seed services for variety maintenance and the provision of basic seed (G4) to seed companies. Ever since 2015, the seed service has limited its role to the production of G1 and G2, anticipating that the public and private seed companies will take over the responsibility of basic seed production. However, the seed companies did not take responsibility for producing G4 for the INRA varieties, which has led to a limited production of certified seeds of these.

Instead, the seed companies resorted to cheaper options, which led to the increase of breeder and pre-basic seed imports from the countries of origin at the expense of nationally bred varieties. A clear strategy is needed to ensure that responsibilities for variety maintenance and local pre-basic seed production are assumed by INRA and/or the seed companies. If these players do play their required role this would advance the business orientation and bring diversification into the national seed system.

The Moroccan variety registration system has permitted the release of many varieties from the national breeding program and from around the globe. This provides an opportunity for Moroccan farmers to benefit from new technologies from elsewhere. The Moroccan variety release system seeks to ensure the addition of new varieties into the official catalogue. This has clear advantages and will help to establish the varieties' commercial merits that translate to the opportunities for generating royalty revenue from sales. The focus on wider adaptation may limit the release of niche varieties with outstanding performance in certain agro-ecologies. However, the release does not often guarantee that all varieties have enough commercial merit to win a significant market share. This may contribute to the failure of the tendering system because many varieties were offered to the companies, but they were not all capable of securing a significant market share or providing revenue to the company or to INRA. In Morocco, the system appears to release many varieties, but cannot cope with commercialization of all the varieties that are available in the national catalogue. Moreover, it is time now to review the varietal release strategy and the national variety catalogue and decide to withdraw those wheat varieties with no significant agronomic merit and commercial performance compared to the new varieties.

The variety release system has made considerable progress over the last 35 years. The service has significant cost implications, which are currently borne by the government. Payment for this service is a good idea in principle, but it

may achieve very little in practice if the majority of breeders work in the public sector and are already short of financial resources. Starting in January 2014, the release system entered a new area to achieve sustainability by recovering costs, revising fees for the application and testing of VCU and DUS trials. A gradual transfer of VCU trials to the private sector through FNIS, under the supervision of ONSSA, is also envisaged. The contribution and responsibility of each party is specified in the contractual agreement to be signed between the two parties. This is a welcome move to be endorsed and applied to ease the financial burden on the government.

Its large inherited market share (91%) gives SONACOS an edge over the relatively younger private seed companies in exploiting the economies of scale, which are essential for the seed business, particularly for those working in low-profit-margin crops. This affects the overall seed system performance and calls for innovative reforms in the policy and regulatory frameworks to promote seed system diversification, resilience, and greater economic sustainability.

Subsidies are proportionate to the price, quantity, and quality of the seed delivered, with varieties/species with a higher grain market price, high productivity, and seed lots with low rates of waste receiving a higher subsidy. The fact that the subsidy applies to the net approved seed quantity delivered instead of the raw seed is a very important element in compensating good seed growers for their better performance.

There is limited or no systematic variety popularization and seed extension service to promote the use of certified seed of the farmers' preferred varieties. Raising farmers' awareness about the economic benefits of using new varieties and certified seeds through better extension and outreach programs could contribute towards generating demand and maximizing certified seed use. Outreach could include demonstration trials or field days held jointly by the Office National du Conseil Agricole (ONCA), INRA, and the seed companies.

Moreover, it is necessary to commission studies to better understand the limiting factors in the seed market and promote greater private sector participation in the wheat seed sector. Even though the average contribution of the formal sector reached 19% in 2013, the informal seed sector remains dominant. This illustrates the need to better understand its role and develop strategies to strengthen and tap into its tremendous potential.

Improved forecasting to determine seed demand could help to optimize carry-over seed stock levels. The large carry-over seed stocks – 38,000 tonnes in 2011/12 and about 77,000 tonnes in 2012/13 – that have been reported

reflect a significant discrepancy between cereal seed production and use. The reported carry-overs of certified seed stock at times were triple the 22,000 tonnes fixed by decree for the period 2011–15. Moreover, the 22,000 tonnes/year carry-over stock level is greater than the current national storage capacity of 17,000 tonnes, indicating a critical shortage in storage facilities.

The recovery of subsidies through seed sales reduces the cost of inputs for seed growers, provides incentives to increase certified seed use by crop producers, and helps seed companies to market. Nonetheless, it would be sensible to think about an exit strategy from direct to a smart and performance-optimized seed subsidy system. Integrating more components of seed system diversification enhancement into the subsidy system could bring greater competition and economic viability into it.

ONSSA is responsible for providing regulatory services for seed certification. With the current plan to expand the provision of the seed supply, it will be necessary to increase the area for seed production and seed testing, which will have to be matched by expanding ONSSA's work force. This will have cost implications that under the status quo will be supported partly by government funds, which are becoming increasingly scarce. For example, given the financial difficulties, ONSSA could not even continue to maintain its laboratory accreditation with ISTA. ISTA accreditation is helpful for the profile of the seed sector and essential for the international seed trade. Therefore, developing clear strategies to ensure the sustainability of the services offered by ONSSA is essential in view of the higher expectations placed on it by GMP.

Establishing mechanisms for greater integration and harmony between technology generation, evaluation, dissemination, and use would help co-ordinate their activities and bring greater efficiency and effectiveness in the performance of the national seed sector. To this end, several things need to be revisited and reviewed:

- The debate about variety evaluation for wide and specific adaptation
- The effect of the current variety licensing system on the imbalance between foreign and locally bred varieties
- The seed pricing mechanism based on prevailing grain market prices, plus a fixed amount calculated without taking the actual cost of production into account.

One of the main challenges the Moroccan wheat sector is currently facing is that, despite considerable investment by national and international wheat

breeding programs, the present average yield levels are much lower than both the global and African averages. Nonetheless, by planting varieties that are less than 20 years old, the typical adopter farmers in Morocco are reaping substantial benefits in yield, consumption, and farm income gains. In the face of such benefits, the low adoption levels of new improved wheat varieties in the country are puzzling. Possible explanations for this condition include:

- A serious lack of information and knowledge of new varieties by farmers
- The formal seed sector continues to produce and commercialize substantial quantities of certified seed of old improved varieties possibly limiting farmers' ability to plant more recent varieties.

Most strikingly, 75% of farmers think they grow improved varieties and do not make any distinction between old and new improved varieties, while only 42% are using varieties released in the last 20 years. A detailed analysis of the determinants of adoption showed that farmer and farm characteristics are the most important factors that affect adoption of improved wheat varieties. For instance, most farmers are not aware of a specific high potential wheat variety released in the last 10 years and hence they do not cultivate it. Berechid, Safi, and Settat Provinces have exhibited relatively high adoption levels, a closer study of which could provide better insights into the drivers of adoption. All these results show that there are opportunities for changing the perceptions of farmers and achieving greater adoption levels, which would lead to further benefits to farmers and the country at large. This calls for more proactive extension work in the country.

Lack of information is the number one constraint influencing farmers' perceptions and limiting adoption. However, both regression results and farmers' opinions showed that access to quality seed of desired varieties is the second most important constraint on adoption. These findings do not come as a surprise because the price gap between certified and uncertified seeds is not significant given the high subsidies on certified seeds. Hence, seed prices cannot explain non-adoption of certified seeds.

Moreover, the current share of certified seeds from the formal sector in total national seed use is only 22%, while the remaining 78%, or the clear majority, still comes from the informal sector. This sector includes farmers' own seeds saved from previous harvests, local seed traders, and local grain markets. This shows the importance of the informal sector in wheat seed supply.

In collecting sex-disaggregated data and the subsequent gender analysis of constraints and opportunities in Morocco's wheat sector, three main findings emerged. First, in the paid labor related to wheat production, women were excluded from the higher-paying technology-intensive tasks, such as combine harvesting because social norms in Morocco, as in many places, connect technology use to masculinity. Apart from a lack of higher-paying skills, women were also paid less for the same tasks performed by men, especially in the informal sector.

Second, it was clear that women's varietal preferences differed from those of men. Most notably, in Saïs, where women focused on varietal traits that affect consumptive quality, such as the dough quality, while men showed greater interest in varietal attributes, such as high yield, disease resistance, and drought tolerance. This could be attributed to the women's lack of involvement in extension programs to acquire knowledge of new varieties.

Third, contrary to common beliefs on WHHs' abilities to adopt innovations, the national survey revealed that women are more likely to adopt new varieties, obtain higher yields, and earn higher farm incomes than their male counterparts.

7.9 Way forward

Intense competition from cheap imports of wheat from the developed world poses a major challenge for the domestic production of wheat. If the wheat sector in Morocco is to continue playing an important role in the political, social, economic, and food security arenas the current policy and regulatory framework needs to provide more incentives to the key actors in the wheat sector.

The current domestic variety licensing system through competitive bidding utterly failed the effort of the public sector wheat breeding program of INRA. In contrast, it was stated that SONACOS and the private seed companies entered licensing agreements with foreign seed companies where the royalty rates and payment mechanisms are specified to import the pre-basic and/or basic seed to produce and market certified seed (R1 and R2) in Morocco.

It is evident that while both the public and private seed companies comply with the licensing agreements of foreign seed companies and are willing to make the payments, it defies logic why INRA failed to enforce the licensing agreement it made with the public and private sectors. There are three possible scenarios:

- The seed companies may import pre-basic or basic seed of 'obsolete' wheat varieties whose PVP has expired and they are under no obligation to pay a royalty other than the cost of the imported seed
- Using a flaw in the agreement, the seed companies deliberately continue to produce seed of old INRA varieties to avoid paying the fees for the new varieties
- The licensed INRA varieties may not have a market demand and, therefore, it is not worth investing in seed production and marketing.

This would seem illogical because, unless the seed companies see any merit in these varieties, they will not show interest in entering into an agreement for acquiring the licenses. Thus, the likely explanation for the current situation is the weakness of the old licensing agreement. The new licensing agreement will, therefore, need to redress this impasse and incorporate clauses that ensure enforcement of the production of a given minimum amount of seed of the licensed variety. This will be beneficial both for the national economy and for the sustainability of the breeding program at INRA.

Although the budgetary implications within public research organizations is a constant source of debate, ensuring the provision of basic seed (G4) is essential for achieving results. In the case of Morocco, the current licensing system for INRA varieties does not provide incentives for seed companies to assume the responsibility of producing G4. Therefore, unless the licensing process changes to incentivize seed companies to assume this responsibility, we argue that resuming the production of G4 by the seed service at INRA is essential for achieving impacts from the investments made by INRA and needs careful considerations for the future. If there is a desire to reinstate the seed service it should be fully equipped with the physical, financial, and human resources to facilitate early generation seed production and avoid competition with research funds. It should become a more autonomous cost center within INRA.

Under the GMP, there is a clear policy declaration to use foreign-bred varieties for the domestic seed market. But there are ongoing investments in public plant breeding. INRA should make a strategic decision whether to strengthen the national breeding program. They can do this by investing in human resources and infrastructure to develop new wheat varieties and avoid dependence on foreign varieties. Alternatively, INRA may also decide to enter partnerships with foreign seed companies and develop varieties for domestic and international markets through 'joint-ownership' and PVP. Either way, the future of INRA is at a crossroads. It needs to make strategic decisions and review

its wheat research program if it is to tackle the challenges of agricultural research in the face of climate change and if it wants to fulfil the vision of the GMP.

Morocco is a member of international and regional organizations involved in the seed sector, such as the OECD seed schemes (1989), the European Union (1991), UPOV (2006), and ISTA (1964). However, it could not continue to maintain its accreditation to ISTA, which is crucial to the international seed trade. ONSSA is the main provider of regulatory, technical, and administrative services to the national seed sector. It is involved in variety evaluation, registration, and release. It grants PVP; implements the seed certification scheme, and licenses the seed companies. The tasks of ONSSA have substantially increased under the GMP. However, neither the expansion of its facilities nor a training plan would guarantee the sustainability of its operations. A self-sustaining variety registration mechanism and seed certification scheme could be a result of an increasingly commercialized national seed sector, including the international trade in seeds (exports and imports). Therefore, variety registration and seed certification should not be restrictive without adding value to the seed business. Expansion should be driven by the business needs of the seed sector. The current regulatory services of ONSSA need to be rationalized and an effective and efficient system put in place where the accreditation of professional associations may play a major role under the supervision of ONSSA.

Current institutional arrangements do not seem to be effective in terms of delivering the much-needed extension services, so new institutional settings might be desirable. The following two strategies, particularly, need to be considered as options for moving forward:

- Strengthening the INRA technology promotion and marketing department to popularize and promote its varieties through more investment in capacity development
- Establishing stronger and more functional links between INRA and the newly established ONCA, by making a clear delineation of responsibilities and creating complementarity between them that will lead to the development of a harmonized national extension strategy.

Women have limited access, roles, or exposure to demonstration trials, farmer field schools, and extension programs. It is important to improve access to information for women as this may increase productivity and contribute to food security, especially when considering the high male outmigration (FAO 2011). To realize this, it is important to hire female extension staff to deliver

information and collect sex-disaggregated data involving women (Dey De Pryck 2014). This is in line with the efforts of ONCA and the GMP, through the Gender Responsive National Budgeting Program, to increase the number of female staff in the national extension system – currently standing at 10% – to enhance the involvement of rural women.

INRA has women breeders and technicians, fully involved in variety development and evaluation, who could take the lead in increasing the involvement of women farmers throughout the variety development, evaluation, and release process. Increasing women's involvement in voicing their preferences for varietal traits needs to be part of the feedback to breeding objectives and varietal development. This is a necessary initial step towards enabling women to benefit equitably with men from improved wheat varieties.

Improving working conditions for women – particularly achieving wage parity with men and mastering highly paid skills – are equally important in realizing gender-responsive and equitable wheat production interventions. The *filière* or value chain approach adopted by the GMP, which concentrates on identifying bottlenecks along the wheat value chain, focuses on creating adequate income generation opportunities for men and women. Organization of women's labor unions, sensitization campaigns, as well as introducing interventions that build the capacity of women (such as training on desirable skills) are essential in enabling women to benefit equitably with men, both socially and economically, from their labor contributions to the wheat production sector.

Developing effective strategies is badly needed for enhancing the supply of certified seed. The strategy should create a conducive environment for existing seed companies and attract new companies to the sector. Such a strategy will increase competition – the ingredient that provides an incentive for seed companies to be more client oriented. In a competitive market, seed companies will make sure to produce varieties that are in demand by farmers. They will also sell the seeds at affordable prices and make the seed available in the right places at the right times. However, alternatives, such as decentralized seed production, should also be considered. It could promote and provide incentives to small- to medium-scale seed enterprises and might provide a better solution to such problems as shortage of supply and high prices, which are hindering the development of the Moroccan wheat sector. Small- to medium-scale seed enterprises are often effective as they usually have aggressive promotion and marketing strategies, which may even complement the weak link of agricultural extension in the country.

The ideal situation would be for farmers to have access to certified seeds from a menu of more recent varieties that are preferred by farmers and consumers alike, along with access to adequate information about their merits. For this to happen in an imperfect market (for example in cases where seed companies have monopoly power) there is a need for government intervention to reconcile and regulate the conflicts of interest among variety developers, seed companies, farmers, and the country's strategic food security and political agenda.

Particularly, there is a need to:

- Expand the seed distribution network with more selling points by exploring the possibility of involving other private input distributors
- Establish variety distribution maps delineating the geographic adaptation and production cycles of the target areas
- Rehabilitate the public seed networks and establish new agreements between seed companies and ONCA with clear specification of the obligations of each party.

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Annex 1: Durum wheat varietal release database, 1980s to 2012

Variety	Breeder or title holder	Release year
Cocorit	INRA Maroc	1982
Jori	INRA Maroc	1982
Kyperounda	INRA Maroc	1982
Mouline 2	INRA Maroc	1982
Oued Zenati	INRA Maroc	1982
Selbera	INRA Maroc	1982
Zeramek	INRA Maroc	1982
Acsad 65	The Arab Centre for the Studies of Arid Zones and Dry Lands (ACSAD)	1984
Marzak	INRA Maroc	1984
Karim	INRA Maroc	1985
Belbachir	INRA Maroc	1988
Isly	INRA Maroc	1988
Massa	INRA Maroc	1988
Oum Rabia	INRA Maroc	1988
Sarif	INRA Maroc	1988
Sebou	INRA Maroc	1988
Tassaout	INRA Maroc	1988
Tensift	INRA Maroc	1988
Anouar	INRA Maroc	1993
Artena	Semences de Provences	1993
D 2971	Semences de Provences	1993
Driss	Svalof Weibull AB	1993
Jawhar	INRA Maroc	1993
Salah	Svalof Weibull AB	1993
Vitron	Semillas Batlle	1993
Yasmine	INRA Maroc	1993
Amine	Svalof Weibull AB	1994

Variety	Breeder or title holder	Release year
Dauno	I.S.E.A Italie	1994
Fadel	Svalof Weibull AB	1994
Mabrouk	Svalof Weibull AB	1994
Saadi	Agri-Obread Wheatention	1994
Acalou	Prograin Génétique	1995
Amjad	INRA Maroc	1995
Marjane	Svalof Weibull AB	1995
Mimoune	Svalof Weibull AB	1995
Ourhg	INRA Maroc	1995
RGN 0027	Pioneer Hi-Bred Int, Inc	1995
SD 112 87	Navara Semillas	1995
Tarek	INRA Maroc	1995
D 7346 B-1	Svalof Weibull AB	1996
Jabato	Asgrow Semillas	1996
Kievlanka	Florimond Desprez	1996
Marjana	INRA Maroc	1996
Unidur	Grpt Agricole Essonois	1996
Inbar	Volcani Institut Israel	1997
Rgl 095	Pioneer Hi-Bred Int, Inc	1997
Tomouh	INRA Maroc	1997
Ocejon	Agrosa Semillas S. A	1998
Poggio	ETS. C.C Benoist	1998
Parsifal	ETS. C. C Benoist	2000
Razzak	INRA – Maroc	2000
Riyad (sboula)	Semillas Batlle	2000
Amria	INRA Maroc	2003
Chaoui	INRA Maroc	2003
D 97730	ETS. C.C Benoist	2003
D 97906	ETS. C.C Benoist	2003
D 97908	ETS. C.C Benoist	2003
Irden	INRA Maroc	2003
Marouane	INRA Maroc	2003
Nassira	INRA Maroc	2003
Polaris	ETS. C.C Benoist	2003
Llanos	Agrosa Semillas S.A.	2004
Valira	Semillas Batlle S.A.	2004

Variety	Breeder or title holder	Release year
Carioca	Serasem-France	2005
Vitrico	Semillas Batlle	2006
Faraj	INRA Maroc	2007
Prospero	Florimond Desprez	2007
Ginseng	Florimond Desprez	2009
Kanakis	Florimond Desprez	2009
Loukoum	Florimond Desprez	2009
Iride	Societa Produttori	2010
Maestrale	Societa Produttori	2010
Attila	Agri-Obread Wheatentions	2011
Grecale	Produttori Sementi Bologna	2011
Isumur	R 2N France	2011
Latinur	R 2N France	2011
Luiza	INRA Maroc	2011
Nour	Florimond Desprez	2011
Ramirez	Serasem	2011
Reglisse	Florimond Desprez	2011
Saragolla	Produttori Sementi Bologna	2011
Boniduro	Semillas Batlle	2012
Lylou	Florimond Desprez	2012

Annex 2: Bread wheat varietal release database, 1980s to 2012

Variety	Breeder or title holder	Release year
Nesma	INRA Maroc	1982
Pinyte	INRA Maroc	1982
Potam	INRA Maroc	1982
Siete Cerros	INRA Maroc	1982
Teguey 32	INRA Maroc	1982
Teguey 9	INRA Maroc	1982
Jouda	INRA Maroc	1984
Marchouch	INRA Maroc	1984
Acsad 59	The Arab Centre for the Studies of Arid Zones and Dry Lands	1985
Saïs	INRA Maroc	1985
Sibara	INRA Maroc	1985
Achtar	INRA Maroc	1988
Baraka	INRA Maroc	1988
Escualo	Semillas Agricolas	1988
Forton	Semillas Agricolas	1988
Kanz	INRA Maroc	1988
Khair	INRA Maroc	1988
Majdia	AGREX Maroc	1988
Saada	INRA Maroc	1988
Saba	INRA Maroc	1988
Mouna	Svalof Weibull AB	1989
Tilila	INRA Maroc	1989
Triana	S. Petrolifero Shell S.A	1990
Alia	Svalof Weibull AB	1991
Bahia	Svalof Weibull AB	1991
Fulmine	I.S.E.A. Spa-Espagne	1991

Variety	Breeder or title holder	Release year
Safia	Svalof Weibull AB	1991
Amal	INRA Maroc	1993
Andalous	Shell S.A	1993
Arelo	Semences de Provences	1993
Arfort	Semences de Provences	1993
Assma	Svalof Weibull AB	1993
Aziza	Svalof Weibull AB	1993
Bushra	Svalof Weibull AB	1993
Massira	INRA Maroc	1993
Mehdia	INRA Maroc	1993
Passarhinho	Florimond Desprez	1993
Rajae	INRA Maroc	1993
Bonpain	Florimond Desprez	1994
Jakma	I.S.E.A Italie	1994
Randa	I.S.E.A Italie	1994
Almirante	Ets Benoist	1995
Fiuza	Florimond Desprez	1995
Wissam	Ets Lemaire Deffontaine	1995
Aguilal	INRA Maroc	1996
Arrehane	INRA Maroc	1996
Guadaloupe	Florimond Desprez	1996
Mulero	Pioneer Hi-Bred Int, Inc	1996
Nejma	Svalof Weibull AB	1996
Orkauz	Ets Benoist	1996
Tigre	INRA France	1996
Arold	Semences Provences-Fr.	1997
Atir	Hazera Israel	1997
Dariel	Hazera Israel	1997
Panifor	Gae Recherche-France	1997
Orion	Ets C.C Benoist	1998
Elastic	Semillas Batlle	2000
Nabila	Hitech Seeds. V	2000
Nassim	Semillas Batlle	2000
H 97 807	ETS C.C Benoist	2003
H 97 813	ETS C.C Benoist	2003
Manal	Florimond Desprez	2003

Variety	Breeder or title holder	Release year
Salama	Florimond Desprez	2004
Radia	Florimond Desprez	2005
Wafia	Florimond Desprez	2005
Fadela	Florimond Desprez	2008
Samia	Florimond Desprez	2008
Bandera	Serasem	2010
Faiza	Florimond Desprez	2010
Kharoba	INRA Maroc	2010
Mantaza	Semillas Batlle	2010
Najia	Florimond Desprez	2010
Resulton	Semillas Batlle	2010
Zinzibar	Serasem	2010
Aliado	Semillas Batlle	2011
Blini	Florimond Desprez	2011
Farinoso	Semillas Batlle	2011
Gades	R 2N France	2011
Greina	Dsp SA Delley Semences	2011
Sagittario	Produttori Sementi Bologna	2011
Siena	R 2N France	2011
Valbona	Dsp SA Delley Semences	2011
Varuna	Dsp SA Delley Semences	2011
Virgile	Florimond Desprez	2011
Granota	Semillas Batlle	2012
Guadalete	Florimond Desprez	2012
Hi 50	INRA Maroc	2012
Remax	Florimond Desprez	2012

Annex 3: List and background of varieties found in farmers' fields

No.	Variety	Bread or durum	Breeder/applicant for release	Date of release	Cross/pedigree	Selection history	Contains CIMMYT material	Contains material from joint CIMMYT/ICARDA programs	Contains ICARDA material	Contains INRA material	Breeding line	Breeding program
1	Achtar	Bread	INRA Maroc	1988	Hork/Yamhill// Kalyansona/Bluebird (Hork/Ymh//Kal/BB)	INRA-1723		x			CIMMYT segregating line or population	Institut National de la Recherche Agronomique (INRA)
2	Aguilal	Bread	INRA Maroc	1996	SAÏS*2/KS85241-14					x		INRA
3	Amal	Bread	INRA Maroc	1993	Bow's'/Buc's'			x				INRA
4	Amjad	Durum	INRA Maroc	1995	Triticumturgidum/3/ Anhinga/Crane/ Cocorit-71//Bittern		x				Cross made in the country, one CIMMYT parent	INRA
5	Anouar	Durum	INRA Maroc	1993			x				CIMMYT segregating line or population	INRA
6	Arrehane	Bread	INRA Maroc	1996	L222 (KLDN)		x				CIMMYT segregating line or population	INRA
7	Baida	NK										
8	Beldi	NK										
9	Blé dur local	Durum										
10	Blé tendre local	NK										
11	Cocorit	Durum	INRA Maroc	1975	RAE/4*TC60//STW63/3/ AA"S"	D27617	x				CIMMYT segregating line or population (CIMMYT Breeding line - Cocorit (CISNE))	INRA
12	Carioca	Durum	Serasem	2005								
13	El Manar	NK										
14	Wafia	Bread	SONACOS	2005								
15	Faiza	Bread	Florimond Desprez	2010								Florimond Desprez
16	Irride (Iride)	Durum	Societa Produttori	2010	Altar-84/Ionio							PRODUTTORI SEMENTI BOLOGNA
17	Jouda	Bread	INRA Maroc	1984	Kal/Blue Bird (Kal/BB)	II26992	x				Cross made in the country, one CIMMYT parent	INRA
18	Karim	Durum	INRA Maroc	1985	JO"S"/AA"S"//FG"S"	CM9799	x				CIMMYT segregating line or population	INRA
19	Kanz	Bread	INRA Maroc	1988	Pavon's'/4/Pato(R)/Cal/3/ Siete Cerros//BB/CNO or (Pavon/4/Pato/Cal/3/7C// BB/CNO67)			x			CIMMYT segregating line or population	INRA
20	Kievlanka (Krifla Kahla)	Durum	Florimond Desprez	1996								Florimond Desprez
21	Manal	Bread	Florimond Desprez	2003								Florimond Desprez
22	Marzak	Durum	INRA Maroc	1984	BD113		x				CIMMYT segregating line or population	

No.	Variety	Bread or durum	Breeder/applicant for release	Date of release	Cross/pedigree	Selection history	Contains CIMMYT material	Contains material from joint CIMMYT/ICARDA programs	Contains ICARDA material	Contains INRA material	Breeding line	Breeding program
23	Massira	Bread	INRA Maroc	1993	L2266/1406.101// Buckbuck/3/VPM 1/MOS83.11.4.8// Nacozari F76			x			CIMMYT segregating line or population	INRA
24	Mazrouba	NK										
25	Mehdia	Bread	INRA Maroc	1993	JUP/BJY//Ures	CM67458-0MAR [MAR]		x			CIMMYT segregating line or population	INRA
26	Merchouch (Marchouch)	Bread	INRA Maroc	1984	KAL/CNO//2*8156/3/ BT908		x				Cross made in the country, one CIMMYT parent	INRA
27	Nassim (Nessma)	Bread	Semillas Batlle	2000	BT1149//Florence/ Aurore C							Semillas Batlle, SA
28	Ouissane	NK										
29	Oum Rabia	Durum	INRA Maroc	1988	HAU/JORI69		x				Cross made in another country, one CIMMYT parent	INRA
30	Ourgh (Orkauz)	Durum	Ets Benoist	1996	D67GTA/2/Boyero/ Bit//Mexicali		x				CIMMYT advanced line	INRA
31	Prosse Pero	Durum	Florimond Desprez	2007								Florimond Desprez
32	Radia	Bread	Florimond Desprez	2005								
33	Rajae (Raja)	Bread	INRA Maroc	1993	Mor's'/Mon's'		x				CIMMYT segregating line or population	INRA
34	Saada	Bread	INRA Maroc	1988	BUTTE//BUTTE/ Arthur71	SD8036					Cross made in other country, no CIMMYT parents	INRA
35	Salama	Bread	Florimond Desprez	2004								Florimond Desprez
36	Tigre	Bread	INRA France	1996								
37	Tomouh	Durum	INRA Maroc	1997	Jori69/ Haurani=OumRabi6	L0589-3L-1AP-2AP-1AP-0SH-0AP			x		ICARDA	INRA (Direct release)
38	Viton (Vitron)	Durum	Semillas Batlle	1993								Semillas Batlle, SA
39	Vitrico	Durum	Semillas Batlle	2006								
40	Wissam (Alliance)	Bread	Ets Lemaire Deffontaine	1995	Cheyenne//Frontana/ Etoile-De-Choisy							Semences LEMAIRE DEFFONTAINES

Annex 4: Quantity of seeds (000 quintals) used by variety and province

Variety	Province									
	Beni Mellal	Benslimane	Berrechid	El Hajeb	El Jadida	El Kelâa	Fez	Guercif	Kénitra	Khemisset
Achtar	68.60	27.92	0.98	25.05	101.76	42.94	0.00	4.57	148.09	7.92
Amal	4.64	0.00	3.42	4.02	2.80	0.40	3.83	0.00	29.18	0.00
Karim	105.57	11.40	8.46	4.53	22.33	20.23	3.86	7.43	1.47	19.16
Radia	0.00	0.00	34.02	28.27	7.25	8.14	0.00	0.00	0.28	31.64
Merchouch	91.63	5.55	0.51	8.29	6.55	27.19	10.89	10.72	5.88	4.59
Marzak	33.52	8.80	25.02	1.05	5.00	18.43	0.00	5.06	0.34	0.47
Arrehane	0.00	39.22	1.28	2.23	14.81	0.00	0.00	0.00	4.61	185.40
Crioca	0.00	9.18	32.81	0.00	0.00	0.24	0.00	0.00	0.00	0.00
Wissam	0.00	0.00	0.00	1.77	0.00	0.00	4.15	0.00	0.00	1.58
Salama	0.13	0.00	10.56	0.00	9.34	0.38	0.00	0.00	0.00	5.26
Saidi	0.00	0.00	0.00	0.00	0.00	2.90	0.96	4.88	0.00	0.00
Tigre	0.00	0.00	0.00	1.05	0.00	0.00	0.00	0.00	9.40	0.00
Blé tendre local	8.73	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Raja	0.00	4.90	0.00	13.63	0.00	0.00	0.00	0.81	0.00	0.00
Nessma	0.00	0.00	9.91	0.65	0.00	0.00	0.00	0.00	0.00	0.00
Viton	2.41	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Baida	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
El Wafia	0.00	0.00	12.87	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cocorit	3.46	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Aguilal	0.00	0.00	0.00	0.00	7.75	0.00	0.00	0.00	0.00	0.00
Beldi	0.00	0.00	0.00	0.00	0.97	0.00	0.00	0.00	0.00	0.00
Prosse Pero	0.00	0.00	4.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oum Rabia	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Blé dur local	3.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Province													
Khenifra	Meknes	My Yacoub	Rehamna	Safi	Settat	Sidi Bennour	Sidi Kacem	Sidi Slimane	Taounate	Taza	Total	Cumulative
39.24	14.51	20.30	83.98	17.09	5.03	50.48	33.96	8.65	29.13	1.40	731.60	3,851.92
0.00	51.21	38.85	3.33	107.01	10.84	18.39	140.07	18.08	80.61	0.00	516.70	3,120.32
3.20	9.00	32.23	33.30	25.67	37.57	32.16	18.17	5.28	55.58	23.49	480.09	2,603.62
0.00	14.20	6.63	5.00	78.30	74.69	19.14	122.78	2.41	12.51	0.00	445.25	2,123.53
0.00	4.85	6.97	99.69	13.03	21.99	20.17	3.32	23.24	41.04	23.39	429.50	1,678.29
46.99	0.00	4.18	15.51	6.24	102.66	42.35	0.53	0.00	7.16	34.57	357.86	1,248.78
2.46	12.32	0.00	0.06	3.22	14.75	4.85	30.99	1.01	0.00	1.12	318.33	890.92
0.00	0.00	0.00	0.77	35.37	40.38	2.25	0.00	0.00	0.00	0.00	121.00	572.59
0.00	2.11	25.30	0.00	0.00	0.00	0.00	0.00	0.00	48.52	0.00	83.42	451.59
0.00	4.18	0.00	1.14	15.26	14.77	12.55	0.00	0.00	0.00	0.00	73.55	368.17
0.00	0.00	0.69	13.72	19.51	0.00	0.00	0.00	0.00	0.00	30.67	73.33	294.62
0.00	23.45	0.00	0.40	0.00	0.00	0.00	0.00	0.00	2.19	0.00	36.49	221.29
23.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	32.07	184.80
0.00	0.00	5.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.78	26.54	152.73
5.72	0.00	0.00	0.37	0.00	5.25	0.00	0.00	0.00	0.00	0.00	21.90	126.18
0.00	0.00	8.33	0.20	0.00	1.09	0.00	0.00	0.00	2.92	0.00	14.95	104.28
14.79	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	14.79	89.34
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.87	74.54
0.76	0.00	0.00	0.00	0.16	0.00	0.00	0.00	0.00	0.00	6.21	10.59	61.67
0.00	0.00	0.00	0.00	0.00	1.09	0.00	0.00	0.00	0.00	0.00	8.84	51.08
0.00	0.00	0.00	0.00	1.48	0.00	1.88	0.00	0.00	0.69	0.00	5.03	42.24
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.07	37.21
3.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.32	33.14
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.31	29.82

Variety	Province									
	Beni Mellal	Benslimane	Berrechid	El Hajeb	El Jadida	El Kelâa	Fez	Guercif	Kénitra	Khemisset
Kenz	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tomouh	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Irride	0.00	0.00	2.85	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Massira	0.00	0.00	0.00	1.12	0.00	0.00	0.00	0.00	0.00	0.00
Mehdia	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Manal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Amjad	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.01
Faiza	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
El Manar	0.00	0.00	1.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Anouar	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ouissane	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Krifla Kahla	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mazrouba	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Vitrico	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ourgh	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Jouda	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	**321.99**	**106.99**	**148.34**	**91.65**	**178.55**	**120.83**	**23.69**	**33.47**	**199.25**	**258.02**

Province													
Khenifra	Meknes	My Yacoub	Rehamna	Safi	Settat	Sidi Bennour	Sidi Kacem	Sidi Slimane	Taounate	Taza	Total	Cumulative
3.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.15	26.51
0.00	3.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.07	23.36
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.85	20.29
0.00	0.00	1.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.38	17.44
0.00	0.00	0.00	0.96	0.00	1.28	0.00	0.00	0.00	0.00	0.00	2.24	15.06
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.19	0.00	2.19	12.81
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.01	10.62
0.00	0.00	0.00	0.00	0.00	1.92	0.00	0.00	0.00	0.00	0.00	1.92	8.61
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.58	6.70
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.17	0.00	1.17	5.11
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.13	0.00	1.13	3.94
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.84	0.00	0.84	2.82
0.00	0.00	0.00	0.47	0.00	0.00	0.00	0.00	0.00	0.26	0.00	0.73	1.97
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.61	0.00	0.61	1.24
0.00	0.00	0.00	0.00	0.60	0.00	0.00	0.00	0.00	0.00	0.00	0.60	0.64
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.04	0.04
142.97	**138.91**	**150.17**	**258.90**	**322.95**	**333.32**	**204.22**	**349.82**	**58.67**	**286.58**	**122.62**	**3,851.92**	

Annex 5: Proportion of seed use by variety and source (%)

Variety	Source						
	State	NOS*	Local seed retailer	Retailers outside the village	Seed companies	Cooperatives	Total
Achtar	20.61	60.54	4.29	10.57	3.98	0.00	100
Salama	13.82	41.45	9.99	26.76	7.97	0.00	100
Arrehane	2.68	40.18	19.36	25.41	12.37	0.00	100
Aguilal	23.34	76.66	0.00	0.00	0.00	0.00	100
Radia	14.61	45.42	31.56	5.69	2.71	0.00	100
Raja	1.11	74.49	2.78	21.62	0.00	0.00	100
Amal	16.52	51.61	14.80	12.46	4.60	0.00	100
Tigre	15.41	80.45	4.14	0.00	0.00	0.00	100
Merchouch	32.51	48.18	8.11	9.58	1.09	0.53	100
Karim	11.47	48.92	16.36	16.79	6.21	0.27	100
Crioca	21.61	39.02	12.49	22.54	4.34	0.00	100
Oum Rabia	94.16	0.00	5.84	0.00	0.00	0.00	100
Tomouh	0.00	100	0.00	0.00	0.00	0.00	100
Marzak	23.45	47.81	10.73	15.49	2.52	0.00	100
Ourgh	0.00	0.00	0.00	0.00	100	0.00	100
Viton	5.96	34.65	0.00	59.39	0.00	0.00	100
Vitrico	0.00	0.00	100	0.00	0.00	0.00	100
Saidi	4.87	57.83	11.51	23.37	2.42	0.00	100
Cocorit	15.13	9.63	10.02	62.93	2.29	0.00	100
Beldi	11.95	29.21	0.00	34.50	24.34	0.00	100
Mazrouba	100	0.00	0.00	0.00	0.00	0.00	100
Mehdia	0.00	70.82	0.00	0.00	29.18	0.00	100
Anouar	0.00	56.16	43.84	0.00	0.00	0.00	100
Ouissane	100	0.00	0.00	0.00	0.00	0.00	100
Krifla Kahla	0.00	100	0.00	0.00	0.00	0.00	100

Variety	Source						
	State	NOS*	Local seed retailer	Retailers outside the village	Seed companies	Cooperatives	Total
Wissam	4.17	56.28	16.37	18.05	5.13	0.00	100
Jouda	0.00	100	0.00	0.00	0.00	0.00	100
Nessma	4.02	26.71	56.81	9.95	2.51	0.00	100
Massira	0.00	53.14	0.00	46.86	0.00	0.00	100
Manal	0.00	0.00	100	0.00	0.00	0.00	100
Blé tendre local	15.42	70.05	8.55	5.97	0.00	0.00	100
Faiza	0.00	100	0.00	0.00	0.00	0.00	100
Blé dur local	39.83	60.17	0.00	0.00	0.00	0.00	100
Amjad	0.00	100	0.00	0.00	0.00	0.00	100
Irride	0.00	26.32	73.68	0.00	0.00	0.00	100
Prosse Pero	0.00	100	0.00	0.00	0.00	0.00	100
El Wafia	37.43	62.57	0.00	0.00	0.00	0.00	100
El Manar	0.00	100	0.00	0.00	0.00	0.00	100
Baida	3.94	56.38	27.28	0.00	12.40	0.00	100
Kenz	0.00	100	0.00	0.00	0.00	0.00	100
Total	**17.81**	**51.19**	**13.30**	**13.39**	**4.21**	**0.10**	**100**

* NOS – Non-Official Sources including own-saved seed.

Annex 6: Yield (kg/ha) by adoption, irrigation, seed type, and agro-ecology

Agro-ecological zone	Adoption status	Irrigation	Total area (ha)			% of total area			Yield (kg/ha) – Area weighted average		
			Certified seed users	Uncertified seed users	Total area (ha)	Certified seed users	Uncertified seed users	Total	Certified seed users	Uncertified seed users	Total
Total of 21 sample provinces	Adopters	Yes	57,895.55	138,655.85	196,551.40	3%	6%	9%	5,573.43	4,738.41	5,209.12
		No	608,038.82	181,075.56	789,114.38	28%	8%	36%	1,214.03	949.12	1,155.67
		Total	665,934.37	319,731.41	985,665.78	31%	14%	45%	1,950.33	1,943.14	1,906.82
	Non-adopters	Yes	60,075.78	116,966.59	177,042.38	3%	5%	8%	3,570.30	3,409.19	3,415.00
		No	263,875.95	771,415.89	103,5291.84	12%	35%	47%	859.33	735.55	773.67
		Total	323,951.73	888,382.48	1,212,334.22	15%	40%	55%	1,385.88	1,125.26	1,234.48
	Total	**Yes**	**117,971.34**	**255,622.44**	**373,593.78**	**5%**	**12%**	**17%**	**4,290.35**	**3,682.68**	**3,975.39**
		No	**871,914.77**	**952,491.46**	**1,824,406.22**	**40%**	**43%**	**83%**	**1,047.99**	**756.65**	**908.96**
		Total	**989,886.10**	**1,208,113.90**	**2,198,000.00**	**45%**	**55%**	**100%**	**1,656.94**	**1,285.41**	**1,479.30**
Favorable	Adopters	Yes	18,771.85	78,545.75	97,317.60	2%	8%	10%	4,941.06	4,877.97	4,960.83
		No	345,678.64	131,102.40	476,781.03	36%	13%	49%	1,227.20	1,007.22	1,180.35
		Total	364,450.48	209,648.15	574,098.63	38%	21%	59%	1,467.01	1,955.60	1,600.82
	Non-adopters	Yes	11,977.34	9,151.90	21,129.24	1%	1%	2%	3,311.62	2,983.12	3,180.32
		No	117,352.80	258,912.33	376,265.13	12%	27%	39%	872.28	752.80	788.02
		Total	129,330.14	268,064.23	397,394.37	13%	28%	41%	1,186.40	1,185.60	1,257.60
	Total	**Yes**	**30,749.19**	**87,697.65**	**118,446.84**	**3%**	**9%**	**12%**	**4,410.33**	**4,217.22**	**4,315.95**
		No	**463,031.43**	**390,014.73**	**853,046.16**	**48%**	**40%**	**88%**	**1,103.48**	**809.67**	**969.76**
		Total	**493,780.62**	**477,712.38**	**971,493.00**	**51%**	**49%**	**100%**	**1,362.09**	**1,474.43**	**1,417.64**
Intermediate	Adopters	Yes	21,266.80	7,541.27	28,808.07	3%	1%	4%	5,435.97	4,807.03	5,319.93
		No	200,481.63	45,886.28	246,367.91	28%	6%	34%	1,214.25	912.34	1,168.99
		Total	221,748.43	53,427.55	275,175.98	31%	7%	38%	1,615.66	1,316.83	1,560.50
	Non-adopters	Yes	29,257.93	69,241.60	98,499.53	4%	10%	14%	3,492.96	3,388.49	3,420.70
		No	63,171.78	272,079.71	335,251.49	9%	38%	47%	829.05	742.78	762.54
		Total	92,429.71	341,321.31	433,751.02	13%	48%	61%	1,585.13	1,113.96	1,233.72
	Total	**Yes**	**50,524.73**	**76,782.87**	**127,307.60**	**7%**	**11%**	**18%**	**4,329.28**	**3,555.69**	**3,919.24**
		No	**263,653.41**	**317,965.99**	**581,619.40**	**37%**	**45%**	**82%**	**1,109.71**	**737.57**	**906.21**
		Total	**314,178.14**	**394,748.86**	**708,927.00**	**44%**	**56%**	**100%**	**1,586.47**	**1,125.71**	**1,344.53**

Agro-ecological zone	Adoption status	Irrigation	Total area (ha)			% of total area			Yield (kg/ha) – Area weighted average		
			Certified seed users	Uncertified seed users	Total area (ha)	Certified seed users	Uncertified seed users	Total	Certified seed users	Uncertified seed users	Total
Unfavorable South	Adopters	Yes	17,417.21	51,249.73	68,666.95	7%	22%	29%	5,926.73	4,646.52	5,619.71
		No	60,474.26	2,482.00	62,956.26	26%	1%	27%	1,297.49	893.88	1,281.08
		Total	77,891.47	53,731.73	131,623.20	33%	23%	56%	2,561.64	3,917.14	2,623.32
	Non-adopters	Yes	8,991.30	18,741.38	27,732.68	4%	8%	12%	3,462.18	3,321.09	3,382.44
		No	17,441.46	57,882.66	75,324.12	7%	25%	32%	885.72	775.11	817.11
		Total	26,432.76	76,624.04	103,056.80	11%	33%	44%	1,734.21	1,810.45	1,833.85
	Total	**Yes**	**26,408.51**	**69,991.11**	**96,399.62**	**11%**	**30%**	**41%**	**4,777.21**	**3,785.29**	**4,483.10**
		No	**77,915.72**	**60,364.66**	**138,280.38**	**33%**	**26%**	**59%**	**1,135.40**	**783.13**	**963.47**
		Total	**104,324.23**	**130,355.77**	**234,680.00**	**44%**	**56%**	**100%**	**2,135.59**	**1,757.14**	**1,995.41**
Mountainous	Adopters	Yes	439.70	1,319.09	1,758.79	0%	0%	1%	5,313.50	4,713.50	5,013.50
		No	1,404.29	1,604.89	3,009.18	0%	1%	1%	87.16	813.50	1,114.05
		Total	1,843.99	2,923.99	4,767.97	1%	1%	2%	957.82	2,763.50	2,533.79
	Non-adopters	Yes	9,849.21	19,831.72	29,680.93	3%	7%	10%	3,527.79	3,419.10	3,458.20
		No	65,909.91	182,541.19	248,451.10	23%	65%	88%	864.75	703.72	747.78
		Total	75,759.12	202,372.90	278,132.03	27%	72%	98%	1,437.06	1,087.00	1,184.60
	Total	**Yes**	**10,288.91**	**21,150.81**	**31,439.72**	**4%**	**7%**	**11%**	**3,646.83**	**3,470.65**	**3,535.30**
		No	**67,314.20**	**184,146.08**	**251,460.28**	**24%**	**65%**	**89%**	**874.90**	**704.55**	**751.61**
		Total	**77,603.11**	**205,296.89**	**282,900.00**	**27%**	**73%**	**100%**	**1,477.88**	**1,106.82**	**1,213.00**

Annex 7: Seed rate (kg/ha) by adoption, irrigation, seed type, and agro-ecology

Agro-ecological zone	Adoption status	Irrigation	Total area (ha)		Seed rate (kg/ha) – Area weighted average		
			Certified seed users	Uncertified seed users	Total area (ha)	Certified seed users	Uncertified seed users	Total
Total of 21 sample provinces	Adopters	Yes	5,7895.6	138,655.8	196,551.4	252.8	246.0	247.4
		No	608,038.8	181,075.6	789,114.4	159.2	154.9	157.4
		Total	665,934.4	319,731.4	985,665.8	172.7	175.3	172.6
	Non-adopters	Yes	60,075.8	116,966.6	177,042.4	240.6	254.1	255.1
		No	263,875.9	771,415.9	1,035,291.8	153.5	157.0	156.0
		Total	323,951.7	888,382.5	1,212,334.2	174.2	171.3	173.4
	Total	**Yes**	**117,971.3**	**255,622.4**	**373,593.8**	**243.7**	**254.7**	**255.1**
		No	**871,914.8**	**952,491.5**	**1,824,406.2**	**157.6**	**156.8**	**157.4**
		Total	**989,886.1**	**1,208,113.9**	**2,198,000.0**	**175.9**	**173.0**	**174.0**
Favorable	Adopters	Yes	18,771.85	78,545.75	97,317.60	260.54	232.92	251.68
		No	345,678.64	131,102.40	476,781.03	164.04	153.40	162.24
		Total	364,450.48	209,648.15	574,098.63	170.80	175.20	172.43
	Non-adopters	Yes	11,977.34	9,151.90	21,129.24	227.82	213.15	229.33
		No	117,352.80	258,912.33	376,265.13	153.55	156.36	155.80
		Total	129,330.14	268,064.23	397,394.37	165.24	172.03	173.90
	Total	**Yes**	**30,749.19**	**87,697.65**	**118,446.84**	**264.55**	**248.72**	**255.08**
		No	**463,031.43**	**390,014.73**	**853,046.16**	**160.40**	**158.30**	**159.16**
		Total	**493,780.62**	**477,712.38**	**971,493.00**	**168.71**	**177.14**	**172.26**
Intermediate	Adopters	Yes	21,266.8	7,541.3	28,808.1	254.58	243.37	252.67
		No	200,481.6	45,886.3	246,367.9	158.09	156.19	157.83
		Total	221,748.4	53,427.5	275,176.0	167.28	164.82	166.74
	Non-adopters	Yes	29,257.9	69,241.6	98,499.5	250.13	262.46	258.54
		No	63,171.8	272,079.7	335,251.5	155.34	160.38	158.94
		Total	92,429.7	341,321.3	433,751.0	180.85	174.28	175.42
	Total	**Yes**	**50,524.7**	**76,782.9**	**127,307.6**	**252.18**	**260.71**	**257.33**
		No	**263,653.4**	**317,966.0**	**581,619.4**	**157.06**	**159.65**	**158.10**
		Total	**314,178.1**	**394,748.9**	**708,927.0**	**171.26**	**172.62**	**171.86**

Agro-ecological zone	Adoption status	Irrigation	Total area (ha)	
			Certified seed users	Uncertified seed users
Unfavorable South	Adopters	Yes	17,417.2	51,249.7
		No	60,474.3	2,482.0
		Total	77,891.5	53,731.7
	Non-adopters	Yes	8,991.3	18,741.4
		No	17,441.5	57,882.7
		Total	26,432.8	76,624.0
	Total	**Yes**	**26,408.5**	**69,991.1**
		No	**77,915.7**	**60,364.7**
		Total	**104,324.2**	**130,355.8**
Mountainous	Adopters	Yes	439.7	1,319.1
		No	1,404.3	1,604.9
		Total	1,844.0	2,924.0
	Non-adopters	Yes	9,849.2	19,831.7
		No	65,909.9	182,541.2
		Total	75,759.1	202,372.9
	Total	**Yes**	**10,288.9**	**21,150.8**
		No	**67,314.2**	**184,146.1**
		Total	**77,603.1**	**205,296.9**

	Seed rate (kg/ha) – Area weighted average		
Total area (ha)	Certified seed users	Uncertified seed users	Total
68,666.9	231.07	253.86	241.36
62,956.3	163.57	111.58	161.54
131,623.2	183.12	225.82	186.00
27,732.7	241.35	240.36	241.08
75,324.1	151.51	152.64	150.72
103,056.8	181.51	188.38	186.98
96,399.6	**238.35**	**243.76**	**240.50**
138,280.4	**159.85**	**150.04**	**154.63**
234,680.0	**180.68**	**182.78**	**182.40**
1,758.8	267.50	262.50	265.00
3,009.2	9.04	150.00	157.38
4,768.0	57.08	206.25	196.47
29,680.9	256.71	246.88	250.48
248,451.1	151.83	157.33	156.09
278,132.0	174.74	169.91	171.28
31,439.7	**257.43**	**247.48**	**251.20**
251,460.3	**151.68**	**157.29**	**155.95**
282,900.0	**175.12**	**170.35**	**171.73**

Annex 8: Net wheat income (MAD/ha) by adoption, irrigation, seed type, and agro-ecology

Agro-ecological zone	Adoption status	Irrigation	Net income (MAD/ha) – Area weigthed average		
			Certified seed users	Uncertified seed users	Total
Total of 21 sample provinces	Adopters	Yes	17,435.05	15,639.97	16,720.76
		No	3,325.38	2,721.31	3,180.21
		Total	5,801.08	6,218.82	5,722.95
	Non-adopters	Yes	12,046.19	11,425.81	1,1416.12
		No	2,139.71	1,856.64	1,937.72
		Total	4,067.61	3,313.08	3,649.69
	Total	**Yes**	**13,871.60**	**12,303.86**	**13,031.36**
		No	**2,778.92**	**1,953.68**	**2,384.99**
		Total	**4,927.86**	**3,878.95**	**4,404.06**
Favorable	Adopters	Yes	15,947.72	15,772.43	15,688.48
		No	3,312.38	2,888.29	3,242.10
		Total	4,122.07	6,070.79	4,642.43
	Non-adopters	Yes	11,090.13	10,512.47	10,800.70
		No	2,135.80	2,048.86	2,061.88
		Total	3,245.97	3,668.41	3,796.84
	Total	**Yes**	**14,445.78**	**13,768.43**	**13,877.14**
		No	**2,900.56**	**2,242.68**	**2,598.86**
		Total	**3,794.83**	**4,569.01**	**4,141.54**
Intermediate	Adopters	Yes	17,185.21	14,912.28	16,676.13
		No	3,313.06	2,596.75	3,204.05
		Total	4,654.81	3,902.08	4,503.23
	Non-adopters	Yes	12,093.83	11,198.78	11,454.50
		No	2,048.42	1,905.56	1,932.73
		Total	4,840.11	3,299.46	3,673.36
	Total	**Yes**	**14,305.11**	**11,617.97**	**12,829.66**
		No	**2,939.63**	**1,942.86**	**2,371.77**
		Total	**4,641.80**	**3,328.54**	**3,937.32**

Agro-ecological zone	Adoption status	Irrigation	Net income (MAD/ha) – Area weigthed average		
			Certified seed users	Uncertified seed users	Total
Unfavorable South	Adopters	Yes	18,701.58	15,889.00	17,893.03
		No	3,611.87	3,165.80	3,595.80
		Total	7,707.07	13,429.88	8,023.70
	Non-adopters	Yes	11,720.31	11,487.15	11,556.84
		No	2,471.22	2,030.37	2,202.26
		Total	5,502.95	5,876.09	5,904.21
	Total	**Yes**	**15,368.65**	**12,861.47**	**14,643.52**
		No	**3,158.22**	**2,094.74**	**2,642.17**
		Total	**6,497.33**	**5,603.41**	**6,206.28**
Mountainous	Adopters	Yes	15,798.20	18,088.80	16,943.50
		No	278.69	2,176.75	3,370.27
		Total	2,885.01	10,132.78	8,312.20
	Non-adopters	Yes	12,100.38	11,467.45	11,697.03
		No	2,021.30	1,698.82	1,787.90
		Total	4,184.80	3,078.41	3,384.93
	Total	**Yes**	**12,346.90**	**11,730.11**	**11,957.06**
		No	**2,073.91**	**1,702.33**	**1,805.47**
		Total	**4,305.80**	**3,161.44**	**3,488.09**

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Political Economy of the Wheat Sector in Morocco: Seed Systems, Varietal Adoption, and Impacts

Literature on the wheat sector in Morocco has been very thin on the ground. This is particularly so for national-level analysis of the country's seed system and varietal release, adoption, and impacts. By producing this book, the authors aim to address this gap in analysis.

As well as a review of existing literature on the topic, this book provides a comprehensive analysis of the seed system in Morocco, using published and unpublished secondary data collected from different sources; some of this data are not adequately documented elsewhere. The book also uses a large dataset collected from a representative sample of 1,230 wheat-growing farm households. These households reside in the 21 major wheat-growing provinces of Morocco, which constitute more than 75% of total wheat production in the country.

This book provides a thorough analysis of the historical evolution of the institutional and policy environment – in Morocco's wheat sector in general and the seed system in particular. It also provides adoption, impacts, and seed demand analysis at household, district, province, and national levels. Given the tremendous amount of data and information this book contains, I believe that it will not only provide guidance for necessary institutional, regulatory, and policy reforms, but will also be the single most important reference material regarding the wheat sector in Morocco for many years to come. The methodological background and the results reported in this book could also inspire similar work in other countries.

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Established in 1977, the International Center for Agricultural Research in the Dry Areas (ICARDA) is a non-profit, CGIAR Research Center that focusses on delivering innovative solutions for sustainable agricultural development in the non-tropical dry areas of the developing world.

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