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Reintroduction of native cotton (*Gossypium Barbadian*) on the North coast of Peru: Analysis of economic feasibility for small producers

Reintroducción de algodón nativo (*Gossypium Barbadense*) en la costa norte del Perú: Análisis de factibilidad económica para pequeños productores

Elena Pisani [1], Mauro Masiero [1], Stefano Scrocco [2]

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Abstract

In Peru the agro-export boom has determined a major shift of large farmers from traditional agro-industrial crops (coffee and cotton) to new agribusinesses (asparagus, oranges, avocados, apples). These dynamics have left room for the small farmers to enter the traditional agro-industrial sector, or into new niche markets as in the case of native cotton. On the North coast of Peru the cultivation of the native and naturally coloured cotton (*Gossypium Barbadense* spp. locally called *algodón El País*) is part of the Moche indigenous culture (a local pre-Inca population). Since 1949 the Peruvian legal prohibition to produce native cotton, linked to the risk of genetic contamination of the industrial white cotton cultivations, made the keeping of these traditional varieties very difficult. Nevertheless the situation has totally changed since 2008 due to Regulation n° 29224 declaring native cotton as a genetic, ethnic and cultural heritage of the country. This study analyses the economic feasibility of re-inserting the native cotton as part of the agricultural production of 50 farmers on the North coast of Peru, proposing a farm economic data analysis, scenario analysis and sensitivity analysis based on OFAT (One Factor at A Time) methodology: the results attest that in all the productive scenarios proposed (10%, 25% and 50% of the farm agricultural surface growing native cotton) the average farm incomes are going to increase. Moreover the sensitivity analysis attests that also in the worst conditions of a 10% decrease in the native cotton price, the average farm incomes with native cotton are higher compared to the business as usual scenario in all three productive scenarios proposed.

Keywords

Gossypium Barbadense • native cotton • small farmers • farm economic data analysis • scenario analysis • sensitivity analysis • Peru

1 Dip. Territorio e Sistemi Agro-forestali dell'Università di Padova, Italia. elenapisani@unipd.it

2 University of Salford - Greater Manchester. The Crescent, Salford, Lancashire M5 4WT, Reino Unido. England

Resumen

En Perú, el auge de la agro-exportación ha determinado un gran cambio para los grandes agricultores, desde los cultivos agrícolas tradicionales (café y algodón) hasta los nuevos agro-negocios (espárragos, naranjas, aguacates, manzanas). Esta dinámica ha dejado espacio a los pequeños agricultores para entrar en el sector agro-industrial tradicional, o en los nuevos nichos de mercados como el del algodón nativo. En la costa norte de Perú el cultivo de algodón nativo y coloreado naturalmente (*Gossypium Barbadense* spp. localmente llamado *algodón El País*) es parte de la cultura indígena Moche (una población local pre-Inca). Desde 1949 la prohibición legal peruana para producir algodón nativo, conectada con el riesgo de la contaminación genética del algodón industrial blanco, hizo muy difícil el mantenimiento de estas variedades tradicionales. Sin embargo, desde 2008 la situación ha cambiado totalmente debido a la Ley n° 29224, afirmando al algodón nativo como la herencia genética, étnica y cultural del país. El presente estudio analiza la factibilidad económica de re-introducir el algodón nativo como parte de la producción agrícola de 50 agricultores en la costa norte de Perú, proponiendo un análisis de los datos económicos de los agricultores, un análisis de escenarios y un análisis de sensibilidad basado en la metodología *OFAT* (One Factor at A Time): los resultados atestiguan que en todos los diferentes escenarios productivos propuestos (10%, 25% y 50% de la superficie agrícola de los agricultores dedicada al algodón nativo), el promedio de los ingresos de los agricultores aumentará. Además, el análisis de sensibilidad atestigua que también en un escenario pesimista de una reducción del 10% del precio del algodón nativo, el promedio de los ingresos de los agricultores con el algodón nativo son mayores comparados con el escenario *business as usual* en cada uno de los tres escenarios productivos propuestos.

Palabras clave

Gossypium Barbadense • algodón nativo • pequeños agricultores • análisis de datos económicos agrícolas • análisis de escenarios • análisis de sensibilidad • Perú

Introduction

The Peruvian agricultural sector underwent a major shift towards neo-liberal policies over the last three decades (9, 25, 32, 35, 44), based on a market-led development, guided by the principles of the Washington Consensus and consolidated by the trade reforms opening Latin America to the international markets (8, 45, 51). The State agro-industrial, marketing, technical assistance and banking enterprises were privatized, drastically reducing the subsidized services for small farmers and peasants. Moreover liberalization of the trade regime, removal of control on domestic prices, devaluation policies, and tariff reductions have opened new opportunities for commercial farmers to exploit the export market specifically in relation to non–traditional agro-exports (11, 12, 13).

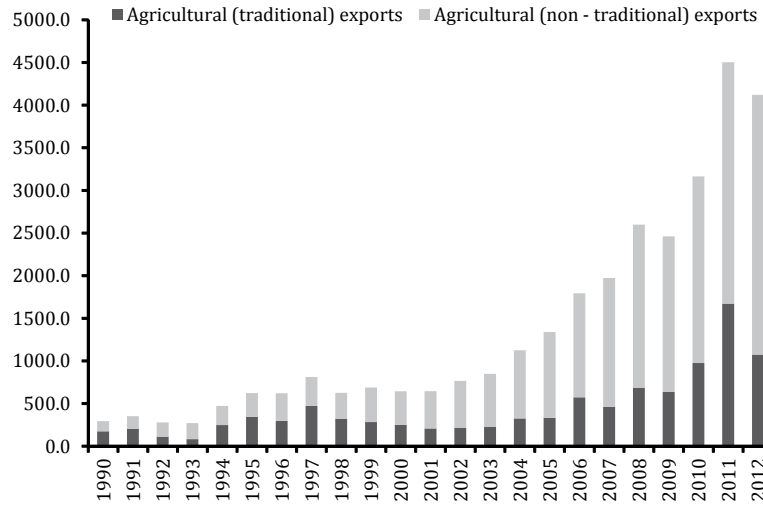
Peru was historically considered a traditional Latin American cradle of the cotton agroindustry, but since the mid-1990s the Toledo-Fujimori-García administrations have promoted the diversification of exports specifically in the high value-added export products (such as asparagus, avocados, grapes, citrus), benefiting from a strong global demand. Peru's total agricultural exports increased from US$ 293.8 million in 1990 to US$ 4,121.8 million in 2012, the rise being mainly due to non-traditional agricultural exports (asparagus, grapes and artichokes) (figure 1).

The asparagus agroindustry has been considered the engine of Peruvian economic growth in recent years (15, 16, 17, 22), determining a substantial change in the economic and institutional dynamics of the coastal agricultural production system.

The asparagus agroindustry has concentrated in specific areas (from the mid-1980s in Ica region and from the mid-1990s in La Libertad region) where a favourable climate allows cultivation for almost the entire year, with a yield ranging from 14 to 24 MT/ha (depending on the regional conditions), which is amongst the highest in the world.

Cost analyses clearly describe the features of asparagus production: high capital-intensive investments, strong coordination required in the production, and integrated post-harvest and distribution stages in order to maintain the quality and safety of the products.

The needs to reduce costs, improve efficiency and lower risks are pushing the agroindustry towards a higher concentration and vertical integration, also sustained by the requirement to comply with stringent public and private standards on quality and safety issues (43).



Source: (6) - Fuente: (6)

Figure 1. Peruvian agricultural exports (traditional and non-traditional) 1990-2012.
Figura 1. Agro-exportaciones peruanas (tradicionales y no tradicionales) 1990-2012.

The opportunity offered by the reforms of the mid-1990s has opened the possibility for the agroindustry to directly own cropland, and consequently to integrate vertically.

These economic and institutional elements represent barriers to entry, which are relevant hindrances for small farmers. The majority of smallholders face numerous constraints that limit their ability to enter the new high-value agriculture value chains, excluding them from important growth opportunity (20, 42). But, as usual, there are two sides to the coin: the major shift of large farmers out of the cotton sector and into asparagus, orange, apple, avocado and *lucuma* has left room for small farmers (little *parceleros*) to start cotton production, not so profitable as the new agribusinesses, but less demanding in terms of investments and organization (12).

Moreover, in very recent years, new economic opportunities have emerged for local farmers tied to the organic cotton niche markets and the related eco-textiles labelling (36, 52). Wang *et al.* (2012) address the question of "textile ecology", described as a growing interest of the general public in the topics of environmental protection and social inclusion as applied by the textile industry in developed and developing countries. With specific reference to organic cotton farming, Abrar *et al.* (2009) sustain that this has been a profitable business in many developing countries based on the use of cheap labour and new organizational schemes. Moreover the conversion from traditional to organic farming is relatively simpler than in developed countries, given that farmers use fewer fertilizers, pesticides, herbicides and genetically modified seeds - due to their relative high costs - and prefer to rely on traditional practices that are environmentally and economically sustainable and minimize risk (2, 38). Besides the agronomic and ecological conditions, the inclusion of small producers in the national and international organic cotton supply chain is a required condition in order to link the local producers with Western consumers. Since the 1980s Fair-trade and Organic product certifications were developed in niche markets, then in the 1990s companies started to join these standards in order to increase their market share and, from the 2000, new forms of self-regulating cooperation among market and non-market actors have emerged, all using third-party certification to document their environmental and social responsibility (18).

Before entering a certification scheme, a sound economic analysis is needed in order to verify the opportunity cost for small farmers to join the new business and to assess the related risks. In this regard many applied researches have been done for India and Pakistan (14, 21, 33, 39), which are important organic cotton producers at international level. Despite the increasing attention on the possibilities for inclusion of small farmers in the organic market chain, it must be noted that limited consideration has been given to native cotton. The scientific literature on native cotton is more concentrated on specific topics such as hybridization between alien plant species and their native congeners (34) and on genetic improvement (26) and not on analysis of costs that smallholders sustain when trying to produce native cotton and to enter more commercial market chains. The research objective of the present paper is to contribute to fill the gap in knowledge related to the native cotton supply by quantitatively analysing how its re-introduction as an

agricultural production could change small farmers' incomes. The analysis is conducted using a farm economic data analysis, scenario analysis, and sensitivity analysis, grounded on OFAT (One Factor at A Time) methodology, based on a cross-sectional dataset of economic and agronomic farm-level data, collected in 2010 by means of a survey, and related to 50 enterprises operating on the North coast of Peru.

The proposed approach is based on estimates of costs and revenues, and on different quantitative scenarios (hypothesis) of native cotton re-introduction (specifically 10%, 25% and 50% of the farmland destined to the crop) and comparing the results with the business as usual scenario (without native cotton). Based on these first results the sensitivity analysis highlights the most favourable conditions in terms of prices, allowing the robustness of the quantitative re-introduction hypothesis to be tested.

Cotton fibre sector

Global dimension

The cotton fibre production and manufacturing industries are relevant economic activities in both developed and developing countries (DCs). In 2012/13 the total world cotton fibre production was 26.9 million MT, while consumption reached 23.6 million MT (27).

Table 1 (page 214) shows the quantitative dimensions of the sector by detailing the beginning stocks, production, consumption, exports and imports and, consequently, the final stocks at world level for different years. Based on the International Cotton Advisory Committee (ICAC) dataset, in the 2013/14 season the 5 main cotton fibre producers are China (6.70 million MT), India (6.37), USA (2.88), Pakistan (2.03) and Brazil (1.59); this ranking has remained unaltered in the last 6 years. Of course the yield differs in relation to specific factors such as climatic and physical conditions and the availability of improved genetic resources. At international level, Australia is the leading actor in relation to cotton productivity (2,488 Kg/ha), followed by Israel (1,821), Turkey (1,760), Brazil (1,529) and China (1,457).

On the consumption side, the main actors at international level are all DCs: China (8.04 million MT), India (5.01), Pakistan (2.60), Turkey (1.04) and Brazil (0.85), confirming once again the data of the previous 6 years (27, 28). These data can partly be explained by the Bennet's Law (stating that the demand side mainly drives sectorial growth), given that the new middle classes in China and India have new consumption patterns due to changes in their incomes (12).

The cotton price at international level has shown interesting performances in recent years compared to other commodity prices and the commodity price boom in 2008 marginally touched cotton prices.

The three main factors determining this unusual trend were: (i) the specific impact of the increased yields in China and India due to the widespread adoption of biotech crops; (ii) the cotton subsidies applied by the USA encouraged increased production and consequently depressed world prices; (iii) the expansion of bio fuels has had a direct impact on the prices of the related agricultural commodities, but cotton cannot be easily substituted by other commodities so the impact has been limited in this case (5).

In recent years, after the price peak of 2011 (5US$/kg), the price started to drop and in the first half of 2012 reached 2 US$/kg (57).

Table 1. The cotton-fibre world production, consumption, balance of trade and stocks (1920-21; 2012-13).
Tabla 1. Producción mundial de algodón en fibra, el consumo, la balanza comercial y las reservas (1920-21; 2012-13).

	Beginning Stocks (1000 MT)	Production (1000 MT)	Imports (1000 MT)	Consumption (1000 MT)	Exports (1000 MT)	Adjustment (1000 MT)	Ending Stocks (1000 MT)	Harvested Area (1000 ha)
1920/21	796	3226	49	1068	1478	40	1564	14693
1930/31	1159	5988	2949	1146	2904	43	1387	18052
1940/41	2343	6998	1644	6130	1481	-57	2649	10364
1950/51	3335	6674	2724	7638	2673	-37	2591	28537
1960/61	4298	10217	3807	10251	3765	250	4542	32901
1970/71	4757	11740	4086	12173	3875	88	4605	31777
1980/81	5586	15502	4547	14383	4414	67	5149	35540
1990/91	6128	21544	6423	20454	5069	-1019	7614	36180
2000/01	11165	19524	5981	20429	5805	154	10672	32946
2010/11	8735	25869	7725	24502	7636	-51	10082	33560
2012/13	15228	26913	9839	23357	10057	0	18566	33892

Source: (27) - Fuente: (27)

The supply outlook of an increased cotton production for the year 2012/13 has induced further price drops (57). The cotton prices indexes of the World Bank are listed in table 2, also presenting the price forecasts (in both nominal and real terms) till 2025.

Genetically modified cotton (GM) and organic cotton are a subject of strong debates in many DCs given their different socio-economic and environmental impacts, and the crucial question of GM crops co-existence with organic farming (4). The main economic features and performances of these sub-sectors are now presented.

GM cotton

Cotton ranks third among the most widespread genetically modified (GM) crops worldwide (7).

The International Service for the Acquisition of Agri-biotech Applications (ISAAA) figures highlight that 69% of the total 35.52 million ha under cotton cultivation are occupied by GM cotton in the form of herbicide tolerant (HT) and insect resistant (IR) plants (7). Currently, China, India, the USA and Pakistan are the countries planting the most GM cotton in terms of area. Some 940,000 ha in Latin America are planted with GM cotton, producing around 384,000 MT of GM fibre. Almost all countries in the region produce cotton from GM varieties, with the exception of Nicaragua and Peru (47).

In terms of economic impacts, across countries using GM HT cotton since 1997 there have been net farm income gains of $907.8 million, mostly (95%) under the form of cost savings and only marginally as yield gains.

Table 2. Cotton price and price forecast in nominal US Dollars and in real 2005 US Dollars (in US cent/kg).

Tabla 2. Precios del algodón y previsión del precio en US$ nominales y en US$ reales 2005 (in US cent/kg).

		1980	1990	2000	2010	2011	2012
		Actual					
Nominal	c./kg.	206	182	130	228	333	197
Real	c./kg.	271	188	146	202	271	163

		2013	2014	2015	2016	2017	2018	2019	2020	2025
		Forecast								
Nominal	c./kg.	180	190	200	205	209	214	219	224	250
Real	c./kg.	147	151	156	157	158	159	159	160	163

The table presents the annual averages, but cotton prices normally shift during the year in relation to the quantity exchanged on the market that, of course, depends on different factors.

La tabla presenta los promedios anuales, pero los precios del algodón normalmente cambian durante el año en relación con la cantidad intercambiada en el mercado que, por supuesto, depende de diferentes factores.

Source: (57) - Fuente: (57)

However, net income gains have diminished in recent years because of numerous factors, including the higher cost of the technology, significant price increases for glyphosate relative to other herbicides and additional costs linked to the adoption of control practices for the management of weeds resistant to glyphosate. With reference to GM IR cotton, the net farm income gains totalised $3.9 billion in 2009.

The amount of total farm income benefit since 1996 corresponds to $19.58 billion. Around 69% of this has derived from yield gains (less pest damage), while the remaining proportion (31%) from reduced expenditure on crop protection (7).

Organic cotton

Reliable data about the production, trade and consumption of organic cotton are difficult to establish. Today around 317,000 ha are certified as organic, involving 214,900 farmers in eighteen different countries and producing about 138,900 MT of organic cotton fibre (46).

In 2006 production was estimated at 23,000 MT (31), while earlier estimates in 2001 and 2004 amounted to 6,000-6,500 MT and 10,000 MT of fibre respectively (48, 49). From 2006 to 2010 there were four years of rapid growth in organic cotton, up to 241,698 MT in 2010 (47), followed by a significant drop in 2011 and some recovery in 2012. There are many reasons behind this drop, including scarcity of organic cottonseeds, as a result of the increasing relevance of GM cotton, and general economic uncertainty that keeps commodity prices down (46).

Although the trend for production of organic cotton is growing, conventional cotton still accounts for about 99% of total world output (31).

The total value for organic cotton textiles (in terms of retail sales) has been estimated at around US$ 6.8 billion in 2011, with projections up to US$ 8.9 billion in 2012 (46).

World organic cotton fibre production is concentrated in relatively few countries: India, Turkey, China, Tanzania and the USA together account for more than 97% of total production. Current legislation on the labelling of organic products in Europe and the USA only covers seed cotton in its raw and unprocessed form, leaving the labelling of organic textiles to the discretion of the manufacturer or retailer.

Many organisations, mostly organic certification bodies, have developed their own voluntary standards for organic finished or semi-finished products (mostly textiles). At consumer level, these products are normally labelled as "produced from organic cotton", with the percentage of organic cotton in the final product varying from case to case (40).

The market for organic cotton is demand-driven and evenly split between Europe and the USA. In the past, organic cotton items were mostly sold online or through a limited number of specialist shops (health stores, organic shops, etc.), but in recent years -as a result of the growing demand- retailers and big brands have increasingly included organic cotton in their product lines (46, 47).

Given the increasing interest in and commitment to sustainable fibre use, the market for organic cotton fibre products is likely to continue growing in the foreseeable future. While the current involvement of large textile brands and retailers is mainly driven by the appeal of ethical and socially/environmentally-responsible consumerism, the expansion of the market due to an increased number of different products, together with widespread media coverage could strengthen consumers' interest in and willingness to purchase organic items (39, 50). At the moment one

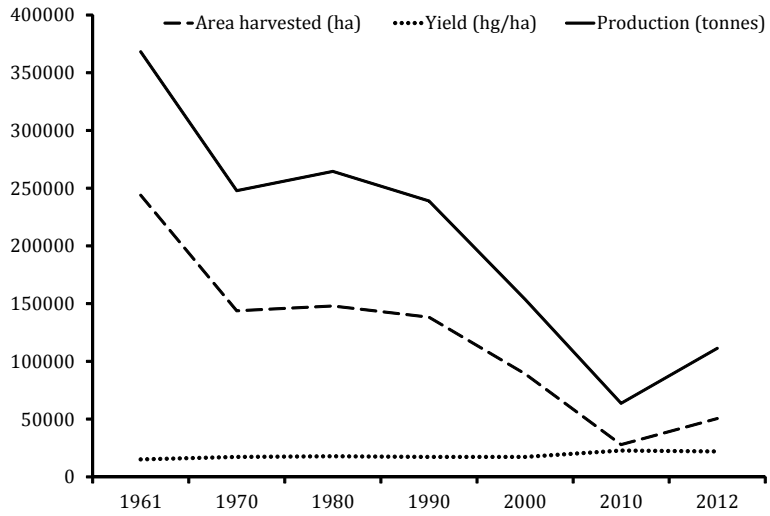
of the limiting factors for the development of the market is not demand but supply, which is preventing organic cotton from obtaining larger market shares.

The Peruvian cotton sector: national dimensions and local specificities

Cotton production in Peru has progressively decreased since the 1960s. Despite the substantial decrease in the production value -in 2012 it corresponds to less than 1/3 of the value registered in 1961- and the progressive decline in the surface harvested, the cotton yield has increased by 46% in the last 60 years, passing from 1.5 to 2.2 MT/ha (figure 2). In very recent years this historical path seems to be at a turning point.

From 2010 to 2012 Peruvian cotton production has doubled (from 63,758 to 111,375 MT) as well as the area harvested (from 27,963 to 50,515 ha) (27).

Peruvian cotton consumption indicates a different performance compared to production and imports that have also progressively increased; the ICAC data indicate a strong intensification of these figures: cotton consumption varies from the 17,418 MT (1960/61) to the current 91,360 MT (estimated for 2013/14) and cotton imports fluctuate from 1,089 MT (1980/81 when the first data were collected) to 54,260 MT (estimated for 2013/14). FAO and ICAC data attest that Peru is a net importer, while during the 1960s the country was a net exporter on the international cotton market. In Peru four commercial varieties are essentially cultivated: *Pima, Tangüis, Supima* and *Aspero*.



Source: FAOSTAT - Fuente: FAOSTAT

Figure 2. Peruvian Cotton: Surface harvested, yield and production (from 1961 to 2012).
Figura 2. Algodón peruano: Superficie cosechada, rendimiento y producción (1961-2012).

Besides the commercial varieties, Peru is traditionally known for its native cotton an ancestral variety of the *Gossypium barbadense sp.* (10, 37, 41) popularly called *algodón El País* or country cotton.

Moreover in the *Lambayeque* and *La Libertad* regions *Gossypium raimondii* is the unique sylvan cotton species present in South America: this native and naturally pigmented cotton (with numerous hues: russet, brown, copper and green) is a small bush that produces a long and fine fibre and which has a higher natural resistance to parasites than other commercial varieties. Its natural habitat is along the coastal areas of South America and more specifically those with a high level of humidity, quite good soil fertility, low rains and absence of frost (54, 55).

The seeds contain a polyphenol (gossypol) that has been studied for its antibiotic capacities specifically related to skin infections (24). Until the beginning of the 20th Century, Peruvian peasants normally cultivated this variety, but after the Second World War white cotton gained economic supremacy.

In Peru the question also assumed a legal dimension: the *Decreto Supremo n° 17 (04/05/1949) sobre políticas sanitaria vegetal* allowed the Ministry of Agriculture to implement compulsory phytosanitary measures to eradicate the native cotton considered as a vector of diseases and pests causing damage to commercial varieties. These measures were implemented until recent years: in 1994 the *Resolución Ministerial n° 0251-94-AG de fecha 26 de mayo 1994* approving the *Texto Único Ordenado del Reglamento del Algodonero* prevented the sowing of native cotton *El País* in the Peruvian coastal valleys where commercial varieties were sown and hampered the conservation of every isolated plant.

Despite these laws, the local farmers put up a strong resistance and continued to plant the native cotton variety for household needs, as they have done for millennia without using chemical fertilizers or pesticides. After many years of opposition and based on scientific evidence (53, 54, 55), native cotton was finally declared as a resistant variety to many pests and diseases and with a relevant capacity to be cultivated in extreme soil conditions (salty soils) and with a lower water demand compared to commercial varieties.

During the 1990s the concern over natural varieties also increased in relation to the US and EU big manufacturing companies' interest in entering the market of environmentally-friendly or organic cotton. Consequently in Peru a resurgence of the ancient textile tradition based on native cotton attracted many international and local actors in order to revitalize the cottonseeds biodiversity and ancient textile practices (10).

These initiatives have been possible thanks to the new Peruvian Environmental Code (1990) that has created the opportunity to protect and recover the natural resources managed by native and peasant communities and, finally, Regulation n° 29224 (2008) has declared native cotton a genetic, ethnic and cultural heritage of Peru. New initiatives have emerged in recent years such as the *Ruta de algodón nativo de colores* (Road of native cotton colours) proposed by the Centre for Innovation and Rural Development (University of *Lambayeque*), aiming to preserve the regional biodiversity, promote Peruvian history, and support eco-tourism activities, and the trade-mark *Algodón Nativo ´Utku Muchik´*(*Túcume - Lambayeque*) promoted by the *Instituto Nacional de Defensa de*

la Competencia y de la Protección de la Propiedad Intelectual (INDECOPI), United Nation Industrial Development Organization (UNIDO), and the Peruvian Ministry of Agriculture.

The government data indicate that, nowadays, 15,000 small farmers normally cultivate native cotton and this is the biggest group of native and naturally coloured producers at world level.

The Moche -a pre-Inca population settled in the Trujillo province from about 100 to 800 AD- cultivated the *algodón El País* since ancient times (as attested by their archaeological remains) and it was a real multi-purpose shrub normally used for the production of textiles (cloth products but also nets and sails for the fishing activity), and the oilseed was used for numerous medical purposes and to waterproof timber (used as construction material), and finally cotton seeds were used as protein intakes for animals (23).

In the Moche district there are 6 specific phenotypes of native cotton: white, brownish-grey, pale-brown, dark-brown (Tumán), brownish-reddish (Huanchaquito), lilac-purple (Zaña).

The soils required for a good development of the plant are silt or clay-like, but the plant has also adapted to salty soils and is normally cultivated with other plants that have a lower salt-tolerance.

The seeding is normally done in May, allowing the development of capsules and, afterwards, of the cotton bolls during the hot months, when the temperature reaches 27-30°C. This variety requires less water than commercial varieties and in desert or semi-desert areas the most suitable irrigation system is drip-irrigation, but flowing irrigation is normally used (19).

Contexts, data collection, and methodology

The Moche district -in the Trujillo province of the La Libertad region in North Peru- has a total population of 39,265 people (29) distributed in 4 sectors (*Moche Pueblo*, *La Campiña* also known as *Moche Viejo*, *Las Delicias* and *Alto Moche* or *Miramar*) and, in ancient times, the district was the capital of the antique Mochica civilization. Agriculture represents a significant economic activity, nevertheless in recent years, thanks to the recuperation of the important cultural heritage (*Las Huacas de Sol y de la Luna*), tourism has rapidly increased 34% of the economically active population is engaged in agricultural, livestock and fishing activities, 12.3% in the industrial sector and 53.7% in commerce and services. In the district 887 farmers operate on a total agricultural surface of 1,084.45 ha (30), which is highly productive thanks to soil quality (alluvial soils) and the irrigation system serving all farms.

Land ownership in the valley is not as concentrated as in other parts of the La Libertad region, as 99.77% of farmers own 81.6% of the agricultural land (table 3, page 220). Farmers are split in two categories: small farmers (*parceleros*) and medium-large farmers, considering a cut-off farm size of 20 ha (as proposed by Escobal, 2002).

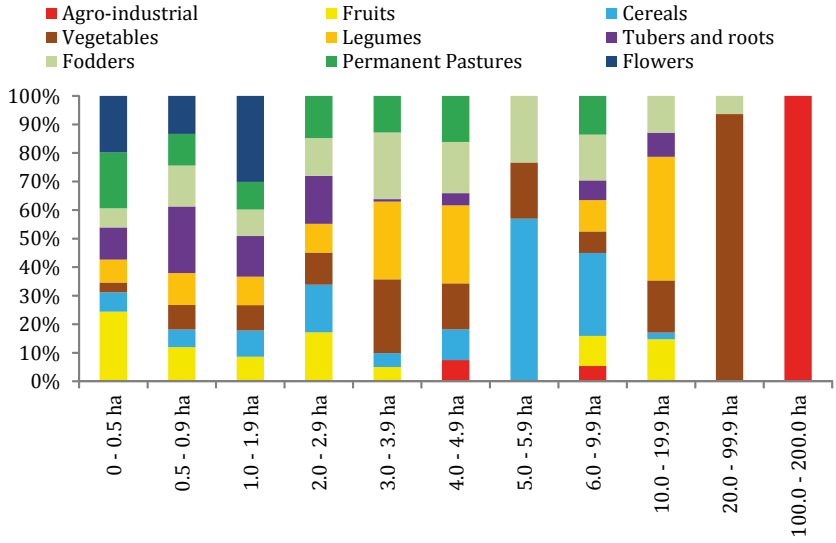
The small farmers normally rely on the diversification of permanent and annual crops, while medium and large farmers specialize in agro-industrial crops and horticultural produce, also given the proximity to the market in the regional capital Trujillo (figure 3, page 220). Agro-industrial crops (both permanent and annual) represent an effective economic option when a small farm is above the cut-off size of 4 ha.

Table 3. Farm class size and agricultural area in the Moche district .
Table 3. Tamaño de las clases agrícolas y área agrícola en el distrito de Moche.

	0 - 0.4	0.5 - 0.9	1.0 - 1.9	2.0 - 2.9	3.0 - 3.9	4.0 - 4.9	Total
N° Farmers	459	162	133	52	21	10	868
%	52.9	18.7	15.3	6.0	2.4	1.1	100.0
% Cumulated	52.9	71.5	86.9	92.9	95.3	96.4	
Surface ha	92.3	110.8	168.5	115.8	69.9	44.2	1084.5
%	8.5	10.2	15.5	10.7	6.4	4.1	100.0
% Cumulated	8.5	18.7	34.2	44.9	51.3	55.4	

	5.0 - 5.9	6.0 - 9.9	10.0 - 19.9	20.0 - 99.9	100.0 - 200	Total
N° Farmers	6	20	3	1	1	868
%	0.7	2.3	0.3	0.1	0.1	100.0
% Cumulated	97.1	99.4	99.8	99.9	100.0	
Surface ha	31.3	148.5	36.4	67.0	200.0	1084.5
%	2.9	13.7	3.4	6.2	18.4	100.0
% Cumulated	58.3	72.0	75.4	81.6	100.0	

Source: (30) - Fuente: (30)



Source: (30) - Fuente: (30)

Figure 3. Different agricultural productions in the Moche district by farm size (%).
Figura 3. Diferentes producciones agrícolas en el distrito de Moche por tamaño de la explotación (%).

Based on the assessments of the IV *Census Nacional Agropecuario 2012* (30), the majority of farmers (87.37%) declare that agricultural activity is unable to generate enough resources to cover the family costs; consequently they rely on rural non-farming activities (handicrafts, transformation of agricultural products, services or other commercial activities) to cover their costs. The factors determining the farmer's decision to cultivate a specific set of crops vary among medium and small farmers: 100% of the medium-large farmers declare that their decision is based on market demand, while small farmers' choices depend on multiple factors, not all based on market signals: *i.e.* the low cost of cultivation (38.68%), the tradition to cultivate the same crops in every cropping season (13.97%), market demand (13.51%), the limited vegetation period of the selected crops (11.20%), technical advice received (1.15%), the price offered in the previous cropping season (1.04%), and water availability (0.35%).

From October to December 2010, CESVITEM Peru - a non-profit organization based in the city of Trujillo- undertook a survey of 50 families in the Moche district with the technical help of the Dept. TESAF of the University of Padova (Italy).

The families were selected based on a snowball sample technique where the selection criterion was the direct knowledge of other farmers owning one or more plants of native cotton. It must be noted that native cotton has almost disappeared in the district as a consequence of the prohibition set by the Peruvian legislation in 1949, so the selected families are those that still retain specific knowledge on how to cultivate the native cotton using ancestral techniques.

The class dimension of the sample is given in table 4, in which the first class (0-0.4 ha) represents 20% of the farmers owning 2.7% of the total agricultural area of the sample, while the last class (10.0-19.9 ha) covers 2% of the farmers and 12% of the total agricultural area; the average farm size is 1.85 ha.

Table 4. Farm class size and agricultural surface owned by person interviewed in the Moche district.

Tabla 4. Tamaño de la clase agrícola y superficie agrícola propiedad de las personas entrevistadas en el distrito de Moche.

	0 - 0.4	0.5 - 0.9	1.0 - 1.9	2.0 - 2.9	3.0 - 3.9	Total
Farmers (n°)	10	8	14	9	5	50
%	20.0	16.0	28.0	18.0	10.0	100.0
% Cumulated	20.0	36.0	64.0	82.0	92.0	-
Surface (ha)	2.5	4.8	18.5	20	15.5	92.3
%	2.7	5.2	20.0	21.7	16.8	100.0
% Cumulated	2.7	7.9	28.0	49.6	66.4	-

	4.0 - 4.9	5.0 - 5.9	6.0 - 9.9	10.0 -19.9	Total
Farmers (n°)	0	2	1	1	50
%	0.0	4.0	2.0	2.0	100.0
% Cumulated	92.0	96.0	98.0	100.0	-
Surface (ha)	0	10	9	12	92.3
%	0.0	10.8	9.8	13.0	100.0
% Cumulated	66.4	77.2	87.0	100.0	-

Source: own elaboration - Fuente: elaboración propia

A cross-sectional dataset of economic and agronomic farm-level data was constructed based on the following variables:

i) personal and family data,

ii) basic farm data (crop types, agricultural surface destined to each crop, total land area of the farm, soil type, irrigation facilities, mechanical inputs, technical assistance),

iii) data on operating costs (variable costs) and allocated overheads (fixed costs) related to the farming activity and gross value of production,

iv) estimated data on the remuneration of different production factors (opportunity cost of unpaid labour, opportunity cost of land, capital recovery of machinery and equipment, interest on operating capital), data on native cotton (costs, revenues). In order to fulfil the research objective -how the re-introduction of native cotton as an agricultural production is going to change the small farmers' income- the methodology was organized in the following consequent steps:

i) the farm economic data analysis was conducted for the 50 farms, based on the data collected *in situ*. The farm economic data analysis is certainly not an innovative methodology (3), but it appears essential for the final purpose of being able to specify under which economic conditions of market prices, quantity and surface cultivated, native cotton is a profitable activity for small farmers;

ii) the economic budget of a hypothetical farm producing 1 ha of native cotton was compiled based on information on costs and revenues collected by means of interviews with farmers already cultivating the product in the Moche district and in other districts of the La Libertad region such as San Martín and Lambayeque. Consequently different quantitative scenarios were tested, specifically: 10%, 25%, and 50% of the agricultural surface of the farm cultivated with native cotton, with a converse reduction of the agricultural surface destined to other crops, in order to assess how the farm costs, revenues and income are going to change and comparing the results with the business as usual scenario - BAU (without native cotton);

iii) the Sensitivity Analysis (SA) was lastly performed, using the OFAT methodology in order to test the reactivity of income (output variable) to possible variations in native cotton price (input variable). OFAT or OAT methodology is one of the most common approaches in SA consisting of changing one-factor-at-a-time to verify what this produces on the output variable. The selected input variable was the native cotton price and different price hypotheses have been tested: -10%, -5%, +5%, +10%.

Results and discussion

The analysis of the farm activity has been performed at levels of costs and revenues. The costs are split into operating costs (seeds, fertilizers, chemicals, transport, rental of machinery and equipment, technical assistance, energy, fuels, lubricants, veterinary costs, interest on operating capital and hired labour) and allocated overheads (opportunity cost of unpaid labour, opportunity cost of land, capital recovery of machinery and equipment).

The gross value of production is mostly related to crop (mainly cereals and vegetables) and livestock production (mainly poultry); 71% of the gross value of production derives on average from crops, but it should be noted that the poultry sector is an important source of revenues mostly for the smaller farm classes.

Table 5 (page 224) details the main elements of the economic budget in US$/ha allowing comparisons among different farm dimensions.

The average operating costs of the 50 farms analysed are 1,303.14 US$/ha, of which 122.89 US$/ha is interest on operating capital (this value is quite high and is mainly due to the high interest rates in Peru). Hired labour adds up to 309.74 US$/ha on average and the opportunity costs of unpaid labour accounts for 1,956.21 US$.

The opportunity costs of land have been estimated at 396.01 US$ and the capital recovery of machinery and equipment at 98.45 US$. Consequently the gross value of production less total costs was 2,475.48 US$/ha on average and the gross value of production less operating costs were estimated at 4,926.16 US$/ha on average.

Analysing the economic values at the level of farm class sizes, it appears that the class size that is more efficient in terms of farm net income is the one from 1.0 to 1.9 ha (the value of production less total costs is equal to 4,607.57 US$/ha, the highest compared to the other classes).

Moreover, looking at the values of the allocated overheads for different farm classes, it is clear that with the expansion of farm size the fixed costs are going to be distributed over a bigger agricultural production.

Despite the classical functioning of economies of scale, the normalized data per ha attests that with the increase of the agricultural surface the income is not automatically going to rise, as different factors affect the economic performance of different farm sizes.

Looking at the relationship between agricultural surfaces harvested and the income data, it appears that in each of the farm classes considered a relevant number declare an economic loss (the percentage is quite high in the first and fourth farm classes: 70% and 77% respectively).

The budget estimate is normally used as a useful instrument for planning and decision-making.

The native cotton budget, presented in table 6 (page 225), is based on specific assumptions in relation to native cotton production that come from information collected at farm level in the Moche district, and on widespread experiences of native cotton production as a small agro-industrial crop in different locations of the La Libertad region (more specifically in the Lambayeque and San Martín districts), moreover experts in cotton farm data analysis and agronomists have also been contacted in order to validate the data.

The variety considered was the *Pardo* (with three different colours *claro*, *illino*, and *rojizo,* this last also known as *huanchaquito*). According to the local information the yield of *Pardo* native cotton ranges from 1,300 to 2,000 kg/ha. In the budget presented in table 6 (page 225) the cotton yield has been estimated at 1,800 kg/ha of which: 990 kg cottonseed; 540 kg lint; 36 kg linter; 234 kg trash.

The price considered for native cotton lint corresponds to 1.43 US$/kg -this is due to the specificity of the native cotton niche market, offering a higher premium price compared to the normal white cotton price- the native cottonseeds obtain a price of 0.21 US$/kg (Peruvian market prices for native cottonseed, linter and seeds without organic certification).

Based on the information collected locally and considering the specificity of native cotton production, the operating costs and allocated overheads have been determined.

Table 5. Value of production and operating costs and allocated overheads (in US$/ha) by farm class size (average values).
Tabla 5. Valor de los costos de producción y de explotación y gastos generales asignados (en US$/ha) por tamaño de las clases agrícolas (valores medios).

	0 - 0.4	**0.5 - 0.9**	**1.0 - 1.9**	**2.0 - 2.9**	**3.0 - 4.9**	**5.0 - 5.9**	**6.0 - 9.9**	**10.0 -19.9**
N° of Farms	10	8	14	9	5	2	1	1
Total operating costs	3,073.85	670.79	1,163.89	791.18	476.88	520.50	1,469.88	741.87
Total allocated overheads	6,199.37	3,074.64	1,477.41	737.05	1,151.43	786.47	839.36	456.65
Total costs	9,273.22	3,745.43	2,641.30	1,528.23	1,628.31	1,306.97	2,309.24	1,198.52
Value of production	11,477.27	6,914.20	7,248.87	1,212.49	3,684.27	2,413.40	5,068.62	665.63
Value of production less total costs listed	2,204.05	3,168.77	4,607.57	-315.74	2,055.96	1,106.43	2,759.38	-532.90
Value of production less operating costs	8,403.42	6,243.41	6,084.98	421.31	3,207.39	1,892.90	3,598.74	-76.24

Source: own elaboration based on the survey undertaken in the Moche district in the 2010-2011 cropping season.
Fuente: elaboración propia en base a la encuesta realizada en el distrito de Moche en la temporada 2010-2011 de cultivo.

Table 6. Budget estimates of the native cotton production in US$/ha in the Moche district.

Tabla 6. Presupuesto de la producción de algodón nativo en US$/ha en el distrito de Moche.

Gross value of production:	**US$/ha**	**%**
Primary product: Cotton	823.68	79.85
Secondary product: Cottonseed	207.90	20.15
Total, gross value of production	**1,031.58**	**100.00**
1. Native Cotton Seed	25.59	2.93
2. Organic Fertilizer	107.35	12.28
3. Integrated pest management	101.60	11.62
4. Rent of equipment	42.93	4.91
5. Fuel, lube and electricity	70.84	8.10
6. Ginning and warehousing	100.23	11.47
7. Transport costs	71.56	8.19
8. Interest on operating capital	73.38	8.39
Total, operating costs	**593.48**	**67.89**
1. Hired labour	38.26	4.38
2. Opportunity cost of labour	-	-
3. Capital recovery of machinery and equipment	160.76	18.39
4. Opportunity cost of land	-	-
5. Taxes and insurance	20.87	2.39
6. General farm overheads	60.82	6.96
Total, allocated overheads	**280.71**	**32.11**
Total costs listed	**874.19**	**100.00**
Value of production less total costs listed	**157.39**	
Value of production less operating costs	**438.10**	

Supporting information:	
Cotton yield: kg/per planted ha	576
Price: US$ per kg	1.43
Cottonseed yield: kg/per planted ha	990
Price: US$ per kg	0.21
Enterprise size	1 ha

Source: own elaboration based on the survey undertaken in the Moche and Lambayeque districts in the 2010-2011 cropping season.

Fuente: elaboración propia en base a la encuesta realizada en los distritos de Moche y Lambayeque en la temporada 2010-2011 de cultivo.

Land preparation, spread of composted poultry manure -which is quite abundant in the Moche district due to the widespread livestock rearing locally and that is important in native cotton production as it provides the most suitable organic matter, and the required micronutrients- pre-irrigation, weed removal and preparation for planting all require an assessment of the costs per hectare for different operations, related to labour, fuel, lube and repairs and rental of equipment, and material costs.

The planting is done using seeds that have not been treated with fungicide -to comply with organic cotton requirements, although in the first years of the re-introduction process the native cotton production will be in line with the transition period requirements- and the planting is at a lower density compared to the conventional one, in order to reduce competition for sunlight, water and nutrients, and encourage boll development. In the Lambayeque district, for example, planting is at 2,500 plants/ha with a distance of 2mx2m.

The integrated pest management (related to diseases, mites and weeds) depends on factors such as: site location, climatic conditions, water availability, pest incidence in the previous year, and the proximity of other crops. Specific techniques are normally used in order to reduce pest risks: such as biological control (natural predators), application of natural pesticides, used in combination with crop rotation and diversification.

The costs related to pest control infield crops as well as those for weed control (which is normally performed using mixed methods, mechanical but also hand weeding and chopping) have been estimated based on the data examined in a location in the Lambayeque district with the same climatic and environmental conditions as the Moche one. Moreover hired labour required for the specific operations (labour-machine; labour-non machine) has been included in the operating costs.

In relation to the allocated overheads, different costs have been considered: the capital recovery of the equipment used in cotton production, and the taxes and insurance.

The costs in relation to opportunity cost of labour and opportunity cost of land have not been included in the specific cotton budget because they are normally considered in the ordinary budget of the 50 farms analysed. Based on the previous elements of the farm budget, the break-even point has been determined as 1,003.40 kg/ha, consequently the farmer has to produce more than this in order to obtain a profit.

The next step is the scenario analysis: the situation "business as usual scenario - BAU" (without the cotton production) has been compared with three different proposed scenarios: to allocate 10%, 25% and 50% of the total agricultural surface of the 50 farms to native cotton production (with a proportional reduction of the existing crops), and consequently to verify how farm incomes are going to change. The different situations are presented in table 7 (page 227).

With the insertion of the native cotton production, the gross value of production is going to decrease in all scenarios compared to the BAU, and the cost structure is also going to change in a significant way, determining an estimated increase in income of +6.12% in the 10% scenario, +15.29% in the 25% scenario, and +30,58% in the 50% scenario (all the values have been normalized referring to an average farm of one hectare).

Table 7. Different economic scenarios in relation to the re-insertion of native cotton production in the Moche district (in US$) normalised values per ha.

Tabla 7. Diferentes escenarios económicos en relación con la re-inserción de la producción de algodón nativo en el distrito de Moche (en US$) valores normalizados por ha.

Per farm in US$/ha	Business as usual (BAU)	Scenario 10%	% Variation compared to BAU	Scenario 25%	% Variation compared to BAU	Scenario 50%	% Variation compared to BAU
Gross value of production (GVP)	6,229.30	6,092.73	-2.19	5,887.87	-5.48	5,546.44	-10.96
Total operating costs	993.40	953.41	-4.03	893.42	-10.06	793.44	-20.13
Total allocated overheads	2,760.43	2,512.45	-8.98	2,140.5	-22.46	1,520.57	-44.92
GVP less operating costs	5,235.91	5,139.33	-1.84	4,994.46	-4.61	4,753.01	-9.22
Income	2,475.48	2,626.87	+6.12	2,853.96	+15.29	3,232.44	+30.58

Source: own elaboration.

Fuente: Elaboración propia.

Both the operating costs and allocated overheads are going to progressively decrease passing from the 10% scenario (-5.15% and -9.01% respectively) to the 25% (-12.88% and -22.53%) and 50% (-25.76% and -45.05%) scenario.

With the increase in agricultural surface growing cotton the fixed costs decrease due to economies of scale, which are substantial in the 50% hypothesis (-44.92%).

Based on the dynamics of the above-mentioned variables, the final results demonstrate that all the set-ups represent a relevant improvement in incomes for the farmers, but the most interesting is the second one with an income increase of +15.29%.

The third scenario is also attractive (+30.58%) and certainly the best in terms of farm profit, but it also requires a substantial change in the farm organization (with a passage from a traditional system towards a more specialized one).

The performance of farm incomes in the three scenarios can been explained by the different operating costs and allocated overheads.

In the first scenario the relative weight of the average allocated overheads on the average total costs are relatively higher compared to the third scenario (72.49% and 34.29% respectively), conversely the weight of the average operating costs are relatively higher in the third scenario compared to the first one (65.71% and 27.51% respectively); this is related to the U-shaped average total cost curve for the farms considered in the analysis.

Consequently, in the initial phase of the possible adjustment strategy regarding native cotton production, the 25% hypothesis is the most feasible for the farmers (and also the more cautious in terms of risk strategy) with the target to progressively increase the agricultural surface once market conditions -specifically the native cotton price- provide suitable and stable circumstances to increase the production.

Lastly the sensitivity analysis (SA) has been performed selecting the native cotton prices as input variable and observing their impact (*i. e*. -10%, -5%, +5%, +10%) on the farm income as output variable.

The results are presented in table 8 (page 229).

The income has been analysed in terms of both the average income of the 50 farms and of the average normalized income per 1 hectare of agricultural surface.

In both cases the income displays a positive performance in relation to the different productive scenarios proposed and compared to the BAU one. Also in the worst case of a 10% reduction in the native cotton price the farm incomes in all the normalized options are higher compared to the BAU (+5.70% in the 10% scenario; +14.25% in the 25% scenario; +28.49% in the 50% scenario).

Conclusions

In Peru the neo-liberal policies of the last 30 years have opened the market to international competition and promoted the development of non-traditional agricultural exports based on strong investments by international and national actors. This major shift has conversely launched the opportunity for small farmers to enter the cotton sector, once dominated by big farmers.

Moreover a relevant interest in native cotton has emerged in recent years, based on a new regulation recognizing its importance as a genetic, ethnic and cultural heritage of the country.

The paper presents how incomes of a selected sample of farms, located on the North coast of Peru, could change in relation to different scenarios in terms of native cotton production. The results indicate that the variation of incomes compared to the BAU scenario ranges between +6.12% (in the case the area destined to native cotton is equal to 10% of the agricultural area of the selected sample) and +30.58% (when the area corresponds to 50% of the farmland).

Moreover income variations have been tested by means of a sensitivity analysis, based on the OFAT methodology, using the native cotton price as input variable: results attest that incomes range between +5.70% (in the worst hypothesis of a 10% decrease in native cotton price) and +32.66% (in the better hypothesis of a 10% increase in native cotton price) compared to the BAU scenario.

This positive results regard the native cotton supply analysis, but further studies are needed to thoroughly investigate the demand side.

Table 8. Sensitivity analysis of the average farm income to different cotton price hypothesis (compared to business as usual scenario) (values in U$S).

Tabla 8. Análisis de sensibilidad de la renta agraria media a diferentes hipótesis de precio del algodón (en comparación con el escenario business as usual) (valores en US$).

Per farm in US$/ha		Average farm income (absolute values)	% Variation in comparison to BAU scenario	Average farm income (normalized values per 1 ha)	% Variation in comparison to BAU scenario
Scenario 10%	**Business as usual (BAU)**	2,819.20		2,475.48	
	A. Price var. -10%	2,825.50	+0.22	2,616.56	+ 5.70
	B. Price var. -5%	2,835.02	+0.56	2,621.71	+ 5.91
	Scenario 10%	2,844.53	+0.90	2,626.87	+ 6.12
	C. Price var. +5%	2,854.04	+1.24	2,632.03	+ 6.32
	D. Price var. +10%	2,863.56	+1.57	2,637.19	+ 6.53
Scenario 25%	**A. Price var. -10%**	2,834.96	+0.56	2,828.17	+14.25
	B. Price var. -5%	2,858.74	+1.40	2,841.06	+14.77
	Scenario 25%	2,882.52	+2.25	2,853.96	+15.29
	C. Price var. +5%	2,906.31	+3.09	2,866.85	+15.81
	D. Price var. +10%	2,930.09	+3.93	2,879.75	+16.33
Scenario 50%	**A. Price var. -10%**	2,850.71	+1.12	3,180.86	+28.49
	B. Price var. -5%	2,898.28	+2.81	3,206.65	+29.54
	Scenario 50%	2,945.85	+4.49	3,232.44	+30.58
	C. Price var. +5%	2,993.41	+6.18	3,258.23	+31.62
	D. Price var. +10%	3,040.98	+7.87	3,284.02	+32.66

Source: own elaboration - Fuente: elaboración propia

Preliminary assessments on the willingness to pay for native cotton products by local and national consumers suggest a strong interest in native cotton fibres and handicrafts, but further research is needed in order to properly quantify the demand side at different levels.

Moreover, the use of native seeds could contribute to the *in situ* conservation of genetic resources, thus turning into an ecosystem service provided by farmers: specific payment mechanisms could be developed to compensate these efforts, assuring additional income opportunities.

In conclusion the revitalization of the Peruvian native cotton sector is a real income opportunity for small farmers, but particular attention has to be paid to: the size of the small farms and the initial investment required to start the activity and, in this case, an accurate evaluation has to be made of the role that international co-operation could play as financing actor.

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