

Opportunities and challenges of integrating crop and livestock systems in the desert reclaimed lands of Egypt

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Keywords

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Summary

The Mediterranean agriculture is constrained by high competition for land and water utilization. One of the challenges for farmers is to increase land productivity through a better use of livestock in mixed crop-livestock farming systems. To assess the opportunities and challenges of integrating crop and livestock activities in irrigated areas, a survey was conducted among 175 small-scale farms in the West Delta desert land of Egypt in 2013/2014. Five regions were investigated and comprised the old reclaimed lands where settlers came in the 1960s, the intermediate reclaimed lands where farmers settled down in the 1980s, and the new reclaimed lands that were attributed to new farmers in the 1990s. The study highlighted two types of farmers' strategies: 1) diversification and specialization with focus on fruit tree plantation by university graduates, who had benefited from the attribution of around two hectares of land in the settlement program since the end of the 1970s; and 2) diversification with emphasis on livestock by common beneficiary settlers from the Nile Valley, who had benefited from the attribution of one hectare of land since the 1990s. Graduates focusing on fruit trees corresponded to a strategy of developing new business activity, whereas common beneficiaries diversifying their farming systems through livestock corresponded to the need to secure a stable source of family income all year round. Whereas diversification appeared to be a driving force for agricultural development in this context, specialization could be a social and economic risk as graduates became more dependent on national and international markets. This was reflected in the perception of farmers who underlined the need to integrate technical, ecological, economic and social constraints in their decisions.

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■ INTRODUCTION

In Mediterranean agricultural systems, the high competition in the use of natural resources (land, water, and nutrients) between crop cultivation and animal husbandry can affect the sustainable development of these systems (Dixon et al., 2010). Meanwhile, it is well recognized that the synergies between cropping activities and livestock husbandry

offer many opportunities for increasing sustainable production, notably through raising productivity and increasing efficiency of resource utilization, for both home requirements and markets (Herrero et al., 2010). Improving feeding systems and agricultural practices enhances water use efficiency, as illustrated in Morocco (Sraïri et al., 2011). Generally, livestock activities are now recognized for their multiple roles in reducing vulnerability of the fragile environment (Ashley et al., 1999; Alary et al., 2015) in diversification and intensification processes (Duteurtre and Faye, 2009). However, integration between livestock and crop activities varies with the farmers' strategies, their perceptions of their environments, and their resource base, in particular the access to land.

In Egypt, large agricultural programs have been developed to expand the agricultural area outside the Nile Valley in the desert lands over the last decades through the development of the traditional flood irrigation system. These programs were promoted by successive Egyptian governments since the 1960s to increase agriculture production, thereby improving national food security and agriculture commodity

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exports. However, these national programs for desert land reclamation sparked large debates about land allocation and best agricultural models that could be developed. Over the time, the programs have benefited different social classes, firstly university graduates in the 1970s and 1980s, then 'common beneficiaries', including land renters, female leading families and government retirees, since the 1990s.

In a previous paper (Alary et al., 2018), we studied the households' dynamics in those desert reclaimed lands of Egypt with regard to land regimes and policy programs. We showed that beyond those formal policy programs, settlers have found different ways to secure their livelihoods and were able to diversify their production systems toward mixed crop-livestock systems. In the present paper, we proposed to highlight the importance of crop-livestock interactions in the farm trajectories from the farm settlement to 2013/2014. The objective of this complementary work was to analyze the trend of crop-livestock integration in the small-scale farms of the reclaimed desert lands in West Delta, the challenges and potentialities that revealed the dynamics between different social groups (i.e. graduates vs common beneficiaries). This work has enriched the literature on the importance of livestock in sustainable agriculture (HLPE, 2016). Locally, it has contributed to defining the potential agricultural models for developing desert reclaimed lands based on farmers' perceptions.

■ MATERIALS AND METHODS

The materials and methods used in this study were based on those described in our previous paper (Alary et al., 2018). The study was conducted in the desert reclaimed lands of Nubaria, West Delta, as part of the national Egyptian program to expand the cultivated lands over the desert areas around the Nile Valley. In this sandy area, livestock activities were investigated, as part of the farming systems, in particular for improving soil fertility and family nutrition. Five regions were investigated with a diversity of situations related to the

date of land reclamation: the Nahda region, where the settlement started in the 1960s, was considered old reclaimed lands; the Bangar and Hamam regions, where the settlement started in the 1980s, were considered intermediate reclaimed lands; and the Tiba and Bustan regions, where land reclamation started in the 1990s, were considered new reclaimed lands. The Hamam region, located downstream the canal, represented a transitional zone with the Bedouin society along the northwestern coastal zones (Figure 1).

In each of those five regions, around 10 to 12 farmers from three to four villages were selected to reflect the diversity of land beneficiaries. We found mainly three types of land beneficiaries: i) the university graduates, coming mainly from urban areas, who benefited two hectares from the program, ii) the common beneficiaries, generally land renters in the Nile Valley, who benefited one hectare, and iii) the new buyers coming from rural or urban zones, who had been interested in investing in agricultural land more recently (Alary et al., 2018). The total sample included 174 farms. This survey was conducted in 2013/2014 within the framework of CLIMED (The Future of Mediterranean Livestock Farming Systems: Opportunity and Efficiency of Crop-Livestock Integration), an ARIMNET (Agricultural Research in the Mediterranean Network) project that involved the assessment of the sustainability of integrated crop-livestock systems in three Mediterranean countries (Egypt, France and Morocco). The survey was conducted by a French-Egyptian team of researchers in animal production and socioeconomics. The farm household survey was based on a semi-structured questionnaire that included six components: household living conditions, land and cropping systems, livestock structure and management, costs and financial issues, dynamics in the farming system over the time of settlement, and social networks. Descriptive statistics for quantitative and qualitative data analysis were used. We could in particular compare the farming systems at the time of settlement and at the time of survey. We also included in the questionnaire some data on the farmers' 'perception' on the 'reasons' explaining their past choices and on the

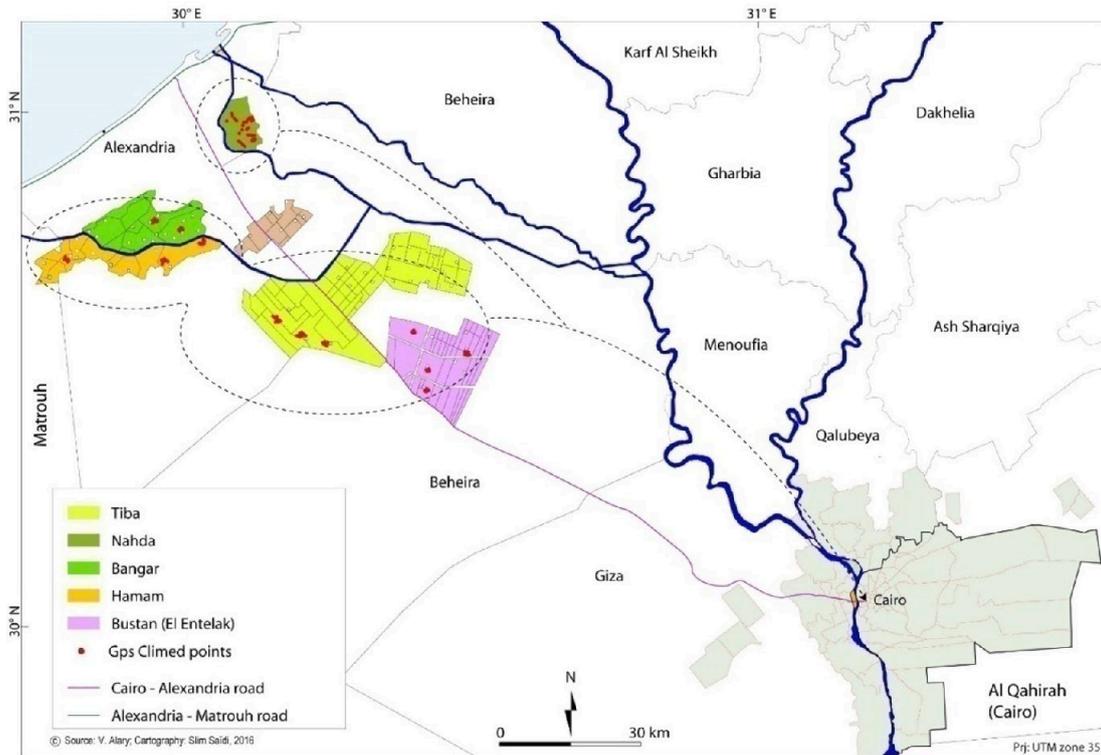


Figure 1: Geographical location of the selected regions in Nubaria, Egypt (extracted from Alary et al., 2016) // Situation géographique des régions sélectionnées dans la Nubie, Egypte (extrait d'Alary et al., 2016)

main ‘opportunities’ and ‘constraints’ they had been facing. Those data helped understand the farmers’ logics and their vision of the key factors for their livelihoods.

■ RESULTS

Farming systems at the beginning of settlement

Overall, two-thirds of the settlers declared that they began to cultivate their reclaimed lands with traditional crops, mainly wheat and Egyptian clover (berseem) in the winter, and maize and vegetables in the summer (Table I). However, regional differences were detected, such as peanut cultivation in Bustan, sugar beet and potato in Bangar, and watermelon in the Hamam, depending on land and water resources. Only 2% of new settlers, all graduates, began their cultivation with cash crops such as fruit trees (mainly oranges) and vegetables. The main livestock species raised were cattle (either Friesian crossbreeds or native breeds) and buffalo for milk and calves followed by mixed sheep and goat flocks (Table I).

Farmers’ reasons to explain their choices

For the majority (53 %) of the 174 surveyed settlers, the main reason for choosing their crops at the beginning of the settlement was “it is the main crop in the region.” In Nahda and Tiba, nearly one-third of farmers emphasized the issue of soil fertility that conditioned the decision to grow berseem or beans (as legumes) between two cereal crops. Potential productivity was also mentioned in Tiba. In Bustan, Bangar and Hamam, between 64% and 79% of the farmers chose traditional crops because it was related to their experience and their domestic needs. Water availability was an issue for the settlers in Hamam, especially those located at the end of the established Hamam irrigation canal. Lack of extension services was highlighted by only 6% of farmers in Bustan.

The types of livestock farming were rather more homogeneous among the five regions than cropping systems. In the new reclaimed regions, around 36% of settlers emphasized the role of cattle and buffalo for providing more income and animal products for family consumption at the beginning of the settlement. In the older reclaimed lands, i.e. Nahda and Bangar, the issue of manure production was highlighted. On the other hand, rearing small ruminants at settlement was a source of rapid cash income due to their high reproduction rate. In Hamam, partially settled by Bedouin inhabitants followed by Bustan farmers, settlers declared that they reared small ruminants as a tradition. The high productivity of sheep flocks was also highlighted by 17% farmers in both regions.

Evolution of farming systems from time of settlement

Based on the interviewees’ responses about the farming system at first settlement, it was possible to reconstitute the main changes of the farming systems in the studied regions (Table II). We could observe a clear reduction in the cereal-based system in favor of tree plantation and non-negligible changes in livestock activities. Around 8% and 23% of the settlers had stopped raising large and small ruminants, respectively. This important reduction in livestock, concerning mainly small ruminants, was devoted to finance tree plantation. Various other reasons were mentioned for this decline, including the incidence of foot and mouth disease in 2013, the increase in concentrated feed prices with the economic instability since 2011, and the intensive labor requirement of livestock activity.

However, those trajectories were not the same in all the regions. In Bustan (new reclaimed lands), 34% of the settlers had replaced their traditional crops with fruit trees. Around 35% of the farmers in Hamam (intermediate reclaimed lands) grew vegetables, mainly watermelon, because of the sandy soil type, and 16% developed their breeding activity due to low and uncertain profits from the strategic

Table I: Farming systems in the reclaimed land regions of Egypt at time of settlement /// *Systèmes d’exploitation agricole des régions de terres récupérées en Egypte au moment de la colonisation*

| Farming system | Nahda (ORL) | Bangar (IRL) | Hamam (IRL) | Bustan (NRL) | Tiba (NRL) | Total |
|--|----------------|-----------------|----------------|-----------------|---------------|-----------|
| | 1960–1990 | 1990–2010 | 1990–2005 | 1990–2005 | 1990–2010 | 1960–2010 |
| Number of farmers | 34 | 30 | 33 | 42 | 35 | 174 |
| Cropping system (%) | | | | | | |
| Cereal-based system (traditional) | 53 | 67 | 64 | 79 | 51 | 63 |
| Cereal mixed system | 29 | 23 | 15 | 5 | 3 | 14 |
| Vegetables | 18 | 10 | 21 | 10 | 46 | 21 |
| Fruit trees | – | – | – | 6 | – | 2 |
| Large ruminant herds’ composition according to purpose (%) | | | | | | |
| Buffalo and cattle for milk and calves | 50 | 63 | 31 | 64 | 43 | 51 |
| Dairy buffalo and cattle | 9 | 17 | 24 | 19 | 28 | 20 |
| Cattle for fattening (native cattle) | 35 | 20 | 24 | 17 | 23 | 23 |
| Without buffalo nor cattle | 6 | – | 21 | – | 6 | 6 |
| Small ruminant flocks’ composition (%) | | | | | | |
| Mixed flock (sheep and goats) | 47 | 43 | 31 | 24 | 37 | 36 |
| Sheep only | 9 | 7 | 15 | 17 | 9 | 11 |
| Goats only | 3 | 13 | 15 | 26 | 28 | 18 |
| Without sheep nor goat | 41 | 37 | 39 | 33 | 26 | 35 |

ORL: old reclaimed lands; IRL: intermediate reclaimed lands; NRL: new reclaimed lands /// *ORL : anciennes terres récupérées ; IRL : terres récupérées intermédiaires ; NRL : nouvelles terres récupérées*

Table II: Farming systems in the reclaimed land regions of Egypt in 2013/2014 /// *Systèmes d'exploitation agricole des régions de terres récupérées en Egypte en 2013/2014*

| Farming system | Nahda (ORL) | Bangar (IRL) | Hamam (IRL) | Bustan (NRL) | Tiba (NRL) | Total |
|--|-------------|--------------|-------------|--------------|------------|-------|
| Number of farmers | 34 | 30 | 33 | 42 | 35 | 174 |
| Cropping system (%) | | | | | | |
| Cereal-based system (tradition) | 42 | 51 | 39 | 31 | 19 | 37 |
| Cereal mixed system | 21 | 17 | 16 | 17 | 8 | 16 |
| Vegetables | 37 | 31 | 35 | 12 | 15 | 28 |
| Fruit trees | 0 | 0 | 10 | 40 | 58 | 19 |
| Large ruminant herds' composition according to purpose (%) | | | | | | |
| Buffalo and cattle for milk and calves | 50 | 50 | 32 | 43 | 29 | 41 |
| Dairy buffalo and cattle | 32 | 47 | 41 | 48 | 37 | 41 |
| Cattle for fattening (native cattle) | 6 | 3 | 0 | 5 | 6 | 4 |
| Without buffalo and cattle | 12 | 0 | 26 | 5 | 14 | 14 |
| Small ruminant flocks' composition (%) | | | | | | |
| Mixed flock (sheep and goats) | 6 | 3 | 18 | 12 | 6 | 9 |
| Sheep only | 21 | 27 | 24 | 21 | 14 | 21 |
| Goats only | 6 | 20 | 9 | 12 | 14 | 12 |
| Without sheep nor goat | 68 | 50 | 50 | 55 | 66 | 58 |

ORL: old reclaimed lands; IRL: intermediate reclaimed lands; NRL: new reclaimed lands /// ORL : anciennes terres récupérées ; IRL : terres récupérées intermédiaires ; NRL : nouvelles terres récupérées

crops. In this region located upstream of the newly established irrigation canal, irrigation is problematic and strategic crops cultivation appeared to be less productive. In contrast to the development in new and intermediate reclaimed lands, the old reclaimed lands of Nahda relied on traditional or mixed cereal crops in 2013/2014. This was due to their proximity with the neighboring Delta lands in terms of connections and market opportunities.

In summary, in both old and intermediate reclaimed lands, farmers mainly relied on cereals (as traditional and secured crops) and vegetables (as cash crops), and less on fruit trees. For the new reclaimed lands (Tiba and Bustan), farmers mainly relied on fruit trees for local markets or exportation. This corresponded to two types of farm strategies: 1) diversification with focus on fruit tree plantation by university graduates who benefited from the attribution of around two hectares of land in the settlement program since the end of the 1970s; and 2) diversification with emphasis on livestock by common beneficiary settlers from the Nile Valley, who benefited from the attribution of one hectare of land in the settlement program since the 1990s.

The main motivation beyond these dynamic changes, as declared by the settlers, was their own and their neighbors' experiences of the prevailing crops (mentioned by 52%). The second group of factors that influenced these dynamics were related to land and water resources such as soil fertility and availability of water (near 32%). The least affecting factors of these dynamics (concerning 16%) were socio-economic, i.e. availability of capital and increasing revenue (16%). This highlighted the major constraints of cultivation in desert lands, which are mainly constituted with sandy and poor soils.

Opportunities and constraints

Based on the settlers' statements regarding their perceptions of what they see as opportunities and constraints in the new reclaimed lands, i.e. land, water, labor and market, it was possible to identify the main factors that could influence changes in the future (Table III).

Availability of land was seen as the major opportunity by more than 90% of the interviewees. In Bangar, the land was an opportunity for 73% of the farmers, but farmers continued to suffer from low soil fertility. On the other hand, marketing of their products was the major constraint for more than 74% of the settlers once the land started to produce. In Nahda, the region was linked to the well-established markets in the Delta, so the market was a constraint for only 58% of them. Availability of family or hired labor was the second constraint perceived by the settlers (63%). Views on water varied greatly between regions; it was perceived as a good opportunity in Tiba and Hamam (49% and 42%, respectively), and a major constraint in Bangar, Bustan and Nahda (73%, 52% and 52%, respectively), mainly because of malfunctions in the management of the irrigation system in these regions.

DISCUSSION AND CONCLUSION

Specialization in fruit trees for the graduate settlers corresponded to their strategy of developing new business, sometimes coupled with a motivation to live in a healthy environment, whereas diversification by the common beneficiaries toward vegetables while maintaining their traditional activities of crops and livestock corresponded to their need to be economically independent from their families. Meanwhile, thanks to the social context in the reclaimed lands, where graduates and common beneficiaries (farmers) interacted with each other, we could observe social changes in their way of conducting their farming systems, e.g. involvement of women in the activities and decisions on the farm. Those social changes refer to some situations observed by Adriansen (2007).

In these changes, livestock has played different roles between settlers' categories over time. At settlement, it constituted the main source of manure to enrich the soil before being a source of crop fertilizer, especially for cash crops. It also represented a way to cover costs of tree plantation and the establishment of settlers' houses. Moreover, the need for forages to feed animals enhanced the role of legumes

Table III: Opportunities and constraints perceived by the beneficiaries in each reclaimed-land region of Egypt (%) // Opportunités et contraintes perçues par les bénéficiaires dans chaque région des terres récupérées d’Égypte (%)

| Factor | Perception | Nahda | Bangar | Hamam | Bustan | Tiba | Total |
|--------|------------------|-------|--------|-------|--------|------|-------|
| Land | Num. of settlers | 33 | 33 | 31 | 42 | 35 | 174 |
| | Opportunities | 91 | 73 | 90 | 98 | 94 | 90 |
| | Constraints | 6 | 21 | 3 | 0 | 6 | 7 |
| Labor | No challenge | 0 | 3 | 3 | 2 | 0 | 2 |
| | Opportunities | 6 | 6 | 10 | 12 | 26 | 12 |
| | Constraints | 76 | 64 | 61 | 55 | 60 | 63 |
| Market | No challenge | 3 | 3 | 0 | 10 | 9 | 5 |
| | Opportunities | 30 | 12 | 16 | 7 | 14 | 16 |
| | Constraints | 58 | 82 | 77 | 74 | 77 | 74 |
| Water | No challenge | 9 | 6 | 6 | 5 | 3 | 6 |
| | Opportunities | 33 | 12 | 42 | 24 | 49 | 32 |
| | Constraints | 52 | 73 | 32 | 52 | 34 | 49 |
| | No challenge | 15 | 15 | 26 | 24 | 17 | 19 |

(berseem) in soil fertility and made it a major component of a successful cropping system. All these functions revealed different roles of livestock in small-scale farming systems.

However, once tree plantation started to produce, the graduates usually reduced their livestock activity to alleviate the pressure on family and hired labor. In contrast, the majority of the common beneficiaries maintained their livestock activity for its multiple roles, and crop-livestock integration proved to be a main pillar in the sustainability of their system and also in the economic stability of the farms, as shown in other contexts by Alary et al. (2019).

The comparative analysis of results between Tiba mainly settled by graduates and Bustan settled by common beneficiaries confirmed these two agricultural models. However, our study showed that one determining factor was land access. As soon as common beneficiaries could increase their cultivated land, they developed fruit plantation, which explained the trend observed in Bustan. Moreover, diversification appeared to be a driving force for agricultural development, as specialization could be environmentally and economically risky. This explained the maintenance of diversified crop-livestock systems in Bustan compared to Tiba, even if farmers in Bustan developed fruit plantation. In old reclaimed lands, livestock production developed into more specialized systems, mainly dairy cattle or buffalo (32% compared to 9% at settlement), with the unspecialized system tending to vanish. Livestock specialization was mainly explained by the local market demand due to the proximity with Alexandria.

All these trends of crop-livestock systems in the reclaimed lands reflected different regional opportunities and constraints, linked with the markets and water access. Where water constituted the major constraint (as in Bangar, Bustan and Nahda), livestock remains a major component in the agricultural models with different orientations according to the market opportunity. For instance, in Nahda, the proximity of the demand allowed the development of the dairy activity. In Hamam, downstream of the canal, water constituted a major constraint compared to the rest of the studied zone. But it was perceived as an opportunity compared with neighboring regions without irrigation infrastructure. In Tiba, the agricultural model based on fruit plantation mainly resulted from the settlers' origin and their willingness to develop a profitable agricultural model oriented to markets.

This overview of the trends of crop and livestock activities at regional level revealed different roles given to animals between farmers according to their origins (graduates vs common beneficiaries), and

local constraints and opportunities. We were able to define different crop-livestock models that characterized the reclaimed lands. One major driver that can influence future trends is the market access that currently constitutes a high constraint both for the development of livestock and crop activities and to their integration, as one pillar of land sustainability.

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Conflicts of interest

There is no conflict of interest between the authors and the results.

Author contributions statement

AA, VA and MAO participated in the conception or design of the work; MAO and VA conceived and tested the questionnaire; XJ elaborated the design and data entry system for collected data and gave his support in data treatment; MO, VA and SAA collected data; AA drafted the first version of the manuscript; VA and MAO performed statistical analyses; VA, SAA and MAO critically reviewed the manuscript.

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Résumé

Aboul Naga A.M., Alary V., Osman M.A., Abd El-Rahim S.A., Juanes X. Opportunités et défis de l'intégration agriculture-élevage dans les systèmes agricoles des terres désertiques nouvellement cultivées d'Égypte

L'agriculture méditerranéenne est soumise à une forte concurrence pour l'utilisation des terres et de l'eau. L'un des défis pour les agriculteurs est d'augmenter la productivité des terres grâce à une meilleure utilisation du bétail dans les systèmes mixtes de culture et d'élevage. Pour évaluer les opportunités et les défis de l'intégration des activités de culture et d'élevage dans les zones irriguées, une enquête a été menée auprès de 175 exploitations familiales dans les zones désertiques à l'ouest du Delta en Égypte en 2013/2014. Cinq régions ont été étudiées et comprenaient les anciennes terres récupérées et mises en culture dans les années 1960, les terres récupérées intermédiaires où les agriculteurs se sont installés dans les années 1980, et les nouvelles terres récupérées qui ont été attribuées aux nouveaux agriculteurs dans les années 1990. L'étude a mis en lumière deux types de stratégies agricoles : 1) la diversification et la spécialisation axées sur la plantation d'arbres fruitiers par les diplômés universitaires qui ont pu accéder à environ deux hectares de terres dans le cadre du programme de colonisation depuis la fin des années 1970 ; et 2) la diversification avec l'accent sur l'élevage par des colons de la vallée du Nil, qui ont pu accéder à des lots d'un hectare de terres depuis les années 1990. La spécialisation fruitière par les diplômés correspondait à une stratégie de développement de nouvelles activités commerciales, alors que la diversification du système agricole avec l'élevage par les autres bénéficiaires correspondait à la nécessité d'assurer une source de revenu familial stable tout au long de l'année. Alors que la diversification semblait être un moteur du développement agricole dans ce contexte, la spécialisation pouvait être un risque social et économique, car les diplômés devenaient plus dépendants des marchés nationaux et internationaux. Cela s'est reflété dans la perception des agriculteurs qui ont souligné la nécessité d'intégrer les contraintes techniques, écologiques, économiques et sociales dans leurs décisions.

Mots-clés : système de culture, ferme d'élevage, diversification, arbre fruitier, terre récupérée, terres arides, Ouest Delta, Égypte

Resumen

Aboul Naga A.M., Alary V., Osman M.A., Abd El-Rahim S.A., Juanes X. Oportunidades y retos para la integración de sistemas de cultivo y ganadería en tierras recuperadas del desierto en Egipto

La agricultura mediterránea está limitada por una alta competitividad por el uso de la tierra y el agua. Uno de los retos para los finqueros es aumentar la productividad de la tierra, a través de un mejor uso de la ganadería mediante sistemas de explotación mixtos de cultivo-ganado. Para evaluar las oportunidades y retos de integrar actividades de cultivo y ganadería en zonas irrigadas, se llevó a cabo una encuesta en 175 fincas de pequeña escala, en las tierras desérticas del delta del oeste en Egipto, entre 2013/2014. Se investigaron cinco regiones, incluyendo las tierras recuperadas precedentemente donde llegaron colonos en 1960, las tierras recuperadas posteriormente donde llegaron colonos en 1980 y las tierras recuperadas más recientemente y atribuidas a nuevos finqueros en la década de los 1990. El estudio resalta dos tipos de estrategias de cría: 1) Diversificación y especialización con énfasis en plantaciones de árboles frutales por parte de graduados universitarios, quienes beneficiaron de la atribución de aproximadamente dos hectáreas de terreno mediante un programa de asentamiento a fines de la década de los 1970; y 2) diversificación con énfasis en ganadería para el beneficio común de los colonos del Valle del Nilo, quienes beneficiaron de la atribución de una hectárea de terreno desde 1990. Los graduados enfocados en los árboles frutales correspondieron a una estrategia de desarrollo de una nueva actividad empresarial, mientras que los beneficiarios comunitarios que diversificaron sus sistemas de cría a través de la ganadería correspondieron a la necesidad de asegurar una fuente estable de ingreso familiar a lo largo del año. Aunque en este contexto la diversificación apareció como una fuerza promotora para el desarrollo agrícola, la especialización podría ser un riesgo social y económico conforme los graduados se tornan más dependientes de los mercados nacionales e internacionales. Esto se reflejó en la percepción de los finqueros que subrayaron la necesidad de integrar las limitaciones técnicas, ecológicas, económicas y sociales en sus decisiones.

Palabras clave: sistemas de cultivo, explotaciones ganaderas, diversificación, árboles frutales, tierras rehabilitadas, tierras de secano, Oeste Delta, Egipto