L'impact de l'intensification agricole sur le bien-être territorial dans un pays du sud Analyse empirique dans la situation tunisienne

Fatma Mhadhbi

THÈSE DE DOCTORAT D'AVIGNON UNIVERSITÉ

École Doctorale 537 « Culture et Patrimoine »
Domaine de recherche : économie agricole et développement
Laboratoire INRAE/Ecodéveloppement

Présentée par Mlle Fatma Mhadbi

Pour l'obtention du grade de Docteur en Sciences économique

L'impact de l'intensification agricole sur le bien-être territorial dans un pays du sud
Analyse empirique dans la situation tunisienne

Soutenue publiquement / à huis clos le 07/12 /2021 devant le jury composé de :

M. Samuel Bates, Pr, université d'Angers (France), rapporteur
M. Jean Pierre Del corso, Pr, ENSFEA/LEREPS (France), rapporteur
Mme Valérie Angeon, Dr INRAE (France), Examinatrice
Mme Myriam Donsimoni, MC, université de Savoie (France), Examinatrice
M. Abdelmajid Saidi, Pr, université Moulay Ismail, Meknes (Maroc), Président de jury
M. Claude Napoléone : Directeur de thèse, Ingénieur de recherche, INRAE
M. Ridha Chkoundali, Co-encadrant, Pr, FSEGN –Unversité de Cartahge (Tunisie)

Résumé: L'objectif principal est de développer une approche analytique en économie régionale permettant de rendre compte de la complexité de la relation entre intensification agricole et bien-être territorial, que ce soit en termes de mesure, d'estimation des freins au changement ou des amorces de solutions. Formellement, dans un premier chapitre, je propose une méthode originale permettant de mesurer l'impact de l'intensification agricole sur le bien-être territorial dans un pays en développement (la Tunisie), au-delà du revenu individuel. Au delà de la méthode, cette relation de causalité complexe a été quantifiée par la mise en œuvre d'un modèle structurel basé sur une approche PLS-PM (Partial Least Squares - Path Modeling). Dans un second chapitre, j'ai utilisé les cadres de la transition agro-écologique qui caractériser empiriquement les facteurs de verrouillage et les déterminants du changement au niveau des agriculteurs. Je mets en exergues des éléments originaux eu égard aux résultats "mainstream" des approches empiriques de la transition agro-écologique, comme le poids de l'histoire nationale ou l'incidence de la faiblesse de l'état. Enfin, dans un dernier chapitre, j'évalue la capacité des agriculteurs des zones rurales tunisiennes à s'adapter aux cadres de "l'économie sociale et solidaire", au titre d'une solution alternative permettant de renforcer la résilience ou la durabilité des territoires.

Mots clés: intensification agricole, bien-être territorial, les facteurs de verrouillage, économie sociale et solidaire.

Abstract: The main objective is to develop an analytical approach in regional economics to account for the complexity of the relationship between agricultural intensification and territorial well-being, whether in terms of measurement, estimation of the obstacles to change or the beginnings of solutions. Formally, in the first chapter, I propose an original method to measure the impact of agricultural intensification on territorial well-being in a developing country (Tunisia), beyond individual income. Beyond the method, this complex causal relationship has been quantified through the implementation of a structural model based on a PLS-PM (Partial Least Squares - Path Modeling) approach. In a second chapter, I used agro-ecological transition frameworks to empirically characterize the lock-in factors and determinants of change at the farmer level. I highlight original elements with respect to the "mainstream" results of empirical approaches to agro-ecological transition, such as the weight of national history or the impact of state weakness. Finally, in a last chapter, I assess the capacity of Tunisian rural farmers to adapt to the frameworks of the "social and solidarity economy", as an alternative solution to strengthen the resilience or sustainability of territories.

Keywords: agricultural intensification, territorial well-being, lock-in factors, social and solidarity economy

Table des matières

Introduction

L'objectif de cette thèse est de produire une étude la plus complète possible sur le concept de bien-être territorial appliqué à la production agricole dans un pays en développement, à travers une étude de cas en Tunisie. Pour ce faire, j'ai d'abord dû concevoir une méthode originale d'évaluation du bien-être territorial, en ce sens que les approches disponibles dans les champs de l'économie régionale et du développement étaient soit focalisées sur les revenus des producteurs, soit contraintes aux échelles nationales (souvent par manque de données aux échelons inférieurs). Ensuite, je me suis penchée sur l'analyse des déterminants des changements dans les pratiques de production afin d'évaluer le potentiel d'amélioration du bien-être. Pour cela, je me suis appuyée sur l'expression des acteurs locaux afin de révéler d'éventuelles spécificités locales inhérentes à la situation de la production agricole dans un pays en développement. Enfin, à partir de ces connaissances, je propose un outil de changement adapté aux éléments de connaissances apportés par ma thèse et basé sur une démarche collective.

1. Contexte : l'avènement puis mise en question de l'intensification agricole

Le modèle d'intensification agricole a communément été considéré comme favorable au développement économique, sous l'impulsion des institutions internationales et plus particulièrement des politiques d'ajustement structurel (Dawson, Martin and Sikor 2016). Il s'est donc progressivement diffusé dans le monde, ouvrant la voie à l'avènement de la Révolution verte en Amérique latine et en Asie du sud dans les 60 et 70. Le critère principal d'évaluation du système de production intensif fait référence à une augmentation de la quantité de production par unité de terre (nourriture, carburant ou fibres), issue de pratiques et technologies de gestion modernisés, notamment par incorporation de progrès technologiques, ou d'une augmentation des intrants (Tilman et al., 2011; Pretty et Bharucha, 2014). Il fut considéré comme une solution à la faim et à la pauvreté et, plus largement, une amélioration de la situation sociale des agriculteurs (Ravallion and Datt 1996 et 2002 ; Datt and Ravallion 1998 ; Ravallion et Chen 2007 et 2009; Pingali 2012), sans empiéter davantage sur les ressources naturelles (accroitre la productivité plutôt qu'étendre les surfaces) et comme un catalyseur essentiel du développement économique (Clay, 2018; Collier and Dercon, 2014; Matson et al., 1997) ; notamment, au titre d'étape de transition vers une économie urbanisée non agricole (D'Amour et al. 2017 ; Dorward et al. 2004). Soutenue par les politiques publiques (Hu, 2020; Magrini et al, 2017), l'intensification des pratiques agricoles conduit, entre autre, à une spécialisation culturale à travers la sélection de nouvelles variétés à haut rendement (VHR) (notamment le blé et le riz pour les plus consommés et échangés), combinée à des engrais de synthèse, des pesticides, ainsi que des équipements mécaniques et d'irrigation. En corollaire, la recherche scientifique agricole s'est concentrée sur un type principal de paradigme

scientifique, orienté vers l'agrochimie et l'ingénierie génétique (Cowan and Gunby, 1996; Pretty and Bharucha, 2014; Vanloqueren and Baret, 2009).

Dans ce contexte, comme de nombreux pays en développement et dans une situation de post-indépendance, la Tunisie, depuis le début de son indépendance jusqu'à présent a privilégié des systèmes agricoles intensifs dirigés vers l'exportation. Sous l'impulsion de la Révolution Verte, les autorités tunisiennes ont ainsi encouragé l'importation de variétés de semences hybrides à haut rendement, notamment en provenance des centres du Groupe consultatif pour la recherche agricole (CGIAR), et du Centre international pour l'amélioration du maïs et du blé (CIMMY) (Gafsi, and Roe 1979 et 1977 ; Purvis 1972), combiné à l'irrigation et à l'utilisation intensive d'engrais chimiques, d'herbicides et d'équipements agricoles (Boughanmi, 1995). Cette politique de haute productivité a permis à la Tunisie de se spécialiser dans des filières à forte valeur ajoutée dans lesquelles elle dispose d'un avantage comparatif (l'huile d'olive, par exemple).

Toutefois, la focalisation des institutions et des financements sur un seul système de production a généré un phénomène *"d'auto-renforcement*[1]*"*, conduisant potentiellement à une situation de verrouillage[2] (Fares, Magrini, 2012 ; Magrini et al 2017) autour du paradigme technologique reposant sur un usage intensif des intrants de synthèse (Fares et Magrini, 2012). En substance, la spécialisation sur une espèce donnée facilite l'acquisition d'une maîtrise technique, la réalisation d'économies d'échelle et une réduction des coût marginaux d'exploitation (Magrini et Nicolas 2019). A titre d'illustration, en Tunisie, si les systèmes à haute productivité a permis au pays de se spécialiser dans des filières pour lesquelles elle dispose d'un avantage comparatif, ils ont généré une dépendance croissante de l'agriculture à des variétés de semences "standard" et entraîné la disparition de variétés locales adaptées au climat du pays (Ministere de l'agriculture, 1995), tels que le maïs, la pastèque"kadousse"et les variétés de blé dur "Biskri, Mahmoudi et Chile".

L'utilisation accrue des méthodes modernes d'agriculture a simplifié les standards de production agro-culturels (Busch, 2011) et tend à favoriser l'homogénéisation des régimes alimentaires à partir de l'industrialisation des filières de transformation et de distribution (Khoury et al. 2014 ; Magrini et Nicolas 2019). De fait, que ce soit par la simplicité des technologies ou par les pratiques sociales, il est observé une réticence au changement, notamment pour abandonner ou réduire l'utilisation des pesticides (Ríos-González et al., 2013), malgré les politiques publiques mises en œuvre dans de nombreux pays (Dessart et al., 2019 ; Hu, 2020 ; Rogério et al., 2020) ; un verrouillage technologique qui a accru la

[1] Dans la littérature évolutionniste, cette notion met en lumière comment la trajectoire technologique agricole réduit le nombre de cultures (spécialisation) par l'utilisation accrue de solution technologiques spécialisées (engrais, pesticides, équipements…)(Fares , Magrini , 2012).

[2] Issue de l'économie politique, cette notion montre comment une technologie peut être adoptée à long terme - voire de manière irréversible - au détriment d'une technologie alternative, même si cette dernière apparaît plus efficace (Arthur, 1989; David, 1985).

focalisation de l'économie agricole nationale vers le marché global et nécessité en corolaire le recours des pays en développement à ce même marché pour importer les denrées alimentaires non produites sur place ou indisponible du fait de l'exportation.

Dans ce contexte, il convient tout d'abord de s'interroger sur l'apport social du système intensif de production agricole (Altieri, 2009), d'autant plus qu'une " nouvelle révolution verte" a lieu en Afrique (Luna, 2020). Or, le débat sur la manière dont le bien-être des territoires ruraux est impacté par l'intensification agricole n'est toujours pas résolu. Le principal argument favorable aux solutions technologiques industrialisées consiste à mettre en avant l'effet positif de l'intensification sur la production alimentaire, mais également comme moteur du développement économique (Dawson et al., 2016 ; Ejeta, 2010 ; Ickowitz et al., 2019). En contrepoint, les controverses se basent sur les répercussions négatives attendues de l'innovation technologique sur le nombre d'agriculteurs et d'emplois salariés, ainsi que la baisse des salaires dans le secteur agricole (Griffin 1974 ; Kerr and Kovali 1999 ; Dawson, Martin and Sikor 2016). On sait également que le système d'intensification a entraîné des transformations profondes dans les sociétés rurales ; par exemple en mettant en cause les systèmes ruraux communautaires par le développement de nouvelles technologies économes en travail et individuellement rentables, renforçant par effet retour l'exode rural (Luna, 2020). Enfin, Rasmussen et al (2018) ont également montré que l'intensification de l'agriculture entraîne rarement des résultats positifs simultanés en matière de services écosystémiques et de bien-être humain. Dans une visée empirique, des études récentes menées en Afrique ont montré que l'intensification de l'agriculture n'a pas permis de remédier aux disparités persistantes en matière d'accès à la terre et aux ressources parmi les petits exploitants, exacerbant la malnutrition et les inégalités au sein des communautés rurales tout en profitant aux grands exploitants, aux populations urbaines et à l'agrobusiness (Bezner-Kerr, 2012; Moseley, 2015).

Pour résumer, je fais l'hypothèse que la généralisation du système productiviste s'est avérée adaptée aux pays occidentaux ou la chine, lorsque la main-d'œuvre libérée pouvait être affectée dans les autres secteurs économiques, mais elle est inadaptée dans les pays en développement où l'emploi dans les secteurs secondaire et tertiaire est insuffisant. Dans ces situations, la productivité agricole est susceptible d'augmenter les quantités produites tout en générant de la pauvreté à l'échelle territoriale et de l'émigration issue des zones de production. En Tunisie, la vallée de la Medjerda et les plaines du Kef dans la région du nord-ouest du pays, illustrent l'exacerbation des inégalités régionales et de l'exode rural issue de l'évolution des structures agraires, du fait de changements de systèmes de culture rapides sur une structure de la propriété et des exploitations déjà fortement concentrées (Gammar, 2019; Mzali, 1997). En corollaire, dans l'hypothèse où il serait avéré que le bien-être territorial est affecté par les processus d'intensification des pratiques agricoles, il convient de s'interroger sur les éléments qui expliquent la permanence d'usage des produits de synthèse par les agriculteurs ; qui de plus sachant les

préoccupations avérées en termes de santé humaine (Elahi et al., 2019) et l'existence d'alternatives fiables parmi lesquelles figurent l'agriculture de conservation (AC), l'agriculture biologique (AB), l'agroforesterie et l'agroécologie (Benoit et al., 2017; Jouzi et al., 2017).

2. Méthodologie de quantification des indicateurs de bien-être ; éviter le réductionnisme

Aborder la relation entre l'intensification agricole et le bien-être territorial est un sujet complexe où des facteurs très différents peuvent entrer en jeu (socio-économiques et démographiques, mais également climatiques). Il est donc nécessaire tout d'abord préciser la notion de bien-être à laquelle je me référerai. Le bien-être a, traditionnellement, été considéré contingent aux activités économiques et à la croissance et a donc été beaucoup mesuré par un indicateur unidimensionnel, correspondant peu ou prou aux revenus. De fait, la majorité des travaux restent dominées par une approche individuelle du bien-être (Elliott et al., 2017 ; Ferraro and Barletti, 2016 ; Ingersoll-Dayton et al., 2004). Or, j'avais vu, le revenu n'est pas le seul déterminant du bien-être de la population (Bischoff et Koch, 2012). D'autres besoins fondamentaux entrent en jeu comme la santé, l'accès à l'éducation, la sécurité alimentaire, l'égalité des sexes, l'insertion sur le marché du travail, l'accès à l'eau et au logement, etc. (Dolan et al., 2006). Plusieurs expérimentations sont d'ailleurs à l'œuvre, comme l'indice canadien du bien-être (ICMÊ), l'indice de l'OCDE pour une meilleure vie et l'indice de bonheur national brut du Bhoutan. Toutefois, malgré la pertinence des mesures "au-delà du revenu", notamment à des fins pratiques et politiques, leur application reste limité dans les pays à faible revenu ou revenu intermédiaire (Kangmennaang and Elliott, 2019). En outre, la pertinence locale des indicateurs utilisés au niveau international peut être interrogée et les données pour les évaluer aux échelles infranationales rarement disponibles, en particulier lorsqu'ils sont appliquées en milieu rural (Nanor, Poku-Boansi et Adarkwa 2021). En reprenant Davern et al (2017) ou Michalos et al (2011), l'identité culturelle, l'inégalité, la sécurité de l'emploi, la santé, la vitalité de la communauté, les loisirs, les facteurs environnementaux et les perceptions subjectives sont des déterminants importants du bien-être d'une population et peuvent être très différents d'une région à une autre.

Dans la perspective de territorialiser l'évaluation du bien-être, j'ai choisi de m'appuyer sur une définition qui permet une reconnaissance de la nature multidimensionnelle de la notion, en me référant à l'indicateur du PNUD (UNDP, 2011), dérivé de l'approche des capabilités de Sen (Sen 1993). Formellement, il s'agit de mesurer le bien-être en agrégeant quatre indicateurs objectifs : l'espérance de vie à la naissance, les années de scolarisation moyennes, les années de scolarisation attendues et le revenu national brut par habitant. Mon objectif est de caractériser le bien-être à l'échelle infranationale et dans une région rurale d'un pays du sud. Au-delà de la mesure elle-même, je voulais également répondre à un enjeu de connaissance sur les outils permettant de quantifier l'impact du système d'intensification agricole sur le niveau de bien-être territorial. En effet, le manque d'attention portée à la

dimension territoriale du bien-être amoindrie la portée de sa mesure dans les pays en développement, en particulier dans les contextes africains.

3. Les processus de changement à partir de d'actions collectives localisées

Au-delà de la mesure de l'effet des systèmes intensifs sur le bien-être territorial, un processus de changement localisé et basé sur les principes de l'action collective (les exploitants définissent leurs besoins et leurs préférences, avec la participation des parties prenantes institutionnelles) est susceptible de minorer l'effet des verrous qui complexifient la transformation du modèle agricole dominant (Crespo, Réquier-Desjardins et Vicente 2014).

C'est dans ce cadre que , je mettrai en perspective le " système alimentaire localisé " (Bele et al., 2018; Cañada and Muchnik, 2011; Hinrichs, 2003, 2000; Muchnik, 2008) dont le but est d'autonomiser les communautés locales et de contribuer à la génération de revenus et à la cohésion sociale par le biais d'actions collectives(Requier-Desjardins et al., 2003).

Cette voie collective se caractérise par une grande diversité des formes d'associations d'habitants ou de producteurs, de coopératives, mais aussi d'organisations coutumières ou de groupes d'entraide (Raimbert et Rebaï, 2017). Sa génération s'est accompagnée de stratégies donnant priorité à la voix des producteurs et à la stimulation des initiatives locales gérées et soutenues par les membres, qui a donné naissance à des paradigmes inspirés des approches du développement local, comme un concept novateur en rupture avec le modèle centralisé dominant : un processus de mobilisation des acteurs favorisant le développement d'une stratégie d'organisation et de valorisation de l'économie locale stimulée par des politiques publiques appropriées (Pecqueur, 2005 ; Campagne et Pecqueur, 2014).

Dans ce contexte, l'économie sociale et solidaire (ESS) apparait comme un instrument de lutte contre la pauvreté et l'exclusion (Utting, 2017) et, pour la Tunisie, comme une alternative aux stratégies centralisées de développement (Elachhab, 2018) basée sur l'action participative et collective (cristallisé dans le vote de la loi 2020/30 relative à l'économie sociale et solidaire - Journal Officiel de la République Tunisienne 2020[3]). Formellement, la mise en place de structures collectives, telles que les coopératives, les sociétés mutuelles ou les groupes d'entraide, est considérée comme un outil permettant aux agriculteurs de mettre en commun leurs ressources afin de faciliter ou développer leurs activités en fournissant des services sociaux et économiques susceptible de compenser les coûts de transaction élevés résultant de leur petite taille (Abebaw and Haile 2013; Chiputwa, Spielman, and Qaim 2015 ; Fischer, Qaim and Goettingen 2012 ; Kruijssen, Keizer and Giuliani 2009). Il est également attendu que l'action collective contribue à l'amélioration du bien-être des petits exploitants à travers la croissance

[3] Cette loi, vise à soutenir les activités collectives fondées sur le principe de solidarité et d'utilité sociale mises en œuvre par les coopératives, les sociétés mutuelles de services agricoles (SMSA), les Groupements de développements agricoles (GDA), les associations et les fondations.

économique rurale, la réduction de la pauvreté et l'amélioration de la sécurité alimentaire (Simmons and Birchall, 2008; Thorp et al., 2005; Verhofstadt and Maertens, 2014).

En Tunisie, un mouvement d'action collective a ainsi marqué les années 1990 avec l'émergence de nouvelles formes d'action perçues comme une conséquence des échecs des programmes centralisés d'ajustement structurel. Il est d'ailleurs marquant de constater que les zones rurales tunisiennes marginalisées et quasi exclues des politiques de développement économique et social, sont celles qui furent traversée par des revendications socio-économiques autour des questions d'emploi, de développement et de justice (Hibou, 2011 ; Allal, 2011) et ont ouvert la période dite de révolution démocratique de 2011, après une décennie de mouvements populaires et de récession économique (El-Idrissi, 2017). A leur suite, le gouvernement tunisien s'est engagé dans la mise en place de deux structures à vocation localisée : les Sociétés Mutuelles de Services Agricoles (SMSA) et les Groupements de Développement Agricole (GDA)[4] (Canesse 2010 ; Mustapha et al. 2015).

Choix du terrain d'étude : le paradoxe d'une région riche avec une population pauvre

La région du Nord-Ouest (Kef, Siliana, Jendouba et Béja)[5] constitue un paradoxe régional[6] représentatif, à mon sens, de la déconnexion entre performance des exploitations agricoles et bien-être territorial autour duquel s'articule la thèse : une région riche avec une population pauvre (Attia, 1986). Depuis l'indépendance, la région du Nord-Ouest se présente, en effet, comme un "amont" destiné à alimenter un "aval" représenté par le nord-est du pays, Tunis et sa région : approvisionnement en produits agricoles ou en eau mais également en main d'œuvre avec un solde migratoire régulièrement négatif (DGAT,2010), alors que l'ensemble de ses richesses devraient confèrer à la région un rôle dans le développement de pôles territoriaux structurants (agriculture, tourisme et agroalimentaire) (DGAT, 2010).

- Une région riche en ressources naturelles. La région possède une forte vocation rurale dotée de plusieurs atouts et richesses naturelles (figure 1) : l'agriculture est l'activité prédominante et repose principalement sur la céréaliculture, l'élevage, le maraîchage et l'arboriculture. Elle dispose de terres

[4] Les GDA: Institués par le Décret n° 1819 de 1999, les Groupements de Développement Agricoles (GDA) sont des organismes d'utilité publique regroupant des propriétaires et des utilisateurs et sont chargés par l'État de gérer certaines ressources naturelles (eaux, forêts…). Ils jouent un rôle très important, car les ressources naturelles, telles que les eaux, les forêts et les pâturages, subissent une forte surexploitation qui, aggravée par les effets du changement climatique, menace de causer des dommages irréversibles.

[5] La région Nord-Ouest couvre une superficie d'un peu plus de 16 000 km², soit 10,8 % de la superficie totale du pays. Elle est délimitée par la mer Méditerranée au nord, avec Tabarka comme seule ville côtière, à l'ouest par l'Algérie, au sud par les gouvernorats de Kairouan, Kasserine et Sidi Bouzid, à l'est par les gouvernorats de Zaghouan, Manouba et Bizerte.

[6] https://www.webmanagercenter.com/2019/01/08/429439/tendances-regionales-le-paradoxe-du-nord-ouest-si-pauvre-et-si-riche-partie-1/

fertiles et d'un potentiel forestier important et varié (40% des ressources forestières du pays - Ain Drahem, Ghar Dimaou, Kisra, Ain Boussaadia les délégations de Nebeur, Sakiet Sidi Youssef et Kef-Ouest, etc.). Elle possède également d'importantes ressources hydriques grâce à ses conditions bioclimatiques et une pluviométrie annuelle avoisinant les 400 mm (certaines années jusqu'à environ 1 000 mm) avec un potentiel important en eaux souterraines estimé à 60%. Cette région est enfin caractérisée par un important potentiel en eaux minérales et thermales (Shimi, 2014). Ces ressources naturelles ont été mobilisées par des ouvrages de rétention (barrages) puis des réseaux de transport d'eau à longue distance ont été développés pour desservir le Nord-Est.

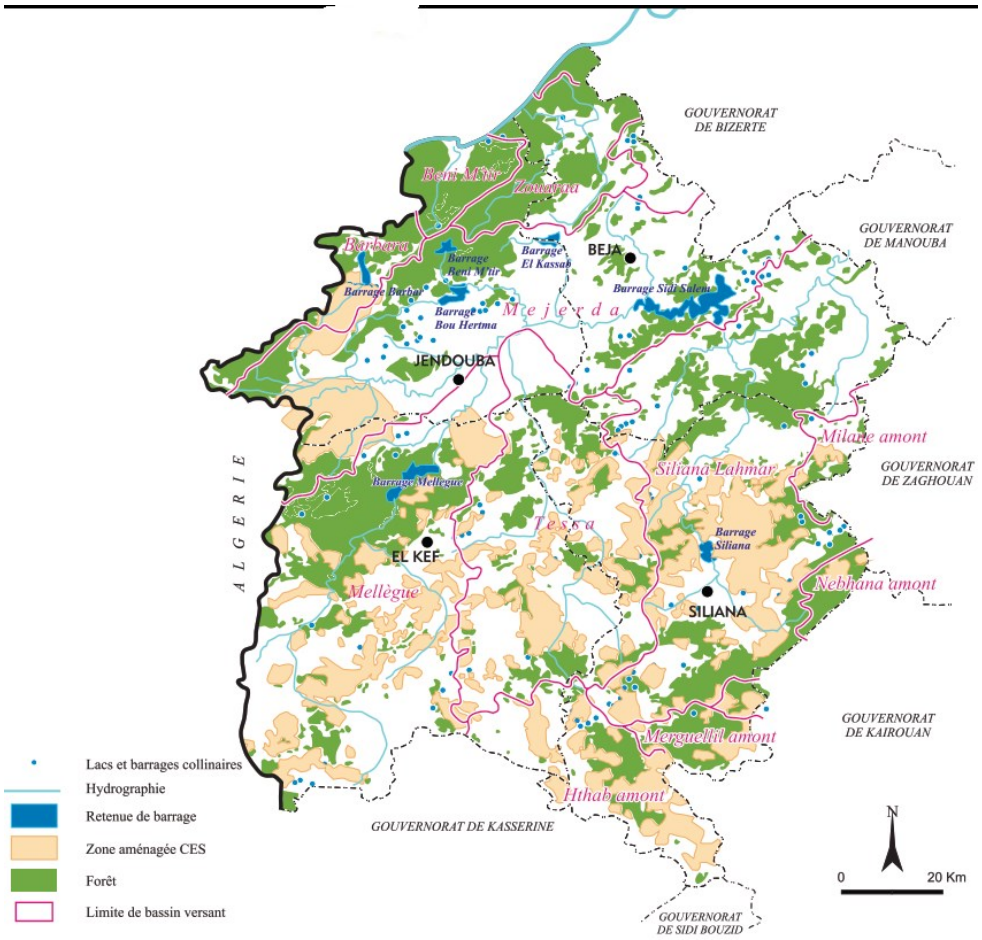


Figure 1 : localisation des ressoureces naturelles de la région du nord_ouest (Atlas cartographique,2010)

- Une région avec une agriculture très moderne. La recherche de la productivité et des économies d'échelle a conduit à la mise en place de grands bassins de production avec une agriculture technologique et privilégiant les marchés urbains. La région du Nord-Ouest est maintenant le plus grand bassin d'agriculture productiviste et moderne de Tunisie, où sont concentrées les activités agricoles les plus

stratégiques du pays, en formant un véritable triangle autour des plaines de la haute vallée de la Medjerda, traversées par les plus importants fleuves du pays « Medjerda », « Mellègue » et « Tessa », et les plaines d'Elkef et de Siliana, situées entre les montagnes de Kroumirie et les steppes de Kasserine, et ouvertes sur les plaines et le littoral du Nord-Est (figure 2). A titre d'exemple, la région Nord-Ouest est la principale zone céréalière du pays, avec près de la moitié environ de la production nationale de céréales ; le gouvernorat de Béja produit près de 12,5% des cultures maraîchères du pays et assure plus de la moitié (60%) de la production céréalière nationale (ODNO, 2017) sur moins de 10% des superficies emblavées du pays.

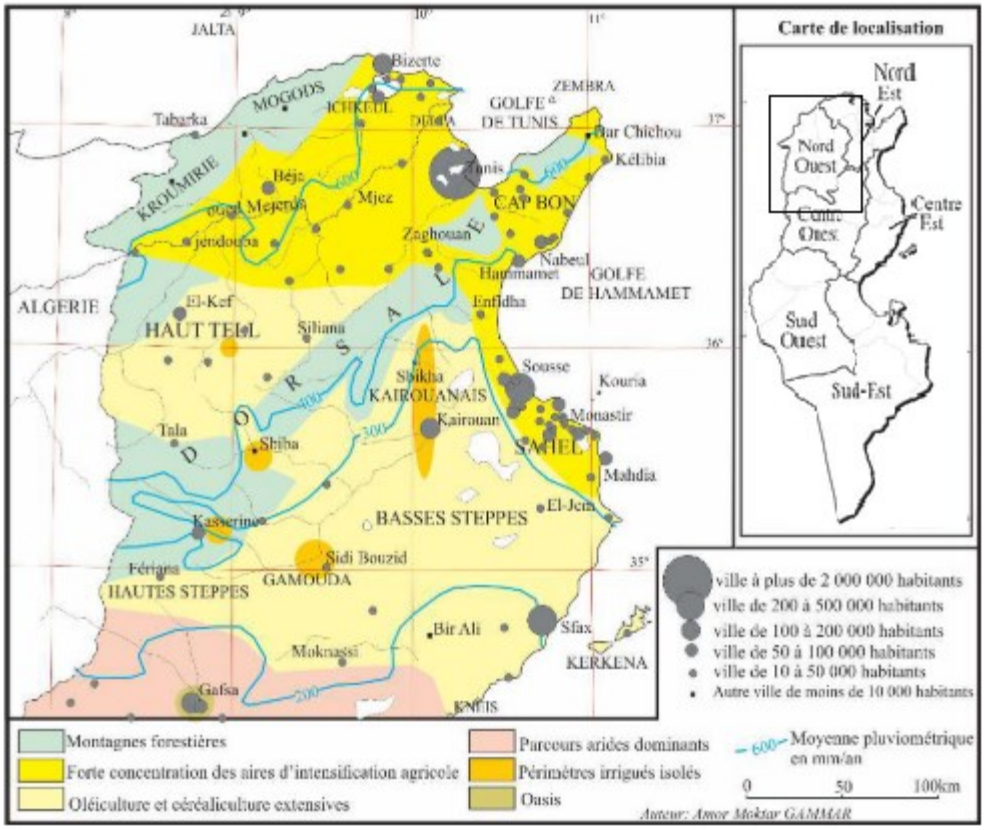


Figure 2 : région d'étude (A.M. Gammar ,2019)

- Mais une région avec un faible niveau de bien-être. La région Nord-Ouest présente l'un des plus faibles niveaux de développement humain en termes d'éducation, de santé, d'emploi et d'infrastructures (Najeh, 2015) : le taux de chômage des jeunes (18-29 ans) est de 45% (Institut national de la statistique de Tunisie) et, alors que la région est riche en eau, 300 000 personnes n'ont toujours pas accès à l'eau potable, principalement en milieu rural (Institut national de la statistique, 2015).

- Et une démographie marquée par l'émigration. L'atonie du processus de développement, ou tout du moins du partage des fruits du développement agricole, a généré des flux migratoires qui ont fait du

Nord-ouest une des régions la plus répulsive du pays (Doukh et al, 2017) avec persistance d'un taux de croissance démographique négatif de -0,36% en 2014.

Pour résumer, en reprenant Attia (1986), de toutes les régions tunisiennes, les populations du Nord-ouest « sont celles qui ont été le plus profondément traumatisées, paupérisées et déracinées au cours de l'évolution récente de la société tunisienne ». Cette évolution est à l'origine d'une dégradation des rapports sociaux de production dont les conséquences sont parmi les principaux freins au développement de la région (Doukh et al, 2017) et, entre autre conséquence, le mouvement migratoire découle du développement rapide de la mécanisation et à l'évolution du système agricole (Mzali, 1997). En outre, au lendemain de l'indépendance l'état a fait de la réduction des inégalités régionales l'un de ses objectifs prioritaires, en promouvant, pour les régions agricoles, la coopération agricole dans ses perspectives décennales. Le modèle coopératif avait pour but la modernisation de l'agriculture par l'introduction de paquets techniques mais il a généré, dans la région du Nord-Ouest, la perte d'identité du petit exploitant et la détention de la plupart des terres par les grands exploitants (Boughanmi, 1997). La grande exploitation mécanisée n'avait pas la possibilité d'offrir les emplois et les revenus suffisants pour intégrer les masses paysannes présentes (Gammar, 2019).

Plan de la thèse

La thèse s'articule autour de trois chapitres. Le premier a une vocation analytique et méthodologique, dans lequel je cherche à savoir comment évaluer au mieux l'impact de l'intensification agricole sur le bien-être territorial dans un pays du sud, au-delà des revenus individuels. Pour quantifier cette relation aux causalités complexes, je propose un modèle structurel utilisant une approche PLS-PM (*Partial Least Squares - Path Modeling*), de mesure formative, en concentrant sur l'analyse des relations entre quatre variables latentes inspirées des proposition d'A. Sen : le bien-être, l'agriculture intensive, le bioclimat et la démographie. La validité empirique du modèle est testée sur la région agricole du nord-ouest de la Tunisie.

Le deuxième article vise à explorer empiriquement les déterminants de la persistance de l'utilisation des pesticides de synthèses dans l'agriculture tunisienne, malgré la disponibilité d'alternatives au modèle agricole productiviste. L'analyse repose sur une enquête de terrain en Tunisie, et plus précisément dans les systèmes céréaliers et légumiers intensifs du nord-ouest, qui a permis d'interroger des agriculteurs et des parties prenantes (ouvriers agricoles, conseillers agricoles, etc.) sur l'utilisation des pesticides, leur intérêt pour la transition vers des pratiques agricoles plus durables et les obstacles rencontrés lors de changements. A partir d'une analyse bibliométrique de ce matériau, j'ai mis en lumière les conditions

de verrouillages qui limitent les possibilité d'arrêt de l'utilisation des pesticides et j'ai étudié les voies possibles de transition vers des systèmes plus durables. Je montre que l'attitude personnelle, les connaissances et les compétences sont des éléments clés, mais non suffisants pour correctement expliquer le verrouillage dans les pays en développement : la structure agricole locale, l'environnement politique et institutionnel empêchent également les agriculteurs de passer à des pratiques plus durables.

Enfin, le troisième article, vise à explorer une voie d'action collective locale en vue de renforcer la résilience ou la durabilité des territoires, en favorisant la préservation de la spécificité des produits alimentaires, des pratiques adaptées au niveau local et une meilleure répartition de la valeur ajoutée. En suivant la littérature et à travers une analyse bibliométrique du matériau issu des entretiens dans la région du nord-ouest de la Tunisie, je montrerai que la construction de collectifs est favorable à la transition des territoires vers plus de durabilité.

L'apport de mon travail de thèse aura ainsi été de trois ordres :

- Offrir un outil de mise en évidence et de mesure des limites du modèle d'intensification agricole au sens du bien-être territorial, à travers une méthode d'analyse statistique permettant de mesurer la relation causale entre l'intensification agricole et le bien-être de la population rurale à l'échelle infra-communal, en tenant compte de la dimension collective du bien-être rural.
- Une analyse empirique des facteurs de verrouillage qui empêchent l'arrêt de l'utilisation des intrants de synthèse par les agriculteurs d'un pays du sud.
- Proposition d'une solution alternative permettant d'atténuer l'effet des verrous autour d'un paradigme sociotechnique axé sur l'utilisation intensive d'intrants de synthèse (mise en place d'une approche localisée basée sur les principes de l'action collective.

Références

Abebaw, D., Haile, M.G., 2013. The impact of cooperatives on agricultural technology adoption : Empirical evidence from Ethiopia. Food Policy 38, 82–91. https://doi.org/10.1016/j.foodpol.2012.10.003

Altieri, M.A., 2009. Agroecology, Small Farms, and Food Sovereignty. Mon. Rev. 61, 102–113. https://doi.org/10.14452/MR-061-03-2009-07_8

Arthur, W.B., 1989. Competing Technologies, Increasing Returns, and Lock-In by Historical Events. Econ. J. 99, 116. https://doi.org/10.2307/2234208

Bele, B., Norderhaug, A., Sickel, H., 2018. Localized agri-food systems and biodiversity. Agric. 8. https://doi.org/10.3390/agriculture8020022

Benoit, M., Tchamitchian, M., Penvern, S., Savini, I., Bellon, S., 2017. Potentialités, questionnements et besoins de recherche de l'Agriculture Biologique face aux enjeux sociétaux. Économie Rural. Rev. française d'économie Sociol. Rural. 49–69. https://doi.org/10.4000/economierurale.5287

Bezner-Kerr, R., 2012. Lessons from the old Green Revolution for the new: Social, environmental and nutritional issues for agricultural change in Africa. Prog. Dev. Stud. 12, 213–229.

Boughanmi, H., 1995. Les principaux volets des politiques agricoles en Tunisie : évolution , analyse et performances agricoles. CIHEAM, Options Méditerranéennes Série B. Etudes Rech. n. 14, 127–138.

Busch, L., 2011. Food standards: The cacophony of governance. J. Exp. Bot. 62, 3247–3250. https://doi.org/10.1093/jxb/erq439

Cañada, J.S., Muchnik, J., 2011. Ancrage et identité territoriale des systèmes agroalimentaires localisés. Econ. Rural. 322, 4–10. https://doi.org/10.4000/economierurale.2962

Canesse, A.-A., 2010. Les Groupements de développement agricole (GDA), entrepreneurs locaux ou relais administratifs ? Quels enjeux participatifs pour les agriculteurs tunisiens ? 243–255.

Chiputwa, B., Spielman, D.J., Qaim, M., 2015. Food Standards , Certification , and Poverty among Coffee Farmers in Uganda. WORLD Dev. 66, 400–412. https://doi.org/10.1016/j.worlddev.2014.09.006

Chriest, A., Niles, M., 2018. The role of community social capital for food security following an extreme weather event. J. Rural Stud. 64, 80–90. https://doi.org/10.1016/j.jrurstud.2018.09.019

Clay, N., 2018. Seeking justice in Green Revolutions: Synergies and trade-offs between large-scale and

smallholder agricultural intensification in Rwanda. Geoforum 97, 352–362. https://doi.org/10.1016/j.geoforum.2018.09.021

Collier, P., Dercon, S., 2014. African Agriculture in 50 Years : Smallholders in a Rapidly Changing World ? World Dev. 63, 92–101. https://doi.org/10.1016/j.worlddev.2013.10.001

Cowan, R., Gunby, P., 1996. Sprayed to Death: Path Dependence, Lock-in and Pest Control Strategies. Econ. J. 106, 521–542. https://doi.org/10.2307/2235561

Crespo, J., Réquier-Desjardins, D., Vicente, J., 2014. Why can collective action fail in Local Agri-food Systems? A social network analysis of cheese producers in Aculco, Mexico. Food Policy 46, 165–177. https://doi.org/10.1016/j.foodpol.2014.03.011

D'Amour, C.B., Reitsma, F., Baiocchi, G., Barthel, S., Güneralp, B., Erb, K.H., Haberl, H., Creutzig, F., Seto, K.C., 2017. Future urban land expansion and implications for global croplands. Proc. Natl. Acad. Sci. U. S. A. 114, 8939–8944. https://doi.org/10.1073/pnas.1606036114

Datt, G., Ravallion, M., 1998. Farm productivity and rural poverty in India. J. Dev. Stud. 34, 62–85. https://doi.org/10.1080/00220389808422529

David, P.A., 1985. Clio and the Economics of QWERTY. Am. Econ. Rev. 75, 332–337.

Dawson, N., Martin, A., Sikor, T., 2016. Green Revolution in Sub-Saharan Africa: Implications of Imposed Innovation for the Wellbeing of Rural Smallholders. World Dev. 78, 204–218. https://doi.org/10.1016/j.worlddev.2015.10.008

Dessart, F.J., Barreiro-hurlé, J., Bavel, R. Van, 2019. Behavioural factors affecting the adoption of sustainable farming practices : a policy- oriented review 46, 417–471. https://doi.org/10.1093/erae/jbz019

Direction Générale de l'Aménagement du territoire (DGAT), Ministère de l'Equipement, de l'Habitat, et de l'Aménagement du térritoire (MEHAT)., 2010. Schéma Directeur d'Aménagement de la Région Economique du Nord-Ouest.

Dolan, P., Peasgood, T., Dixon, A.M., Knight, M., Phillips, D., Tsuchiya, A., White, M., 2006. Research on the relationship between well-being and sustainable development 1–52.

Dorward, A., Kydd, J., Morrison, J., Urey, I., 2004., 2004. A policy agenda for pro-poor agricultural growth. World Dev. 32, 73–89. https://doi.org/10.1016/j.worlddev.2003.06.012

Doukh et al, 2017. Schéma Directeur d'Aménagement et de Développement du gouvernorat du Kef.

Ejeta, G., 2010. African Green Revolution Needn't Be a Mirage. Ethics Behav. 4, 253. https://doi.org/10.1207/s15327019eb0403_9

El-Idrissi, S., 2017. Peut-on parler d'un mouvement de l'économie sociale et solidaire en Tunisie ?, in: Forum International de l ' Économie Sociale et Solidaire - Engagement , Citoyenneté et Développement : Comment Former à l ' Économie Sociale Solidaire ?".

Elachhab, F., 2018. L'ÉCONOMIE SOCIALE ET SOLIDAIRE EN TUNISIE, UN POTENTIEL TROISIÈME SECTEUR ? Assoc. RECMA | 349, 71–86.

Elahi, E., Weijun, C., Zhang, H., Nazeer, M., 2019. Agricultural intensification and damages to human health in relation to agrochemicals: Application of artificial intelligence. Land use policy 83, 461–474. https://doi.org/10.1016/j.landusepol.2019.02.023

Elliott, S.J., Dixon, J., Bisung, E., Kangmennaang, J., 2017. A GLOWING footprint: Developing an index of wellbeing for low to middle income countries. Int. J. Wellbeing 7, 1–27. https://doi.org/10.5502/ijw.v7i2.503

Fares M, Magrini MB, T.P., 2012. Transition agroécologique, innovation et effets de verrouillage : le rôle de la structure organisationnelle des filières. Le cas de la filière blé dur française. Cah. Agric. 21, 34–45. https://doi.org/10.1684/agr.2012.0539

Ferraro, E., Barletti, J.P.S., 2016. Placing wellbeing anthropological perspectives on wellbeing and place. Anthropol. Action 23, 1–5. https://doi.org/10.3167/aia.2016.230301

Fischer, E., Qaim, M., Goettingen, G., 2012. Linking Smallholders to Markets : Determinants and Impacts of Farmer Collective Action in Kenya. World Dev. 40, 1255–1268. https://doi.org/10.1016/j.worlddev.2011.11.018

Gafsi , S., and Roe, T., 1979. Adoption of Unlike High-Yielding Wheat Varieties in Tunisia. Econ. Dev. Cult. Change 28, 119–133. https://doi.org/10.1086/451156

Gafsi , S., and Roe, T., 1977. Adoption Of Unlike High Yiekding Wheat Varieties in Tunisia. Staff Pap. Ser. Univ. Minnesota Instituteof Agric. Home Econ.

Gammar, A.M., 2019. Dynamiques rurales et conservation forestière dans le Nord de la Tunisie. Rev. géographie Alp. 0–13. https://doi.org/10.4000/rga.6441

Griffin, k., 1974. The green revolution : an economic analysis. Population (Paris). 29, 946.

Habib Attia, 1986. Problématique du développement du Nord-Ouest tunisien. Rev. Occident. Musulman Mediterr. 41–42, 264–280. https://doi.org/10.3406/remmm.1986.2123

Hinrichs, C.C., 2003. The practice and politics of food system localization. J. Rural Stud. 19, 33–45. https://doi.org/https://doi.org/10.1016/S0743-0167(02)00040-2

Hinrichs, C.C., 2000. Embeddedness and local food systems: Notes on two types of direct agricultural

market. J. Rural Stud. 16, 295–303. https://doi.org/10.1016/S0743-0167(99)00063-7

Hu, Z., 2020. What Socio-Economic and Political Factors Lead to Global Pesticide Dependence ? A Critical Review from a Social Science Perspective.

Ickowitz, A., Powell, B., Rowland, D., Jones, A., Sunderland, T., 2019. Agricultural intensification, dietary diversity, and markets in the global food security narrative. Glob. Food Sec. 20, 9–16. https://doi.org/10.1016/j.gfs.2018.11.002

Ingersoll-Dayton, B., Saengtienchai, C., Kespichayawattana, J., Aungsuroch, Y., 2004. Measuring psychological well-being: Insights from Thai elders. Gerontologist 44, 596–604. https://doi.org/10.1093/geront/44.5.596

Journal Officiel de la République Tunisienne, 2020. Loi n° 2020-30 du 30 juin 2020, relative à l'économie sociale et solidaire 1399–1403.

Jouzi, Z., Azadi, H., Taheri, F., Zarafshani, K., Gebrehiwot, K., Passel, S. Van, Lebailly, P., 2017. Organic Farming and Small-Scale Farmers : Main Opportunities and Challenges. Ecol. Econ. 132, 144–154. https://doi.org/10.1016/j.ecolecon.2016.10.016

Justin, BISCHOFF et KOCH, M., 2012. Lorraine: une analyse multidimensionnelle du bien-être. epsilon.insee.

Kangmennaang, J., Elliott, S.J., 2019. Health & Place ' Wellbeing is shown in our appearance , the food we eat , what we wear , and what we buy ' : Embodying wellbeing in Ghana. Health Place 55, 177–187. https://doi.org/10.1016/j.healthplace.2018.12.008

Kerr, J., Kovali, S., 1999. Impact of Agricultural Research On Poverty Alleviation : Conceptual Framework with illustrations from the literature. Environ. Prod. Technol. Div. Food Consum. Nutr. Diqscussion Pap. n° 56.

Khoury, C.K., Bjorkman, A.D., Dempewolf, H., Ramirez-Villegas, J., Guarino, L., Jarvis, A., Rieseberg, L.H., Struik, P.C., 2014. Increasing homogeneity in global food supplies and the implications for food security. Proc. Natl. Acad. Sci. U. S. A. 111, 4001–4006. https://doi.org/10.1073/pnas.1313490111

Kruijssen, F., Keizer, M., Giuliani, A., 2009. Collective action for small-scale producers of agricultural biodiversity products TRIGGER : Food Policy 34, 46–52. https://doi.org/10.1016/j.foodpol.2008.10.008

Labiadh, I., 2017. La Tunisie à l ' épreuve de la territorialisation Réalités et perspectives du modèle de développement territorial.

Luna, J.K., 2020. ' Pesticides are our children now ': cultural change and the technological treadmill in

the Burkina Faso cotton sector. Agric. Human Values 37, 449–462. https://doi.org/10.1007/s10460-019-09999-y

Magrini et al, 2017. Transition vers des systèmes agricole et agroalimentaire durables : quelle place et qualification pour les légumineuses à graines ? Rev. Française Socio-Économie 18, 53. https://doi.org/10.3917/rfse.018.0053

Magrini, M., Nicolas, B., 2019. Technological Lock-In and Pathways for crop Diversification in the Bio-Economy, in: Agroecosystem Diversity. pp. 375–388. https://doi.org/10.1016/B978-0-12-811050-8.00024-8

Matson, P.A., Parton, W.J., Power, A.G., Swift, M.J., 1997. Agricultural intensification and ecosystem properties. Science (80-.). 277, 504–509. https://doi.org/10.1126/science.277.5325.504

Melanie T. Davern, Lucy Gunn, , Billie Giles-Corti, S.D., 2017. Best Practice Principles for Community Indicator Systems and a Case Study Analysis: How Community Indicators Victoria is Creating Impact and Bridging Policy, Practice and Research. Soc. Indic. Res. 131, 567–586. https://doi.org/10.1007/s11205-016-1259-8

Michalos, A.C., Smale, B., Labonté, R., Muharjarine, N., Scott, K., Moore, K., Swystun, L., Holden, B., Bernardin, H., Dunning, B., Graham, P., Guhn, M., Gadermann, A.M., Zumbo, B.D., Morgan, A., Brooker, A.-S., & Hyman, I., 2011. The Canadian index of wellbeing.Technical Report 1.0.ON: Canadian Index of Wellbeing and University of Waterloo. Waterloo.

Ministere De L'Agricolture, 1995. tunisie : Rapport De Pays Pour La Conference Technique Internationale De La Fao Sur Les Ressources Phytogenetiques, Ministere de l'Agriculture. Tunis.

Moseley, W.G., 2015. Food Security and "Green Revolution," in: International Encyclopedia of the Social & Behavioral Sciences: Second Edition. https://doi.org/10.1016/B978-0-08-097086-8.91019-5

Muchnik, S.C. and T., 2008. Systèmes agroalimentaires localisés: État des recherches et perspectives. Cah. Agric. 17, 513–519. https://doi.org/10.1684/agr.2008.0251

Mustapha, A. Ben, Faysse, N., Marlet, S., Jamin, J., 2015. N atures S ciences S ociétés Une action collective analysée par ses acteurs : une association d ' irrigants en Tunisie 23. https://doi.org/10.1051/nss/2015055

Mzali, H., 1997. Marché du travail, Migrations Internes et Internationales en Tunsie. Rev. Région Développement 151–183.

Nanor, M.A., Poku-Boansi, M., Adarkwa, K.K., 2021. Determinants of subjective wellbeing in rural communities: Evidence from the Juaben Municipality, Ghana. Cities 113, 103140.

https://doi.org/10.1016/j.cities.2021.103140

Office de Développement du Nord-Ouest, 2017. Gouvernorat de Béja en chiffres.

Pingali, P.L., 2012. Green Revolution: Impacts, limits, and the path ahead. Proc. Natl. Acad. Sci. 109, 12302–12308. https://doi.org/10.1073/pnas.0912953109

Pretty, J., Bharucha, Z.P., 2014. Sustainable intensification in agricultural systems. Ann. Bot. 114, 1571–1596. https://doi.org/10.1093/aob/mcu205

Purvis, M.J., 1972. The Adoption of High Yielding Wheats in Tunisia. Staff Pap. 13677, Univ. Minnesota, Dep. Appl. Econ. https://doi.org/10.22004/ag.econ.13677

Raimbert et Rebaï, 2017. Collectifs et développement durable des territoires ruraux en Amérique latine. EchoGéo 0–25.

Rasmussen, L.V., Coolsaet, B., Martin, A., Mertz, O., Pascual, U., Corbera, E., Dawson, N., Fisher, J.A., Franks, P., Ryan, C.M., 2018. Social-ecological outcomes of agricultural intensification. Nat. Sustain. 1, 275–282. https://doi.org/10.1038/s41893-018-0070-8

Ravallion, M., Chen, S., 2009. China's (uneven) progress against poverty. Gov. Rapid Growth China Equity Institutions 82, 49–95. https://doi.org/10.4324/9780203881385

Ravallion, M., Chen, S., 2007. China's (uneven) progress against poverty. J. Dev. Econ. 82, 1–42. https://doi.org/10.4324/9780203881385

Ravallion, M., Datt, G., 2002. Why has economic growth been more pro-poor in some states of India than others? J. Dev. Econ. 68, 381–400.

Ravallion, M., Datt, G., 1996. How Important to India's Poor Is the Sectoral Composition of Economic Growth? World Bank Econ. Rev. 10, 1–25.

Requier-Desjardins, D., Boucher, F., Cerdan, C., 2003. Globalization, competitive advantages and the evolution of production systems: Rural food processing and localized agri-food systems in Latin-American countries. Entrep. Reg. Dev. 15, 49–67. https://doi.org/10.1080/08985620210144983

Ríos-González, A., Jansen, K., Javier Sánchez-Pérez, H., 2013. Pesticide risk perceptions and the differences between farmers and extensionists: Towards a knowledge-in-context model. Environ. Res. 124, 43–53. https://doi.org/10.1016/j.envres.2013.03.006

Rogério, C., Augusto, J., Borges, R., Armando, J., Machado, D., 2020. Science of the Total Environment A review and some re fl ections on farmers ' adoption of sustainable agricultural practices worldwide. Sci. Total Environ. 729, 138831. https://doi.org/10.1016/j.scitotenv.2020.138831

Sen, A., 1993. Capability and well-being, The Philosophy of Economics.

https://doi.org/10.1017/CBO9780511819025.019

Shimi, A., 2014. ENJEUX SOCIAUX, ECONOMIQUES ET POLITIQUES D'UTILISATION DES RESSOURCES EN EAU DANS LE NORD-OUEST TUNISIEN.

Simmons, R., Birchall, J., 2008. The role of co-operatives in poverty reduction : Network perspectives 37, 2131–2140. https://doi.org/10.1016/j.socec.2008.04.016

Thorp, R., Stewart, F., Heyer, A., 2005. When and How Far is Group Formation a Route Out of Chronic Poverty ? 33, 907–920. https://doi.org/10.1016/j.worlddev.2004.09.016

Tilman, D., Balzer, C., Hill, J., Befort, B.L., 2011. Global food demand and the sustainable intensification of agriculture. Proc. Natl. Acad. Sci. U. S. A. 108, 20260–20264. https://doi.org/10.1073/pnas.1116437108

UNDP, 2011. Human Development Report 2011 Sustainability and Equity: A Better Future for All. New York. https://doi.org/10.1080/19962126.2013.11865067

Utting, P., 2017. Public Policies for Social and Solidarity Economy: Assessing Progress in Seven Countries.

Vanloqueren, G., Baret, P. V., 2009. How agricultural research systems shape a technological regime that develops genetic engineering but locks out agroecological innovations. Res. Policy 38, 971–983. https://doi.org/10.1016/j.respol.2009.02.008

Verhofstadt, E., Maertens, M., 2014. Can agricultural cooperatives reduce poverty ? Heterogeneous impact of cooperative membership on farmers ' welfare in Rwanda.

Does agricultural intensification enhance rural wellbeing? A structural model assessment at the sub-communal level: case study in Tunisia

Article submitted to the journal of Development Studies

Fatma Mhadhbi[a]*, Claude Napoléone[a] and Guy Boussougou Boussougou[a]

[a] Ecodeveloppement, INRAE, 84000 Avignon, France

*corresponding author

Abstract: We examine the impact of agricultural intensification on the wellbeing of rural communities in a developing country at a sub-communal scale. To measure the interaction of this complex causal relationship, a statistical approach was applied using partial least squares path modeling (PLS-PM) in its formative structure. PLS-PM modeling simultaneously relates measured variables (manifest variables) and conceptual variables (latent variables), incorporating other variables such as bioclimate and demography. This approach makes it possible to characterize the spatial structure of links between intensive agriculture and wellbeing in order to facilitate government intervention to improve the wellbeing of rural households, avoiding the need for cumbersome and costly surveys when the scope of public action is extended to a region or a country. Our findings show that the generalization of the productivist system is not always appropriate in developing countries, such as our case study where employment in the secondary and tertiary sectors is insufficient to absorb the rural exodus. In these situations, agricultural intensification leads to poverty and migration in the production areas and increases disparities in social wellbeing within rural areas.

Key-words: agricultural intensification, rural wellbeing, developing country, partial least squares-path modeling, Tunisia.

1. Introduction

Since the advent of the Green Revolution in Latin America and South Asia in the 1960s, and its coupling with the International Monetary Fund and structural adjustment policies of the 1980s, the intensive system became the cornerstone in agricultural development programs and policies aiming to spur economic growth in the developing country (Clay, 2018). This intensification of agricultural practices, supported by public policies (Hu, 2020; Magrini et al, 2017), generally leads to crop specialization through the selection of new high-yielding varieties (HYVs) (especially wheat and rice for the most consumed and traded), combined with synthetic fertilizers, pesticides, mechanical and irrigation equipment contributed substantially to the tremendous increases in food production (Clay, 2018; Pingali, 2012; Tilman et al., 2002). In terms of social benefits, the Green Revolution has contributed to reducing poverty on a large scale, fighting hunger for millions of people and converting thousands of hectares of land to agricultural crops (Pingali, 2012).

However, the debate on how rural wellbeing is impacted by agricultural intensification is still unresolved. Beyond the well-known environmental and human health concerns (Elahi et al., 2019), recent studies in Africa showed that agricultural intensification has done little to address persistent disparities in access to land and resources among smallholder farmers, exacerbating inequality among rural communities while benefiting large farmers, urban populations and agribusiness (Bezner-Kerr, 2012; Moseley, 2015). While some studies in Zambia on the well-being of smallholder farmers, show that adoption of improved maize varieties tend to increase crop yields, food security and household income (Mason and Smale, 2013; Smale and Mason, 2014), other studies in sub-Saharan African countries focusing on the disaggregated local impacts of intensification (Abro et al., 2014 [Ethiopia] ; Bezner-Kerr, 2012; Harrigan, 2003 [Malawi]; Kijima, Otsuka & Sserunkuuma, 2011 [Uganda]; Wanjala and Muradian, 2013 [Kenya]) highlighted the costs and material vulnerabilities for poor smallholder farmers, and their lack of benefit from this policy.

So, a crucial issue is how to assess the impact of agricultural intensification on the rural population's wellbeing? This is especially challenging since wellbeing can be seen as a broad and fuzzy concept that is intrinsically complex (Martinetti, 2000), while poverty or inequality are mainly identified by one-dimensional indicators, usually based on monetary variables (Sen, 1973). Since the publication of the World Human Development Report in 1990, emphasis has been placed on several dimensions other than income that can affect the level of individual wellbeing. The UNDP Human Development Report, 2010 proposed a composite indicator, the Human Development Index (HDI), which is used to evaluate countries' human development rate. This indicator measures not only per capita income growth but also more qualitative factors in building human capital (health, education, food security, and gender equity) (Anand and Sen., 2000). The latest UNDP' report *"Beyond income, beyond averages, beyond today"* (UNDP, 2019) looks again at inequalities beyond income, in which any assessment must consider money, but it must also go beyond that to include other inequalities, for example in health and education.

So, several tools have tried to gone "beyond income", such as the Canadian Index of Wellbeing (CIW), the OECD's Better Life Index and Bhutan's Gross National Happiness Index (Elliott et al., 2017). Their findings suggest that cultural identity, inequality, job security, health, community vitality, leisure, environmental factors, and subjective perceptions are equally important factors shaping a population's wellbeing (Davern, Gunn & Giles-Corti, 2017; Michalos et al., 2011). Wellbeing thus includes not only material but also other interdependent dimensions: the relational dimension and the subjective dimension, which concerns the individual, social and cultural norms and values that influence people's preferences and behavior (Gough, McGregor & Camfield, 2007). In Tunisia, as in most developing countries, very little research has focused on the multidimensional approach to poverty (Ayadi et al., 2005; PNUD, 2004; Riadh and Mongi, 2013). Such studies generally constructed a composite index of wellbeing, mainly rooted in Sen's capability approach (Sen, 1993) based on non-monetary indicators like durable goods, housing conditions and education, or a bi-dimensional analysis of poverty based on income and housing (Bibi, 2002).

However, the Sen's capability approach integrates a set of wellbeing factors related to the quality of human existence into a formal and quantitative methodology that need to access to scarcely available quantitative variables that reflect fundamental aspects of wellbeing (employment rates in the agricultural sector, schooling, health and access to drinking water, and women's employment…). In addition, critics of HDI make it clear the weaknesses of this analytical on a spatial distribution of human development perspective (Harttgen and Klasen, 2012). The issue is that the indicators used at the international level do not always seem to be relevant at the local level, especially when applied in rural areas (Nanor et al., 2021) (the indicators require information that is not always available at the rural or local level). This problem can be solved by reducing the target areas from the national to communal or sub-communal level. As Jalan and Ravallion (1998) have shown that the greatest poverty reduction is achieved when the target areas are villages or municipalities. For instance, Baker and Grosh (1994) found that the smaller the target areas, the greater the potential for poverty reduction. Moreover, the lack of attention to the collective dimension of wellbeing diminishes the effectiveness of this indicator in developing countries, especially in African contexts. Indeed, as Evans and Prillelrensky (2007) predict collective wellbeing is realized through universal access to quality health care and public education, and depends on policies that promote social justice, which in turn distribute resources through progressive taxation systems.

Beyond the literature on the impact of agricultural intensification on the living conditions of the rural population, we assume that intensive agriculture may have a negative impact on the wellbeing of the rural population. To this end, we propose to use partial least squares modeling (PLS-PM), which allows us to estimate the effects of unmeasured elements or latent variables that have proven to be well suited to measure this complex causal relationship such as agricultural intensification and the level of welfare

of the rural population, beyond the income of the intensive farmers themselves (and incorporating other control variables such as demography and bioclimate). To test its robustness, we applied our methodology in rural areas in Northwestern Tunisia at the sub-communal scale.

The paper is organized as follows: Section 2 describes the case study area. Section 3 presents the evaluation methodology and data. Section 4 presents the results of our empirical assessment of agricultural intensification's impact on rural wellbeing of rural people. The relevance of this research and its limitations are discussed in Section 5.

2. Case study description

Tunisia is a Mediterranean country located in eastern North Africa between Algeria (in the west) and Libya (in the south). It covers a total area of 164,000 km², of which 30% (4,800,000 ha) is usable agricultural area (UAA). Tunisia is characterized by a Mediterranean climate with a soft winter and a hot summer. It is located at the end of the eastern part of the Atlas Mountains, and in the northern part of the Sahara Desert.

Since independence, Tunisia is characterized by a heterogeneous agricultural sector (Elloumi, 2006a) combining modern market-oriented farming and traditional agriculture geared towards self-consumption. Attempts have long been made to reduce this heterogeneity through agricultural and land policies. First, a collectivist policy (1962 to 1972) promoted in a same time agricultural cooperatives and private capital intensive farms. Agricultural cooperatives aimed to foster smallholding farmers clustered around nuclei composed of the former colonialist settlers' farms taken over by the State. Private capital intensive farms were focused on major irrigation projects launched, together with intensive chemical fertilizer use and new equipment. These were intended to modernize and intensify cropping systems, with the aim of creating a surplus in the agricultural sector to replace imports and turning its work force and production (food and raw materials) into a modern urban-industrial sector (Hunt, 1974; Attia, 1986; Boughanmi, 1995). The failure of cooperatives' experiences (Amamou et al., 2018; Mzali, 1997) and the development of the industrial activities, tertiary sector and the coastal tourist areas supported by national economy policy (Dhaher, 2010) generated the largest wave of rural exodus in its history (Picouet, 2002). This structural change led to a larger intensification of production systems (irrigated agriculture, fruit-growing, vegetables, fodder farming) (Kassab,1981) and the introduction of new high-yielding hybrid seed varieties for accelerated cereal production (Gafsi, and Roe, 1979, 1977; Purvis, 1972).

In this context, since the late 1980s, Tunisia has implemented an agricultural structural adjustment program (PASA) supported by the International Monetary Fund (IMF) with the aim of liberalizing

Tunisian agriculture and improving the competitiveness of its agro-food industries. This process of liberalization was accelerated by the signing of the World Trade Organization (WTO) agreements (1995), then the partnership agreement with the EU (since 1996) and the creation of free trade zones, allowing Tunisian agriculture access to international markets thanks to its comparative advantage in certain crops (citrus fruits, fruits and vegetables, sugar and fodder crops). Under this policy of modernization, contemporary Tunisian rural development was transformed by the introduction of the green revolution technology package, combined with irrigation and intensive use of chemical fertilizers[7], herbicides, high-yielding varieties of seeds and agricultural equipment (Boughanmi, 1995). This change in the structure of agricultural production has greatly increased dependence on "standard" seed varieties and has led to the disappearance of a large variety of local seeds adapted to the local climate and drought (Ministere De L'Agricolture, 1995).

In a same time, this technological trend enhance territorial heterogeneity: Tunisia has long suffered from rural migratory movement, especially from the northwestern regions, stemming from the agrarian crisis particularly affecting the Medjerda Valley and the Kef plains as well as from the rapid development of mechanization and the evolving farming system (Gammar, 2019; Mzali, 1997). To deal with these problems, in 1984, Tunisia adopted a new regional policy called the "Integrated Rural Development Program" (IRDP), targeting less-favored areas (Elloumi, 2006b). The objective of this program was to promote the emergence of small and medium-sized intensive and diversified family farms with high labor intensity and high added value: intensive livestock farming, vegetable and irrigated fruit production (African Development Bank group Tunisia, 2003; Elloumi, 2006a; Gana, 2008). Thanks to these regional programs, Tunisia experienced a substantial reduction in the level of poverty and its basic infrastructure improved, especially in rural areas, with better access to drinking water, electricity and sanitation (Béchir, 2011). However, Tunisia's agricultural regions remain those where poverty is the most pronounced, especially the Central-Western and Northwestern parts of the country (Ayadi et al., 2005; Nasri and Belhadj, 2014; PNUD, 2004). Outstanding are the governorates of Kef, Kassrine, and Beja, where poverty reaches respectively 34.2%, 32.8% and 32% (Nasri, 2016).

The study was conducted in the Northwest region (see Figure.1), bounded to the west by the Tunisian-Algerian border, to the east by the capital and to the north by the Mediterranean Sea. The region is composed of four governorates (sets of municipalities): Beja, Jendouba, Kef and Siliana. It accounts for 19% of the country's exploitable agricultural area and represents Tunisia's regional paradox: that of a rich region in terms of water resources and agricultural production with extremely poor inhabitants (Habib, 1986). This agricultural region is reputed for its fertile land and large water reserves, due to its

[7] The use of pesticides continues to increase (in tons): In 2010 it was 3182.1 tons; in 2011 it rose to 4586.5 tons and in 2012 to around 6425.3 tons (sources: Tunisian Republic, UNDP, 2014).

agro-pedoclimatic conditions and in particular its annual rainfall, approaching 400 mm (some years as high as around 1000 mm).In terms of agricultural production, the governorate of Beja produces almost 18.62% of the country's cereals and 12.5% of its vegetable crops (Office de Développement du Nord-Ouest, 2017). However, in a same time, it also has one of the lowest levels of human development in terms of education, health, employment and infrastructure (Najeh, 2018): for instance, the unemployment rate among young people (18-24 years old) is 33.8% in the Northwest, or according to figures released by the Department of Water and Rural Drinking Equipment of the Ministry of Agriculture, some 300,000 people still do not have access to drinking water, mainly in rural areas (Nasri, 2016).

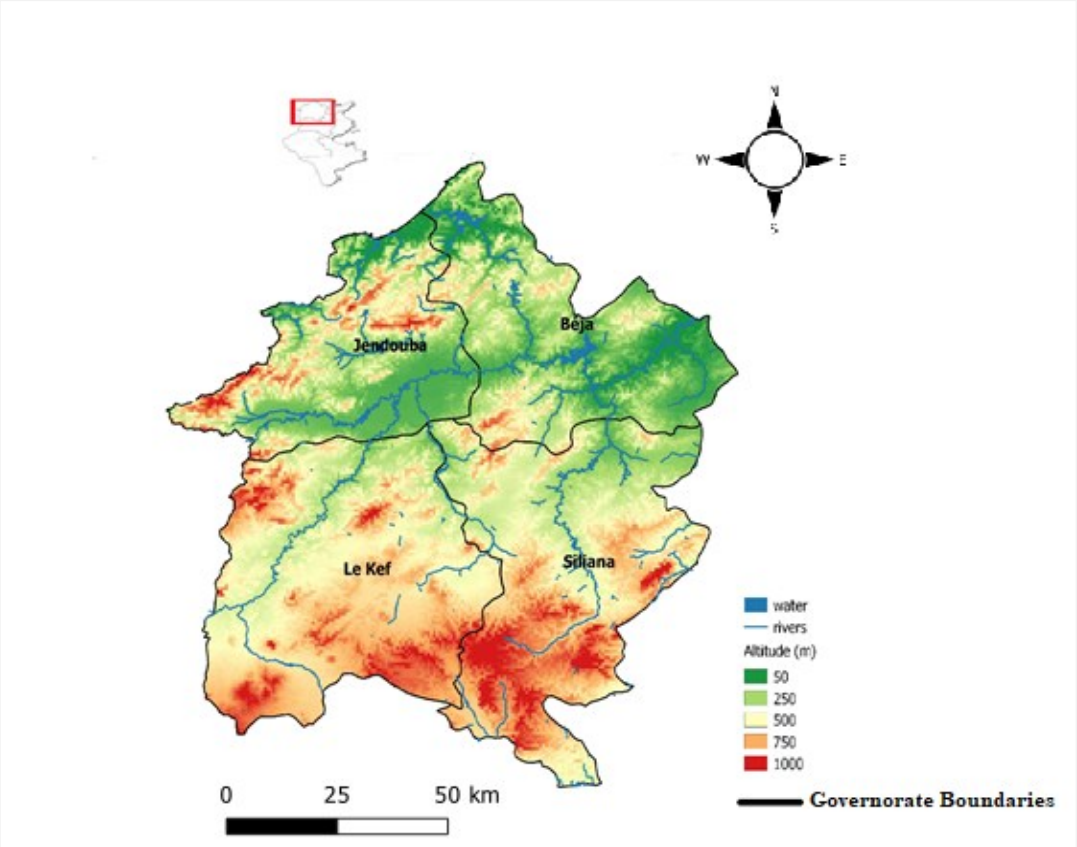


Figure1. The North-west region of Tunisia

3. Methodology, data

Our aim is to assess the relationship between intensive agriculture and wellbeing in rural areas of the Northwest region of Tunisia, where agriculture is concentrated and the populations that depend on it. We have implemented a structural model -a Partial Least Squares - Path Modeling (PLS-PM) approach- that enable to incorporate both the available data and unmeasured factors.

3.1 Partial least squares – Path modeling

The Partial Least Squares Path Modeling (PLS–PM) approach enables the effects of an unmeasurable phenomenon to be assessed, using structural equation modeling (Wold, 1966 and 1980) and a set of available indicators (income, health, education level, yields, chemical input use, irrigation, etc.) (Rodrigues et al., 2019). It is well-suited to exploratory analyses (Sosik, Surinder, Kahai and Piovoso, 2009). The PLS–PM structural equation model can be implemented via two sub-models (see Fig 1): (1) the structural model or inner model, which relates endogenous latent variables (LV) and (2) the measurement model or outer model, which specifies the relationships between an LV and its observed or manifest variables (MV) (Garson, 2016) i.e. the LV is a non-observable variable (or construct) and can be described by a set of manifest variables (MV) (Henseler and al. 2016). In the inner model, the connections between LV are quantified through path coefficients (β), while the links between LV and MV in the outer model are quantified through weights (W) (Hair Jr et al., 2014) (figure 1).

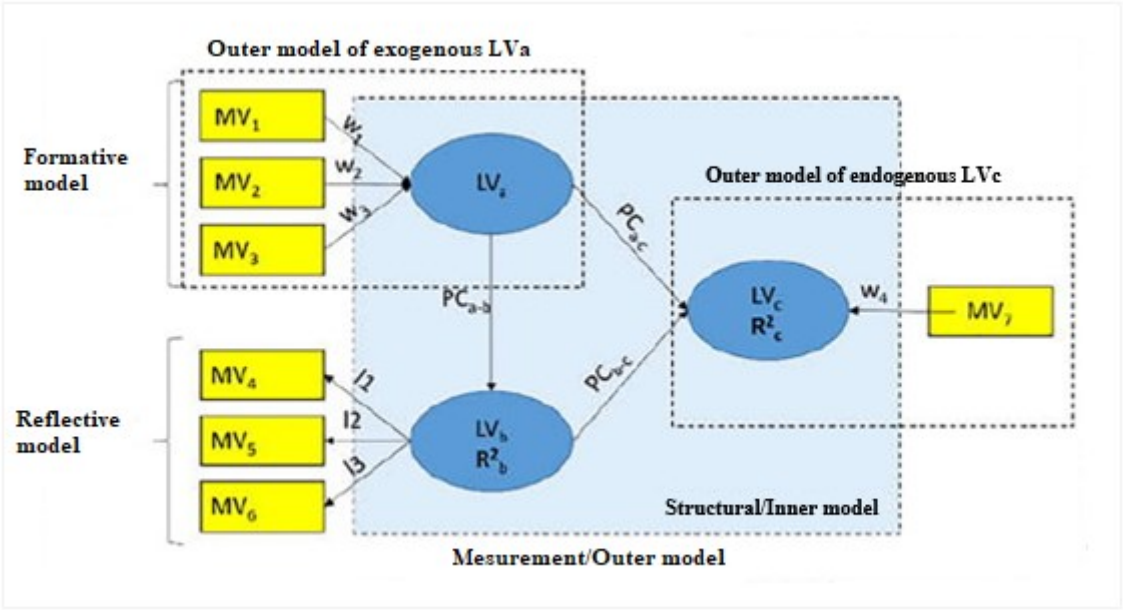


Figure2: structural equations model.

Symbols: MV—measured variables; LV—latent variables; P- path coefficients; w—weight, l — loading; R^2—coefficient of determination (Rodrigues et al., 2019)

The path coefficients represent the influence of exogenous (independent) variables on endogenous (dependent) latent variables. The measured score of an LV (LVm; Eq. (1)) is the weighted sum of the scores corresponding to the VM. The predicted score of an endogenous LV (for example, LVp,c; Eq. (2)) is the weighted sum of all associated exogenous latent variables, where weights are now represented by path coefficients (Rodrigues et al., 2019):

$$LVm = \sum_{i-1}^{n}(MVi - Wi) \qquad (1)$$

$$LVp,c = LVm,a \times \beta ac + LVmb \times \beta bc \qquad (2)$$

PLS–PM can handle both formative and reflective measurement models. In a reflective measurement model, the construct is the cause of the indicators. In a formative model, the indicators cause or form the construct (see Fig. 1) (Sarstedt and al 2014). In cases where the indicators do not reflect the theoretical construct but rather combine to produce it, a formative measurement model is appropriate (Diamantopoulos and Temme, 2013; McIntosh et al., 2014). The formative perspective distinguishes many of the complex measures used in the economics literature. Examples include the index of sustainable economic welfare (Herman E Daly, John B.Cobb, 1990), the Human Development Index (UNDP, 1990) and the quality of life index (Johnston, 1988).

In socioeconomic analysis like the present study, models are mainly conceived as a formative construct, generated by a weighted linear combination of indicators such as income, employment, educational attainment, and place of residence (Bollen and Lennox, 1991; Hauser and Goldberger, 1971). To better evaluate the relevance of the formative constructs, we followed three indices or quality metrics adapted from Diamantopoulos and Winklhofer (2001). The first step was to precisely define the domain of the studied constructs and then to ensure that the indicators covered the whole of this construct. We based our definition on theory to ensure the sufficient representation of the studied concepts. The second step involved determining whether the structural relationships were meaningful, by measuring the coefficient of determination R^2 of the endogenous constructs. In this sense, the R^2 indicates the amount of variance in the dependent latent variable explained by its independent variables (see-figure 1). To evaluate the level of collinearity between formative indicators, we calculated the variance inflation factor (VIF) to detect potential failures in the adjustment of the training set that might impact the estimation of parameters (weights and path coefficients) (Rodrigues et al., 2019). This step ensures the external validity of the model by examining the outer model weights and the relative contribution of the measured variables to the definition of its corresponding latent variable (Garson, 2016). In the last step, we assessed the global validity of this complex model through the goodness-of-fit index (GoF) (Tenenhaus, Vinzi, Chatelin & Lauro, 2005).

Each LV was measured at three levels of structural relationship, drawing on a formative measurement model set-up:

- In the first step, causal relationships between manifest variables (MV) used in the structural model were assessed through estimating path coefficients(Joe F. Hair Jr, Marko Sarstedt, Lucas Hopkins, 2014). In this step, we assessed the quality of the structural model: the R^2 coefficient was used to measure the model's predictive accuracy (Table 3) and the variance inflation factor to control for collinearity bias ($\text{VIF} = \frac{1}{1-\text{R2}}$).

- Then, the mediation relationships in the PLS-PM model were analyzed to explore the degree of causality in assessed relationships, thus indicating the strength of the direct and indirect effect. External validity was verified through the outer model weights (Figure 2).
- The last step consisted in assessing the overall validity of the model through the goodness-of-fit index. The GoF can be calculated using the square root of the geometric mean of the average communality multiplied by the average R^2 ($\mathrm{Gof} = \sqrt{\mathrm{communality} \cdot \mathrm{R2}}$) (Tenenhaus and al 2005).

3.2. The structural model

Based on an estimation of the similarity of the information provided by the manifest variables, we have identified 18 VMs that correspond to a block of 4 latent variables (LVs) (see Table1), This estimation is based on correlation matrices (see Appendix A):

"Agriintensive": This variable served three purposes. First, it described intensive agriculture more broadly than the standard variables (size of farms, commodities supply, incomes). Second, it served as a baseline for our impact assessment of wellbeing effect. Third, it enabled us to link this system of agricultural production with all the climatic conditions and the factors related to the rural society transformations stemming from the modernization of the agricultural sector (rural exodus, feminization, etc.). We used yield statistics derived from quantities produced and amounts of surface area involved in production for three major crops (vegetables, wheat and arboriculture), considering two production systems (irrigated - high input vs rainfed - low input): quoted *ti* for irrigated portion of crop and *th* for rainfed high-input portion of crop (sources : Spatial Production Allocation Model data - SPAM) (Wood-Sichra et al., 2016).

"Wellbeing": A local welfare index was used to quantify the rural population's quality of life from statistical studies based on non-monetary attributes. The variables were chosen to reflect the fundamental aspects of wellbeing other than income in rural areas: employment rate in the agricultural sector, schooling, health and access to drinking water and women's employment, with reference to the UNDP Human Development Index (sources: databases of the National Institute of Statistics of Tunisia) (Sen, 1993, 1976; Anand and Sen, 2000, 1994; UNDP, 2019, 2010).

"Bioclimate": Climate factors are among the most important natural indicators (especially the rainfall) in developing countries such as Tunisia, with a direct impact on agricultural yield; one of the prime factors is precipitation and temperature (in our case for the years 1970-2000). Bioclimate variables were derived from monthly temperature and rainfall values to make them more biologically meaningful. They

represent extreme or limiting climatic factors (Chebil, Mtimet & Tizaoui, 2011): temperature of the coldest and warmest month and precipitation of the wet month and wettest quarters (sources: databases of Global Digital Elevation Model and World CLIM data base).

"Demography": This variable refers only to the population in rural areas. The data used come from two main sources: the first is part of the DIVERCROP project (https://divercropblog.wordpress.com) and the second is the general census of the population 2014 (Statistics Tunisia, 2014)

Table 1: Measured variables used for Partial Least Squares-Path Modeling

latent variable	Measured Variable	Units	Description	Source
Agriintensive	Y-th-wheat Y-th-pulse Y-th-arbo Y-ti-whea Y-ti-vege	Cell 10 km	Yield statistics derived from quantities of major agricultural products, vegetables, wheat and arboriculture, produced by two production systems: - ti- High Input: Crop production with area equipped for either full- or partial- control irrigation that uses improved inputs such as modern seed varieties and chemical fertilizer as well as advanced management such as soil/water conservation measures - th-rainfed high Input: Rainfed crop production that uses high-yield varieties, optimal application of fertilizer, chemical pest, disease and weed controls, and may be fully mechanized .	Maps Spam[1]
Bioclimate	Alti-min	Meters	Minimum altitude by cell	Global Digital Elevation Model[2]
	BIO6	Cc	Min Temperature of Coldest Month	WORLDCLIM database[3]
	BIO8	Cc	Mean Temperature of Wettest Quarter	
	BIO13	Mm	Precipitation of Wettest Month	
	BIO16	Mm	Precipitation of Wettest Quarter	
Wellbeing	Employ-agri	%	employment rate for rural population in agriculture	General census of population and housing 2014[4]
	Employ-rate _w	%	employment rate for women in agriculture	
	Water	%	Rate of rural population access to drinking water	
	School	%	Rate of rural population access to schooling	
	Health	%	Number of inhabitants per doctor (by thousand)	
Demography	Density	inhabitant/km²	Number of inhabitants per km2	Hyde data base[5]
	Pop-rural	Cell 10 km	Percentage of rural population (rural population by cell * 100) / total population by cell	General census of population andhousing2014
	Migration	Cell 10 km	difference between number of people migrating to and number of people migrating from a given rural area during a given period	

Source:
[1]https://www.mapspam.info/about/
[2]https://asterweb.jpl.nasa.gov/gdem.asp
[3]http://worldclim.org/version2
[4] Statistics Tunisia http://census.ins.tn/fr/resultats
[5] https://themasites.pbl.nl/tridion/en/ themasites/hyde/download/index-2.html
Note:
Migration ; the difference between the number of people moving into a given rural area and the number moving out during a given period.

4. PLS-PM results

The LV Bioclimate was considered exogenous (independent variable), meaning that statistical inferences between LVs were assessed from it, and the others – Agriintensive, Demography and Wellbeing – were considered endogenous (dependent latent variable).

4.1 External validity: Outer model

The contribution of each MV to explaining structure variation for the formative structure were assessed through outer weights used to identify the effect of each latent variable in the theoretical structure (as the sum of direct and indirect relationships), as described above (Figure 3).

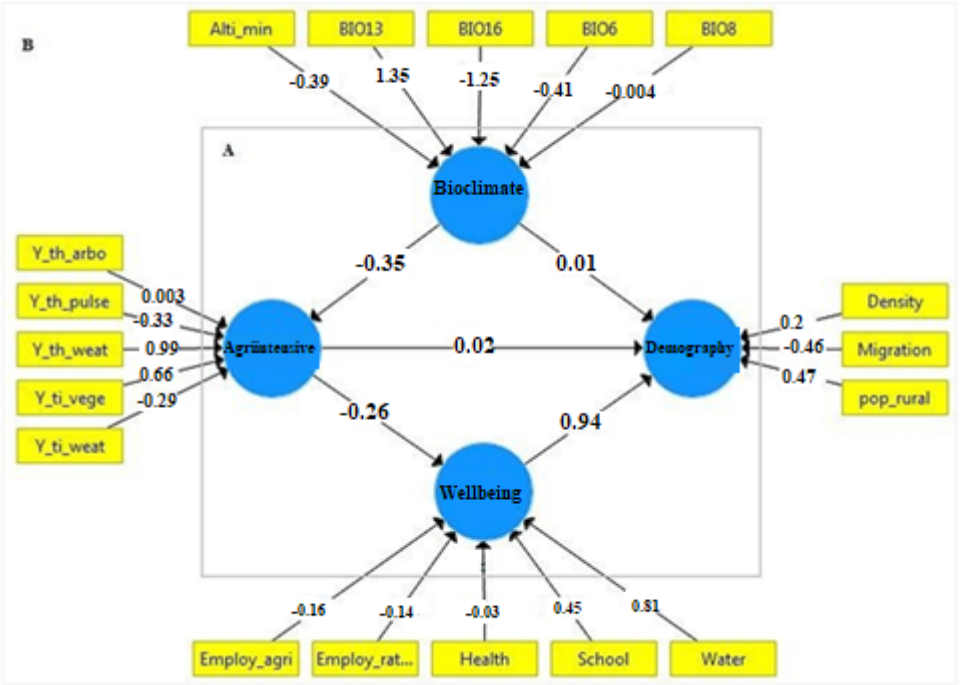


Figure3: Diagram of PLS-PM.

Panel A: summarizes the various structural regressions of the causality model. Circles represent the latent variables, namely "Bioclimate"," Agriintensive", "Wellbeing" and "Demography". Panel B: rectangles represent formation variables. Arrows represent links between formation variables and associated latent variables, as well as among related latent variables, while arrow labels are weights and path coefficients that quantify those links

We can see some hugely intuitive relations, like the negative impact of migrations on demography when the density has a positive one. Some weights are weak and thus show little effect on their constructs. In addition, the variables rainfed high-input wheat production (*y_th_wheat* -W = 0.99) and irrigated

vegetable production (*y_ti_ vege* - W=0.64) are given positive weights in the model. Without surprise, that means that their contribution to the Agriintensive is greater than that of the rest of the crops.

In terms of wellbeing, obviously lower levels of employment, health and access to drinking water imply lower wellbeing. However, there are three surprising negative relationships with agricultural employment, the rate of women's employment and health. The explanation should be sought in the overall interactions among these factors, keeping in mind the Tunisia's regional paradox, in which an area with high level of agricultural production can experience a high level of poor people. To illustrate how the wellbeing of the rural population can be impacted by the level of basic social services such as health, employment, education and access to drinking water, an interesting variable is the share of women in agricultural employment. The rural part of northwestern Tunisia is characterized by a high rate of female employment in agriculture, mainly in intensive farming (Bouzidi, Nour & Moumen, 2011), which can be interpreted as positive (higher family income). However, our wellbeing indicator highlights a negative effect on wellbeing (Figure 3), for which there are two possible explanations. First, the feminization of the agricultural sector in activities that rely on an intensive workforce with a very low level of education, low wages and no health coverage (Elloumi, 1993; Gana, 2008). Second, a huge male exodus from rural areas to cities or abroad (exodus has a negative effect on wellbeing in the source region). Lastly, our results show the importance of schooling in the wellbeing of the rural population. In Tunisia, the educational system is free and compulsory, which has allowed universal education (Law 1991): the enrollment rate for 6-14-year-olds reached 95.2% in 2006, with a huge equity between girls and boys. Despite these efforts, at regional level there are disparities that call for correction, especially considering the worrying secondary school drop-out rates in some governorates.

4.1.1. Geographical distribution of spatial units connected with intensive agricultural areas

In a second step, we conducted a cluster analysis of the latent variable scores to spatially identify the causal relationship between the agricultural spatial latent variables. we identified and characterized four classes of spatial units, labelled 1 to 4 (Figure.4):

Cluster 1: This class is characterized by the largest basin of modern and productive agriculture (*y_ti_wheat,y_ti_vege,y_th_pulpses, y_th_arbo*),where all the most strategic agricultural activities of the country are present, despite these natural and economic potentialities, this class is also the one where the living conditions of the rural population are the most unfavorable in terms of access to basic public services (hospitals, schools, water sanitation), with high rates of unemployment (Employ-agri).

Cluster 2 : This class is distinguished by the highest population density (ex Beja, kef, Medjez el-Bab, Ghardimaou,Tabarka, Makthar) in the region and its most favorable bioclimatic conditions (*BIO13,*

BIO16), these areas are the rainiest, in the extreme north-west of the region, especially in the high mountains or is concentrated the most important forestry potential of Tunisia. These areas are also those where the standard of living of the population is favorable which benefits from high urban connectivity and thanks to the many family networks (ex: Ghardimaou) that are widely distributed in the cities and abroad develop activities and various solidarities that contribute to the maintenance of farms and heritage and attract investment.

Cluster 3: These areas are characterized by an increasingly intensive production system that has allowed the development of diversified vegetable (*y_ti_vege*). and fruit crops in close relationship with the food industry and a high intensity of labor, with priority to cereal crops especially in the valley of the Medjerda and the plains of Kef. These areas are also distinguished by the importance of water infrastructure, the density of farms and intensive production units, the presence of storage facilities and processing, which has created local employment for rural labor, especially rural women.

Cluster 4: These areas are distinguished by their low population density (*100 inhabitants / km2*) and a low standard of living. They are known to be the area of cereal production par excellence of the country (*y_th_wheat, y_ti_wheat*) especially in the plains of Kef and Siliana, with a lesser importance of tree crops with a marked dynamism of intensive and productive market gardening in the plains (*Alti_min*) of Sers and El Ksour and Dahmani thanks to the development of irrigated areas.

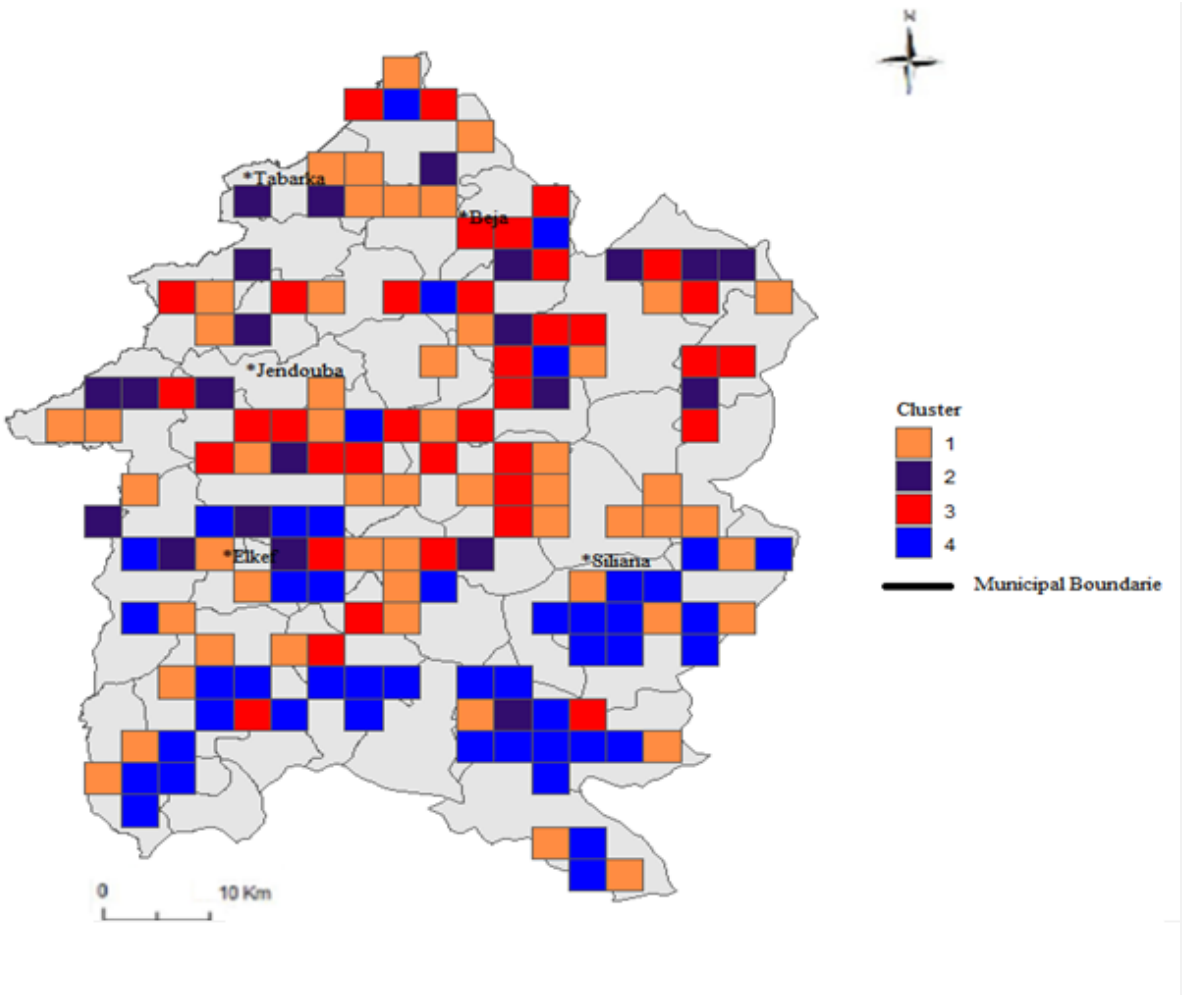


Figure 4: Geographic distribution of clusters at the sub-communal scale.

In conclusion, our classification using statistical tools (PLS-PM model with latent variables) shows that it is possible to characterize and map at the local level the level of well-being of rural communities according to their sensitivity to the impact of agricultural intensification.

4.2 Inner Model

The inner model which link endogenous latent variables (LVs) highlights the negative impact of the Bioclimate variable on the Agriintensive indicator (ß= -0.35 – see table 2). This result was expected, given the increased climate risk to the yield of agricultural production in Tunisia's Northwest region due to drought in some large cereal areas, such as Siliana and Elkef. In addition, the inner model shows other intuitive relationships, like the huge positive correlations between Wellbeing and Demography (ß= 0.94). This indicates that factors driving rural wellbeing (schooling, healthcare, access to drinking water) are more readily available in cities than rural areas. The fact that the population is concentrated in the lowland areas more suitable for agricultural activities, and thus where weather conditions are favorable,

is reflected in the positive relationship found between Bioclimate and Demography. Formally, these results highlight the important role of demography and suggest that demography mediates the relationship between Agriintensive and Wellbeing. Further analysis shows that Agriintensive has a stronger indirect effect on Demography (-0.25-see Table 2, see Appendix C).

Table 2:Total Effects

Relationships		*Indirect*	*Total effect*
Bioclimate	Agriintensive	0.00	-0.35
Bioclimate	Wellbeing	0.09	0.09
Bioclimate	Demography	0.08	0.09
Agriintensive	Wellbeing	0.00	-0.26
Agriintensive	Demography	-0.25	-0.23
Wellbeing	Demography	0.94	0.94
Note: Total effect= direct effect (inner model) + indirect effect =-0.35+0.00=-0.35			

Interestingly, the results clearly show that the variable *Agriintensive* has a negative impact on the wellbeing of the rural population (ß= -0.26). Intensive agriculture is not known to offer rural workers attractive conditions: farm labor suffers from low wages, lack of health coverage, and a reduced employment rate due to the increasing sophistication of machines. The negative net migration recorded in Northwestern Tunisia can be explained by changing agricultural structures, in particular in the Medjerda Valley and the Kef Plains, where there is a strong emphasis on ownership and more capital-intensive production systems (irrigation infrastructure and rapid mechanization) (Bounouh & Gsir, 2017). According to the 2014 census, only five municipalities in the Northwest region had positive net population growth, while the remaining 35 municipalities experienced a net population deficit.

The tests of overall significance validate the predictive power of the endogenous constructs (Table 3). The Commonality indicates how much of the variability of the block is reproducible by the latent variable. The contribution at the R^2 index is mainly due to the demographical effect (0.69). As a consequence, the population effect tends to obscure other weak signals' dynamics. The redundancy index, used to measure the quality of the structural model for each endogenous latent variable, takes into account the measurement model. High redundancy means great predictability. In our study, the average wellbeing redundancy represents the fact that the *Bioclimate*, *Agriintensive* and Demography indicators predicted 64% of the variability of the Wellbeing indicators. This statistical analysis measures how much greater the variance of an estimated coefficient is in the presence of collinearity. The Collinearity assessment means of the VIF yielded values between 1.07 and 7, 14, which is well below the threshold value of 10 and facilitates the interpretation of PLS-PM results.

Table 3: Summary of the Structural Model Indices

Type		R^2	*Commonality*	*redundancy*	*VIF*
Bioclimate	Exogenous	0	0. 61	0.00	1
Agriintensive	Endogenous	0.12	0.17	0.02	1.14
Wellbeing	Endogenous	0.06	0.69	0.04	1.07
Demography	Endogenous	0.86	0.69	0.64	7.14

Note: $R^2 \leq 0.3$ low, $30 < R^2 < 60$ Moderate and $R^2 \geq 60$ High

The robustness of the model (including measurement and structural models) was assessed by the goodness-of-fit index (GOF) which, at 0.46, shows that the quality of the fit is satisfactory to support the validity of the overall model.

5. Discussion and conclusion

The structural modeling approach allow us to treat a large number of factors closely related to links between agricultural intensification and the wellbeing of the rural population, such as climate and demography. The results show the well-known relationship with the usual variables involved in agricultural dynamics, like bioclimate (temperature and rainfall regime), which requires more attention to the negative impacts of climate change on agricultural production, especially on vulnerable groups living in rural areas, including smallholder farmers who use rain-fed agriculture for their livelihoods (Thinda et al., 2020). In addition, our results highlight the negative effect of the bioclimate indicator on intensive agriculture, raising the issue of introducing crops that are more sensitive to water stress – as previously pointed out (Laajimi, 2007) – and of sustainability. This is especially relevant given the current climate change trend, and in a food insecurity perspective (Chebil et al., 2011; Grami and Ben Rejeb, 2015; World Bank, 2012).

More interestingly, and centrally for us, our results also highlight the negative effect of agricultural intensification on rural wellbeing. This goes beyond the income of farmers practicing intensive agriculture. Indeed, the trend towards intensification is a major source of concern for rural communities in terms of wage levels, increasing unemployment rates that prompt them to migrate, or health (use of chemical inputs). This is highlighted by a number of studies that indicate that agricultural intensification rarely leads to concomitant positive outcomes in ecosystem services and human wellbeing (Rasmussen et al., 2018) otherwise less likely to reduce poverty where there is high inequality and can lead to exacerbating poverty or marginalizing disadvantaged groups (Negin et al., 2009). Along these same lines, Luna (2020) shows that the intensification system has led to profound transformations in rural societies, for example by challenging rural communal systems through the development of new labor-

saving and individually profitable technologies, thus reinforcing the knock-on effect of rural-urban migration.

Studies in Africa show that the implementation of the intensification system has amplified undernourishment and inequality in rural communities while benefiting large-scale farmers, urban populations, and agribusiness (Bezner-Kerr, 2012; Moseley, 2015), and that current rural development policies may inhibit investments to support farmers' incomes (Dorward et al., 2004).

This is particularly true in Tunisia, where there is an explosion of inequalities in productivity and living standards between farmers: on the one hand, large mechanized and subsidized farms, and on the other, manual family farms where the techniques of the green revolution are inappropriate and counterproductive (pollution, debt, etc.). The consequence of this phenomenon is rural exodus and mass unemployment. So, such exploratory work paves the way for new or improved models to evaluate rural population wellbeing indicators from a sub-communal perspective. Our results illustrate the measurement of wellbeing at the sub-communal level beyond the monetary dimension by focusing more on the social and climate dimensions that most affect the prosperity of the rural population or the equity of a development.

In terms of policy, this finding does not argue for abandoning pro-intensive policies[8], but rather in favor of complementary actions that will protect rural employment and health within changing agricultural systems. These could help avoid the exacerbation of poverty that results from ignoring social inequalities and environmental concerns in intensification policies (Bezner-Kerr, 2012; Ellis & Maliro, 2013). In this perspective, our methodological proposal provides a way to assess at local level, a wellbeing effect of public action. The Tunisian example is pertinent: people widely welcomed the agricultural transformation, launched through the government's policies because it brought increased yields of specific types of crops, such as cereals and vegetables. However, this enhanced agricultural performance may have exacerbated existing risks (loss of rural jobs on the social side, increased chemical inputs on the environmental side, and costly agricultural equipment on the economic side) and introduced new risks, as when high-yielding varieties of seed are poorly adapted to the form of crops, to the climate or to the farming systems (Clay & King, 2019).

Using the PLS method within the framework of structural equation models to perform spatial analysis has many advantages (see Figure 3): this spatial classification allows to propose a spatial analysis, without carrying out a costly field surveys based on human potential. This classification allows to characterise intensive agriculture beyond the standard variables (land size, quantity of inputs, mechanisation...) but rather to identify links between irrigated and fertilised or rainfed crops and wellbeing, at the sub-communal scale. Moreover, when areas have an unusually high incidence of

[8] World Bank. Questions and Answers for the Tunisia Irrigated Agriculture Intensification Project https://www.worldbank.org/en/news/factsheet/2018/05/17/questions-and-answers-for-the-tunisia-irrigated-agriculture-intensification-project

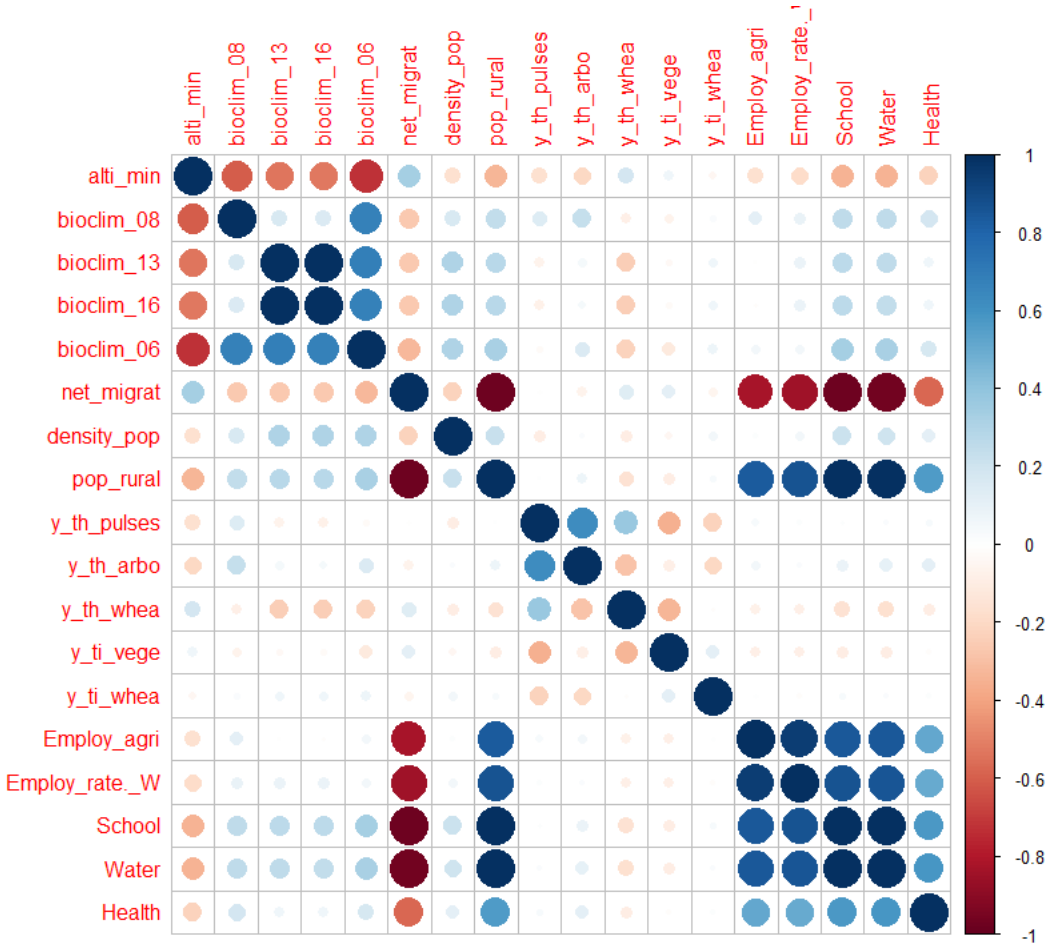
poverty, such spatial location serves to highlight target variables that able to improve the wellbeing of rural households, especially when labor or household income are not fully mobile (Park and Wang, 2001). For instance, our results promote economic development through public investment in infrastructure (e.g., targeted loans, integrated rural development projects…) rather than providing direct consumption subsidies, for instance. Moreover, the structural form of our model allows to adapt it to other comparable areas, taking into account bioclimatic, socio-economic, demographic and geographic specificities.

Our study presents some limitations, not least the inherent limitations of the PLS method itself (Sosik, Surinder, Kahai & Piovoso, 2009). Firstly, the measurement of formative constructs has not yet given rise to the same consensus as that for reflective constructs; a common criticism is that the parameter estimation can be either negative or positive. Estimates therefore become asymptotically correct only under a dual condition of "consistency" (McDonald, 1996): the size of the sample must be very large, as must the number of indicators per variable. In practice, these conditions are almost never met, which leads to a tendency to somewhat underestimate structural relationships and overestimate the contribution of indicators to the constructs (weights). Secondly, we have shown in this study that intensive agriculture has an overall negative impact on the wellbeing of rural communities. However, this general statement applies only to the rural areas we have selected and to the wellbeing category we have chosen. Therefore, in other locations and given other value systems, cultural identity, inequality, job security, health, community vitality, leisure, environmental factors, and subjective perceptions, which are important determinants of a population's wellbeing and are not the same around the world (Davern et al 2017; Michalos et al 2011), our result might be different. In addition, the index we have chosen seems to be reductive in the sense that the local definition of wellbeing has not been well taken into account in this research, which has focused on the academic factors of wellbeing: health care, work, education and access to drinking water. This focus contrasts sharply with traditional development indicators such as land, livestock and agricultural income as priorities for wellbeing, and traditional practices strongly linked to household-level food security. In the same way, other collective and contextual attributes such as sense of belonging, security, community support, and environmental change with its associated effects on food and water security, access to work collective services (schools, hospitals, public transport, etc.) may help to finely identify the elements that influence the quality of life of a community. The absence of some statistical data like individuals' income, difficult to measure in developing countries, also limits our definition of rural wellbeing. In Tunisia, there are few indications of farm income due to the absence of tax returns for most farmers (Granier, 1975) and a more precise definition of wellbeing is the next research challenge of our study.

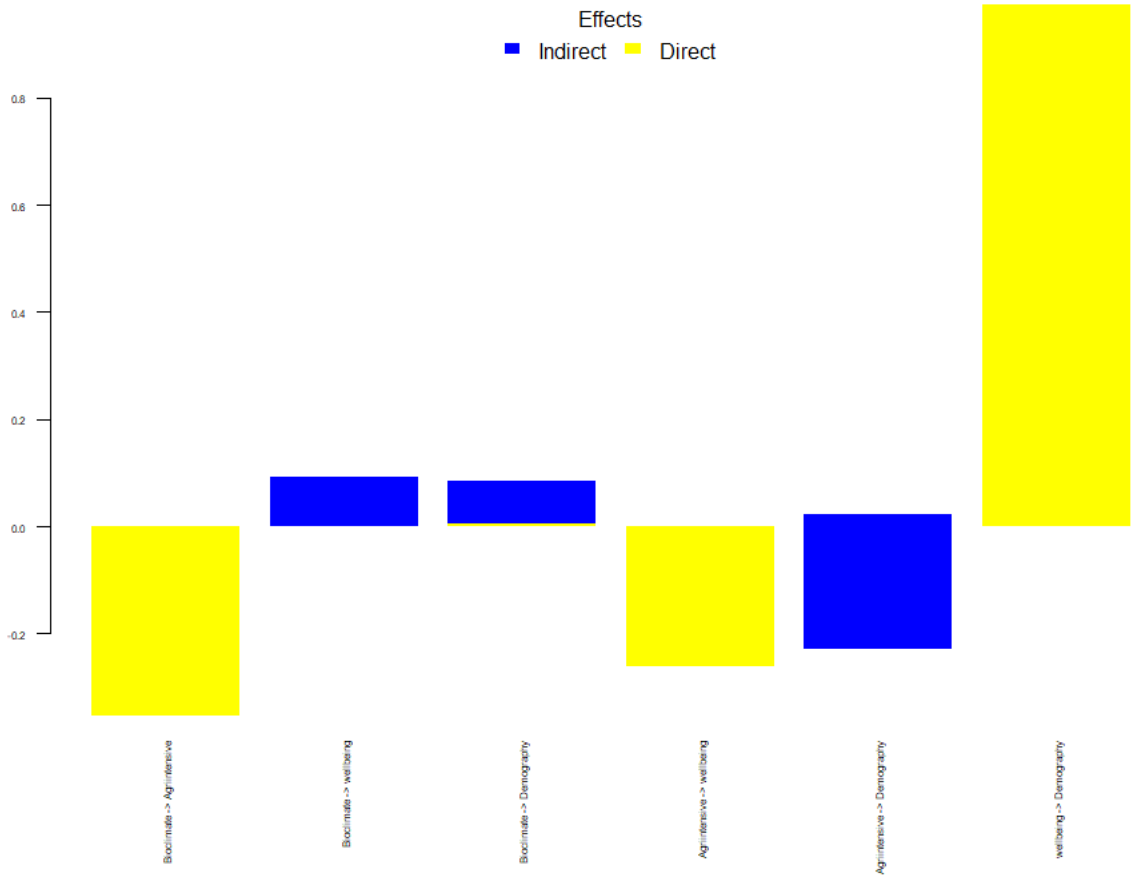
To conclude, this study illustrates the benefits and potential of using a statistical approach appropriate to issues involving unmeasured variables, such as the impact of agricultural intensification on rural

wellbeing at the sub-national level. We believe this approach can support future rural policy-making in developing countries. Our findings show that the generalization of the productivist system was appropriate in many industrial countries, when the freed labor force could be allocated to other economic sectors, but it is inappropriate in developing in developing economies (Atta-Ankomah and Osei, 2021) such as our case study where employment in the secondary and tertiary sectors is insufficient to absorb rural migrations. In these situations, agricultural intensification risks increasing the quantities produced while generating territorial poverty and emigration and increasing social wellbeing disparities in the production areas.

Appendix A: Correlation matrices of candidate manifest variables of the latent variables



Appendix B: Total effects (direct + indirect)



6. Reference

Abro, Z.A., Alemu, B.A., Hanjra, M.., 2014. Policies for agricultural productivity growth and poverty reduction in rural Ethiopia. World Dev. 59, 461–474. https://doi.org/10.1016/j.worlddev.2014.01.033

African Development Bank group Tunisia, 2003. integrated rural development project phase II project performance evaluation report (PPER), African Development Bank group Tunisia.

Amamou, H., Ben, M., Aouadi, H., Khemiri, H., Mahouachi, M., Beckers, Y., Hammami, H., 2018. Climate Risk Management Climate change-related risks and adaptation strategies as perceived in dairy cattle farming systems in Tunisia. Clim. Risk Manag. 20, 38–49. https://doi.org/10.1016/j.crm.2018.03.004

Amartya Sen, 1973. Poverty , inequality and Unemployment Some Conceptual Issues in Measurement. Econ. Polit. Wkly. 8, 1457–1464.

Anand.S and Sen.A, 2000. the income component of human development index. J. Hum. Dev. 1, 83–106.

Anand.S and Sen.A, 1994. Humain Development Index: methodology and measurement. Hum. Dev. Rep. Off. Occas. Pap.

Atta-Ankomah, R., Osei, R.D., 2021. Structural Change and Welfare: A Micro Panel Data Evidence from Ghana. J. Dev. Stud. 57, 1927–1944. https://doi.org/10.1080/00220388.2021.1939864

Ayadi, M., Chtioui, N., El Lahga, A., 2005. Analyse Multidimensionnelle de la Pauvreté en Tunisie entre 1988 et 2001 par une Approche Non-Monétaire. PEP, a Pap. Present. Dur. 4th PEP Res. Netw. Gen. Meet. Colombo, Sri Lanka.

Béchir, R., 2011. Pauvreté et politiques d'amélioration du niveau de vie, une étude sur le cas Tunisien. New Medit 10, 4–10.

Bezner-Kerr, R., 2012. Lessons from the old Green Revolution for the new: Social, environmental and nutritional issues for agricultural change in Africa. Prog. Dev. Stud. 12, 213–229.

Bibi, S., 2002. Mesurer la pauvreté dans une perspective multidimensionnelle : une revue de la litt ´ erature. Fac. des Sci. Econ. Gest. Tunis CREFA-CIPREE, Univ. Laval, Canada. 26.

Bollen, K., Lennox, R., 1991. Conventional Wisdom on Measurement: A Structural Equation Perspective. Psychol. Bull. 110, 305–314. https://doi.org/10.1037/0033-2909.110.2.305

Boughanmi, H., 1995. Les principaux volets des politiques agricoles en Tunisie : évolution , analyse et performances agricoles. CIHEAM, Options Méditerranéennes Série B. Etudes Rech. n. 14, 127–138.

Bounouh, A., and Gsir, S., 2017. Migrations et environnement en Tunisie : Relations complexes et défis pour le développement Migrations et environnement en Tunisie : Relations complexes et défis pour le développement, Organisation internationale pour les migrations.

Bouzidi, Z., EL Nour, S., Moumen, W., 2011. Le travail des femmes dans le secteur agricole : Entre

précarité et empowerment Cas de trois régions en Egypte , au Maroc et en Tunisie. Popul. Counc.

Chebil. A, Mtimet.N, Tizaoui.H, 2011. Impact du changement climatique sur la productivité des cultures céréalières dans la région de Béja (Tunisie). African J. Agric. Resour. Econ. 6, 144–154.

Clay, N., 2018. Seeking justice in Green Revolutions: Synergies and trade-offs between large-scale and smallholder agricultural intensification in Rwanda. Geoforum 97, 352–362. https://doi.org/10.1016/j.geoforum.2018.09.021

Clay, N., King, B., 2019. Smallholders' uneven capacities to adapt to climate change amid Africa's 'green revolution': Case study of Rwanda's crop intensification program. World Dev. 116, 1–14. https://doi.org/10.1016/j.worlddev.2018.11.022

Dhaher, N., 2010. L'aménagement du territoire tunisien : 50 ans de politiques à l'épreuve de la mondialisation. EchoGéo 13, 0–14.

Diamantopoulos, A., Temme, D., 2013. MIMIC models, formative indicators and the joys of research. AMS Rev. 3, 160–170. https://doi.org/10.1007/s13162-013-0050-0

Diamantopoulos, A., Winklhofer, H.M., 2001. Index Construction with Formative Indicators: An Alternative to Scale Development. J. Mark. Res. 38, 269–277. https://doi.org/10.1509/jmkr.38.2.269.18845

Dorward, A., Kydd, J., Morrison, J., Urey, I., 2004. A policy agenda for pro-poor agricultural growth. World Dev. 32, 73–89. https://doi.org/10.1016/j.worlddev.2003.06.012

Elahi, E., Weijun, C., Zhang, H., Nazeer, M., 2019. Agricultural intensification and damages to human health in relation to agrochemicals: Application of artificial intelligence. Land use policy 83, 461–474. https://doi.org/10.1016/j.landusepol.2019.02.023

Elliott, S.J., Dixon, J., Bisung, E., Kangmennaang, J., 2017. A GLOWING footprint: Developing an index of wellbeing for low to middle income countries. Int. J. Wellbeing 7, 1–27. https://doi.org/10.5502/ijw.v7i2.503

Ellis, F., Maliro, D., 2013. Fertiliser subsidies and social cash transfers as complementary or competing instruments for reducing vulnerability to hunger: The case of Malawi. Dev. Policy Rev. 31, 575–596. https://doi.org/10.1111/dpr.12026

Elloumi, M., 2006a. L'agriculture tunisienne dans un contexte de libéralisation. Région et Développement 23.

Elloumi, M., 2006b. Les politiques de développement rural en Tunisie : Acquis et perspectives. Options Méditerranéennes Sér. A / n, 55–65.

Elloumi M, 1993. Du développement agricole au développement rural. Le cas des zones semi-arides en Tunisie. Économie Rural. 213, 18–23. https://doi.org/10.3406/ecoru.1993.4513

Evans, S.D., Prillelrensky, I., 2007. Youth and democracy: Participation for personal, relational, and colleqive well-being. J. Community Psychol. 35, 681–692. https://doi.org/10.1002/jcop.20172

Forjaz, M.J., Prieto-Flores, M.E., Ayala, A., Rodriguez-Blazquez, C., Fernandez-Mayoralas, G., Rojo-Perez, F., Martinez-Martin, P., 2011. Measurement properties of the Community Wellbeing Index

in older adults. Qual. Life Res. 20, 733–743. https://doi.org/10.1007/s11136-010-9794-2

Gafsi , S., and Roe, T., 1979. Adoption of Unlike High-Yielding Wheat Varieties in Tunisia. Econ. Dev. Cult. Change 28, 119–133. https://doi.org/10.1086/451156

Gafsi , S., and Roe, T., 1977. Adoption Of Unlike High Yiekding Wheat Varieties in Tunisia. Staff Pap. Ser. Univ. Minnesota Instituteof Agric. Home Econ.

Gammar, A.M., 2019. Dynamiques rurales et conservation forestière dans le Nord de la Tunisie. Rev. géographie Alp. 0–13. https://doi.org/10.4000/rga.6441

Gana, A., 2008. Restructurations agricoles en Tunisie : adaptations et différenciation. Autrepart 46, 81. https://doi.org/10.3917/autr.046.0081

Garson, G.., 2016. PARTIAL LEAST SQUARES (PLS-SEM) 2016 Edition.

Gough, I., McGregor, J.A., Camfield, L., 2007. Theorising wellbeing in international development, Wellbeing in Developing Countries: From Theory to Research. https://doi.org/10.1017/CBO9780511488986.002

Grami, D., Ben Rejeb, J., 2015. Impact of Climate Change on Grain Farming Yield in a Northwestern Region of Tunisia [Beja]. New Medit Mediterr. J. Econ. Agric. Environ.

Granier, R., 1975. Note sur les revenus agricoles en Tunisie. Etud. Int. 6, 255. https://doi.org/10.7202/700548ar

Habib, A., 1986. Problématique du développement du Nord-Ouest tunisien. Rev. des mondes musulmans la Méditerranée 264–280.

Harrigan, J., 2003. U-Turns and full circles: Two decades of agricultural reform in Malawi 1981-2000. World Dev. 31, 847–863. https://doi.org/10.1016/S0305-750X(03)00019-6

Harttgen, K., Klasen, S., 2012. A Household-Based Human Development Index. World Dev. 40, 878–899. https://doi.org/10.1016/j.worlddev.2011.09.011

Hauser, R.M., Goldberger, A.S., 1971. Erratum: The Treatment of Unobservable Variables in Path Analysis. Sociol. Methodol. 6, 212. https://doi.org/10.2307/270898

Henseler, J., Hubona, G., Ray, P.A., 2016. Using PLS path modeling in new technology research: Updated guidelines. Ind. Manag. Data Syst. 116, 2–20. https://doi.org/10.1108/IMDS-09-2015-0382

Herman E Daly, John B.Cobb, C.W.C., 1990. For the Common Good: Redirecting the Economy Toward Community, the Environment, and a Sustainable Future., Beacon Press. Boston.

Hu, Z., 2020. What Socio-Economic and Political Factors Lead to Global Pesticide Dependence ? A Critical Review from a Social Science Perspective.

Hunt, D., 1974. Structural reform in Tunisian agriculture: The producer co-operatives programme, 1962-69. Agric. Adm. 1, 263–284. https://doi.org/doi.org/10.1016/0309-586X(74)90048-X

Jalan, J., Ravallion, M., 1998. Are there dynamic gains from a poor-area development program? J. Public Econ. 67, 65–85. https://doi.org/10.1016/S0047-2727(97)00052-2

Joe F. Hair Jr, Marko Sarstedt, Lucas Hopkins, V.G.K., 2014. Partial least squares structural equation

modeling (PLS-SEM): An emerging tool in business research. Eur. Bus. Rev. 26, 106–121. https://doi.org/10.1108/EBR-10-2013-0128

Johnston, D.F., 1988. Toward a comprehensive 'quality-of-life' index. Soc. Indic. Res. 20, 473–496. https://doi.org/10.1007/bf03359553

Kassab, A., 1981. L ' agriculture tunisienne sur la voie de l ' intensification. Ann. Géographie L'agriculture 55–86. https://doi.org/doi : https://doi.org/10.3406/geo.1981.20003

Kijima, Y., Otsuka, K., Sserunkuuma, D., 2011. An inquiry into constraints on a green revolution in sub-Saharan Africa: The case of NERICA Rice in Uganda. World Dev. 39, 77–86. https://doi.org/10.1016/j.worlddev.2010.06.010

Laajimi, A., 2007. Les périmètres irrigués en Tunisie: Un enjeu pour le développement de la production agricole. Les notes d'alerte-CHIEAM 30, 1–3.

Luna, J.K., 2020. ' Pesticides are our children now ': cultural change and the technological treadmill in the Burkina Faso cotton sector. Agric. Human Values 37, 449–462. https://doi.org/10.1007/s10460-019-09999-y

Magrini et al, 2017. Transition vers des systèmes agricole et agroalimentaire durables : quelle place et qualification pour les légumineuses à graines ? Rev. Française Socio-Économie 18, 53. https://doi.org/10.3917/rfse.018.0053

Martinetti, E.C., 2000. A Multidimensional Assessment of Well-Being based on Sen's Functioning Approach. Riv. Int. Sci. Sociali 1999, 1–37.

Mason, N.M., Smale, M., 2013. Impacts of subsidized hybrid seed on indicators of economic well-being among smallholder maize growers in Zambia. Agric. Econ. (United Kingdom) 44, 659–670. https://doi.org/10.1111/agec.12080

McDonald, R.P., 1996. Path Analysis with Composite Variables. Multivariate Behav. Res. 239–270. https://doi.org/10.1207/s15327906mbr3102

McIntosh, C.N., Edwards, J.R., Antonakis, J., 2014. Reflections on Partial Least Squares Path Modeling. Organ. Res. Methods 17, 210–251. https://doi.org/10.1177/1094428114529165

Melanie T. Davern, Lucy Gunn, , Billie Giles-Corti, S.D., 2017. Best Practice Principles for Community Indicator Systems and a Case Study Analysis: How Community Indicators Victoria is Creating Impact and Bridging Policy, Practice and Research. Soc. Indic. Res. 131, 567–586. https://doi.org/10.1007/s11205-016-1259-8

Michalos, A.C., Smale, B., Labonté, R., Muharjarine, N., Scott, K., Moore, K., Swystun, L., Holden, B., Bernardin, H., Dunning, B., Graham, P., Guhn, M., Gadermann, A.M., Zumbo, B.D., Morgan, A., Brooker, A.-S., & Hyman, I., 2011. The Canadian index of wellbeing.Technical Report 1.0.ON: Canadian Index of Wellbeing and University of Waterloo. Waterloo.

Ministere De L'Agricolture, 1995. tunisie : Rapport De Pays Pour La Conference Technique Internationale De La Fao Sur Les Ressources Phytogenetiques, Ministere de l'Agriculture. Tunis.

Moseley, W.G., 2015. Food Security and "Green Revolution," in: International Encyclopedia of the

Social & Behavioral Sciences: Second Edition. https://doi.org/10.1016/B978-0-08-097086-8.91019-5

Mzali, H., 1997. Marché du travail, Migrations Internes et Internationales en Tunsie. Rev. Région Développement 151–183.

Najeh, A., 2018. Agriculture , inégalités et développement régional en Tunisie : une analyse par une grille articulant les cinq formes de capital .Politiques Agricoles et Alimentaires : Trajectoires et Réformes, in: Colloque SFER Montpellier 20-21 Juin 2018. p. 24.

Nanor, M.A., Poku-Boansi, M., Adarkwa, K.K., 2021. Determinants of subjective wellbeing in rural communities: Evidence from the Juaben Municipality, Ghana. Cities 113, 103140. https://doi.org/10.1016/j.cities.2021.103140

Nasri, K., Belhadj, B., 2014. Pauvreté et développement régional en Tunisie : Nouvelle approche multidimensionnelle 1–13.

Nasri, 2016. Annual Report Of Infrastructure Indicators 2015-2016.

Negin, J., Remans, R., Karuti, S., Fanzo, J.C., 2009. Integrating a broader notion of food security and gender empowerment into the African Green Revolution. Food Secur. 1, 351–360. https://doi.org/10.1007/s12571-009-0025-z

Office de Développement du Nord-Ouest, 2017. Gouvernorat de Béja en chiffres.

Park, A., Wang, S., 2001. Regional Poverty Targeting in China..pdf. J. Public Econ. 734–764. https://doi.org/10.1016/S0047-2727(01)00108-6

Picouet, M., 2002. Formes de mobilité et dynamique de l'environnement en Tunisie. Rev. Eur. Migr. Int. 18, 51–65. https://doi.org/10.4000/remi.1638

Pingali, P.L., 2012. Green Revolution: Impacts, limits, and the path ahead. Proc. Natl. Acad. Sci. 109, 12302–12308. https://doi.org/10.1073/pnas.0912953109

PNUD., 2004. Stratégie de réduction de la pauvreté : Étude du phénomène de la pauvreté en Tunisie. Bur. du Coord. Résident en Tunisie 115.

Purvis, M.J., 1972. The Adoption of High Yielding Wheats in Tunisia. Staff Pap. 13677, Univ. Minnesota, Dep. Appl. Econ. https://doi.org/10.22004/ag.econ.13677

Rasmussen, L.V., Coolsaet, B., Martin, A., Mertz, O., Pascual, U., Corbera, E., Dawson, N., Fisher, J.A., Franks, P., Ryan, C.M., 2018. Social-ecological outcomes of agricultural intensification. Nat. Sustain. 1, 275–282. https://doi.org/10.1038/s41893-018-0070-8

Riadh, B. et, Mongi, S., 2013. Taux de pauvreté et ses mesures en Tunisie. New Medit 12, 2–10.

Rodrigues, V.S., do Valle Júnior, R.F., Sanches Fernandes, L.F., Pacheco, F.A.L., 2019. The assessment of water erosion using Partial Least Squares-Path Modeling: A study in a legally protected area with environmental land use conflicts. Sci. Total Environ. 691, 1225–1241. https://doi.org/10.1016/j.scitotenv.2019.07.216

Sen, A., 1993. Capability and well-being, The Philosophy of Economics. https://doi.org/10.1017/CBO9780511819025.019

Sen, A., 1976. Poverty: An Ordinal Approach to Measurement. Econometrica 44, 219. https://doi.org/10.2307/1912718

Smale, M., Mason, N., 2014. Hybrid Seed and the Economic Well-Being of Smallholder Maize Farmers in Zambia. J. Dev. Stud. 50, 680–695. https://doi.org/10.1080/00220388.2014.887690

Sosik, J.J., Surinder , S.k., Kahai and Piovoso, M.J., 2009. Silver bullet or voodoo statistics?: A primer for using the partial least squares data analytic technique in group and organization research. Gr. Organ. Manag. 34, 5–36. https://doi.org/10.1177/1059601108329198

Statistics Tunisia, 2014. the general census of the population and the household 2014.

Streeten, P., Burki, S. J., ul Huq, M., Hicks, N., & Stewart, F., 1981. First things first; meeting basic human needs in developing countries., Oxford Uni. ed. New York.

Tenenhaus, M., Vinzi, V.E., Chatelin, Y.M., Lauro, C., 2005. PLS path modeling. Comput. Stat. Data Anal. 48, 159–205. https://doi.org/10.1016/j.csda.2004.03.005

Thinda, K.T., Ogundeji, A.A., Belle, J.A., Ojo, T.O., 2020. Understanding the adoption of climate change adaptation strategies among smallholder farmers: Evidence from land reform beneficiaries in South Africa. Land use policy 99, 104858. https://doi.org/10.1016/j.landusepol.2020.104858

Tilman, D., Cassman, K.G., Matson, P.A., Naylor, R., Polasky, S., 2002. Agricultural sustainability and intensive production practices 418, 671–677. https://doi.org/https://doi.org/10.1038/nature01014

UNDP, 2019. Human Development Report 2019 Beyond income , beyond averages , beyond today. New York.

UNDP, 2010. Human Development Report 2010. The Real Wealth of Nations. Pathways to Human Development UNDP. New York.

UNDP, 1990. Humain development report 1990. New York.

Wanjala, B.M., Muradian, R., 2013. Can Big Push Interventions Take Small-Scale Farmers out of Poverty? Insights from the Sauri Millennium Village in Kenya. World Dev. 45, 147–160. https://doi.org/10.1016/j.worlddev.2012.12.014

Wold, H., 1980. Data Analysis by Partial Least Squares Data Analysis by Partial Least Squares. Analysis Evaluation, 47–74.

Wood-Sichra, U., Joglekar, A.B., And, You, L., 2016. Spatial Production Allocation Model (SPAM) 2005. Harvest. Work. Pap. Washington, D.C. Int. Food Policy Res. Inst. St. Paul Int. Sci. Technol. Pract. Policy Center, Univ. Minnesota 1–87.

World Bank, 2012. Etude de la Banque mondiale La Tunisie face aux changements climatiques .Évaluation et Actions pour accroitre la résilience et le développement . Washington, D.C.

Article 2: Lock-in factors preventing transition from intensive to sustainable agriculture in developing countries: the case of Tunisia

This Article is submitted to Ecological Economics journal

Fatma Mhadhbi[a]*, Guillaume Ollivier[a], Claude Napoléone[a]

[a] Ecodeveloppement, INRAE, 84000 Avignon, France

*corresponding author

Abstract: Despite decades of research on the negative effects of chemical inputs, farmers around the world still make extensive use of pesticides. Many lock-in factors, often context-dependant, have been found to prevent farmers from converting to sustainable practices. This study investigates such lock-in mechanisms operating in Tunisia. Based on a directional questionnaire with open-ended questions, we surveyed 111 interviewees, mostly farmers and stakeholders (farm workers, agricultural advisers, etc.). Using a lexicometric analysis of the interviews, we typified arguments justifying intensification practices and inputs, and the stakeholders' opportunities for change. Our analysis reveals the strong dominance of intensive practices (85% of farmers), which most respondents claimed as essential to their survival, especially pesticides, despite awareness of their impact on the environment. We also address institutional determinants of this situation: while policies provide huge incentives for intensification, the weak, inadequate intervention of the Tunisian state before and after the revolution, coupled with corruption, are detrimental to more sustainable practices. Moreover, the collective option appears controversial due to the traumatic memory of past authoritarian policies. Our analysis thus highlights two important social traits in in developing country situations: a weak state combined with corruption leading to proliferation of uncontrolled chemical inputs and the country's institutional history modifying symbolic representations of options for change (here, collective solutions).

Keywords: intensive agriculture, technological lock-in, chemical inputs, organic farming, Tunisia

1. Introduction

A "new Green Revolution" is actually occurring in Africa (Luna 2020), although many researchers warn it may reproduce the failings of the Green Revolution in terms of negative impact on the environment, health, and social equity (Altieri 2009; Pingali 2012). In addition to analyzing the impacts of this intensification based on high-yielding varieties (HYVs), chemical fertilizers, pesticides, monoculture, mechanization, and irrigation, abundant research both in academia and in the field has long proposed alternative paths (Ollivier and Bellon 2013). These include conservation agriculture since the 1930s, integrated pest management (IPM) since the 1950s, organic farming (OF), agroforestry and agroecology since the 1970s. Many of these alternatives, particularly OF, offer recognized advantages: less risky, reduced cost due to increased autonomy (Benoit et al. 2017; Jouzi et al., 2017), lower environmental impact (Lacour et al. 2018), adaptation and resilience to climate shocks (Aguilera et al. 2020; Debray et al. 2018; Jouzi et al. 2017). Analysis of practical experiences of these alternatives has led to the identification of principles for designing sustainable systems that are now internationally recognized (FAO, 2018; Reijntjes, 1992).

Yet studies continue to point to farmers' reluctance to change their practices, particularly to abandon or reduce pesticide use, in spite of public policies implemented in many countries (Hu 2020; Rogério et al. 2020; Dessart, Barreiro-hurlé, and Bavel 2019). In developing countries, farmers tend to be even bigger users of pesticides, often more toxic ones, than in countries with more stringent regulations (Ecobichon 2001; Handford, Elliott, and Campbell 2015). Thus, given the challenges facing farmers in developing countries, there is a need to understand why change, or the decision to implement more sustainable farming practices, is so slow. Gaining this insight is particularly crucial because hugely export-oriented agricultural policies may enhance countries' food dependency and have a fundamental historical effect, as in the case of the 2011 Tunisian Revolution (Ayeb.H et Bush.R 2019; Gana 2012).

An extensive literature has examined, under diverse theoretical perspectives, the numerous, not consensual, context-dependent, and intertwined factors influencing the (non-)adoption of sustainable practices (Adnan et al. 2019; Hu 2020). Following Hu (2020), we identify two major approaches: individualistic behavioral and macro-level structuralist ones.

The individualistic approaches focus on determinants of farmer decisions, either psychological – like farmer risk-aversion regarding productivity or profitability loss (Chèze, David, and Martinet 2020) - or demographic – like gender, age, education (J. L. Wagner et al. 2016; Burton 2014). Following the intensive academic focus on individual behavioral determinants, a growing literature discusses the restrictive hypothesis of profit-maximization (Kirman, 2011) and shows the role of non-economic concerns in the adoption of sustainable practices. Farmers are also motivated by moral - (intrinsic) ethics of individuals - and social considerations - tailoring behavior to one's peer group, the desire for status,

altruism or conforming to one's social identity (Mzoughi 2011). Many studies use the Theory of Planned Behavior (Ajzen,1991), or derived frameworks, and econometric analysis of questionnaires, to model individuals' social-psychological constructs, where beliefs, motivations, and intentions to change interact. For instance, Bakker et al. (2021) show that farmer intentions to reduce pesticide use are constrained by social norms and the neighborhood effect. Taking a diffusionist approach to innovations (Adnan et al. 2019; Rogers 1962), they note the key role of the quality and structure of the relational network in adoption decisions.

Looking beyond social norms on individualistic behaviors, the more rarely employed structuralist approaches (Schut et al. 2014) consider change in a systemic way, i.e. considering collective, institutional, and political levels. Although the field of Transition Studies rarely considers agriculture (Ollivier et al. 2018; El Bilali 2019), its framework, the Multi-level Perspective (MLP, see Elzen et al., 2011), conceives socio-technical transition through the interactions within and among innovation and a dominant socio-technical regime, defined as an assemblage of normative (laws, standard, social norms, market rules) and cognitive routines, both under the pressure of landscape (i.e. global trends). To understand resistance to change, authors analyzing agricultural systems use the concepts of 'path dependency' and 'lock-in', both of which come from evolutionary economics (Arthur 1989). Path dependency is used to describe situations where history influences present decisions, and lock-in refers to situations where an initial technological configuration produces a dominant and self-reinforced position, even if more efficient alternatives are available later on (David, 1985). The more the initial technology is adopted, the more it excludes alternatives and makes the socio-technical system less reversible (Arthur 1989). This is due to three factors (Kallis and Norgaard 2010; Perkins 2003) :1) learning economies – the performance increase while adopters acquire knowledge and skills that fit the technology, while previous or alternative ones are marginalized (Cowan and Gunby 1996; Hu 2020); 2) economies of scale – technology costs decrease while yield rapidly increases; and 3) expansion of socio-technical interdependencies and network externalities – users become dependent on the technology, which is gradually linked to infrastructures and new dependent technologies and actors.

Other researchers have since specified and expanded the set of interacting factors explaining lock-in. For instance, pesticide dependency can partially be explained by the increasing R&D orientation toward the enhancement of pesticides in the face of pest resistance, at the same time as research on biological alternatives is losing funding (Cowan and Gunby 1996; Vanloqueren and Baret 2008). Wilson and Tisdell (2001) argue that the introduction of pesticides has decreased production costs and increased short-term yields, so that even reluctant people are forced to adopt them to remain competitive. This is further reinforced by public incentives and by the fact that long-term negative externalities are invisible or ignored. More recent studies (Fares, 2012; Magrini and Nicolas, 2019) show that the lock-in of agrifood systems may result from systemic reinforcement, inertia or blockage due to interrelated factors, such as rules and standards around social and market transactions or the quality of products, or from

inappropriate organizational settings such as specialization and integration. In Cambodia, Flor et al. (2020) reveal a lock-in effect of social arrangements and informal rules among farmers, pesticide sellers, and laborers. In Norway, Kuokkanen et al. (2017) identify the mechanisms ensuring increasing returns based on separate but interdependent processes in production, supply chain, and policies, resulting in a systematic resistance to change. Finally, while some lock-in factors are the unintentional results of system configuration, which the actors are unaware of , others arise from the passive or active strategies used by certain powerful actors to defend their interests, even though maintaining the system is unsustainable (Avelino and Wittmayer, 2016; Darnhofer et al., 2012; Dedieu et al., 2015; Mialon and Mialon, 2018; Villemaine, 2018; Wilson and Tisdell, 2001).

Studies on lock-in factors converge with those using the treadmill metaphor or theory (Luna 2020; Ward 1993; Nicholls and Altieri 1997) which sees lock-in situations as a result of interactions, self-reinforcement, and chain reactions of a system of factors. First, there is the pesticide treadmill around the development of pest resistance and the depletion of beneficial insects so that constantly increasing investment in new pesticides is required (Lieneke Bakker et al. 2020). The treadmill metaphor can be extended to other context-dependent factors. For instance, Luna (2020) shows that agricultural intensification in Burkina Faso resulted from the convergence of cultural evolution (the rise of individualism), local demographic trends inducing labor shortages (rural migration and schooling), and accessibility to labor-saving and short-term profitable technologies (e.g. GMO and pesticides), despite their harmful environmental and health effects.

In this context, this article explores the persistence of pesticide use and lock-in affecting small-scale agriculture in a developing country context and despite the availability of alternatives to the productivist agricultural model. Following the literature, we assume that while personal attitude, knowledge, and skills are key factors, they do not fully explain the lock-in. The local agricultural structure and political and institutional environment prevailing in developing countries also prevent farmers from switching to more sustainable practices. To test our assumption in the field and in the developing country, we studied the Tunisian case. We focused on the plains of the North-western region (Fig. 1), where cereal and vegetable crops are concentrated and generally depend on intensive systems. In 2018, we implemented a survey based on questionnaires with open-ended questions. Farmers and other stakeholders(see **Erreur ! Source du renvoi introuvable.** for details) were interviewed on the use of pesticides, their interest in changing to more sustainable agricultural practices through reducing or eliminating synthetic inputs, in particular pesticides, and the obstacles they perceived as likely to render this difficult. To analyze these actor discourses, we adopted a lexicometric analysis appropriate to the processing of data from our field studies. In addition to well-known factors, such as technological dependency/treadmill or asymmetries of information drivers, our analysis reveals two previously

unexplored factors to take into account, particularly for some developing country situations: a weak state combined with corruption leads to proliferation of uncontrolled chemical inputs, and the country's institutional history modifies symbolic representations of options for change (here, collective solutions).

The rest of the article is divided into four sections. Section 2 outlines the situation prevailing in the agricultural sector in Tunisia since its independence. Section 3 describes our survey and analysis methodologies. The results of our field survey are presented in section 4 and we provide a discussion and conclusion in section 5.

2. Tunisia's agrarian situation

From the beginning of the colonial era to the liberalization processes in the 80's, agricultural policies in Tunisia favored intensive export-oriented agricultural systems. Under the impetus of the Green Revolution, the Tunisian authorities encouraged the importing of high-yield hybrid seed varieties from CGIAR centers, particularly CIMMYT in Mexico (Gafsi and Roe, 1979, 1977; Purvis, 1972). These seeds are highly productive but require the intensive use of chemical inputs, This has continued to increase, as shown by the doubling of pesticide imports between 2010 and 2016 (Zarai 2017), with little national legislation governing their use (Mhadhbi et al. 2018). At the same time, small farms quantitatively dominate agriculture (Jouili 2015): more than 54% of farms occupy less than 5 ha and face a multitude of natural constraints (e.g. low and irregular rainfall, low fertility of soils). In fact, although agriculture is considered a growth sector in Tunisia, the resources allocated to its long-term development and proper functioning remain limited. The democratic transition since the 2011 Revolution, instead of leading to a new agricultural and rural development strategy (Chebbi and Khechimi 2019), has merely extended the previous unambitious policies involving support measures and general intervention in the domestic market (direct management of producer prices and control of input prices). In addition, support policies are conditional on farmers having a land title and a bank account as well as being solvent (Jouili 2009), likely prohibitive constraints for the smallest of them.

Sizeable obstacles face all Tunisian farmers in the transition to a more sustainable model: for instance, the low level of education and the ageing of the farm manager (Laajimi and Ben Nasr, 2008; Richard, 2006). Among the direct factors influencing farmers' decision to change their farming practices, two stand out: farm size and type of farming (irrigated vs. rainfed) (Jouili 2015, 2016). Irrigated farms are highly specialized, mainly cultivating a few profitable crops, often market garden crops (tomato, potato, bell pepper), with a short vegetative cycle (more than one harvest per year). In contrast, in rainfed agriculture, farmers practice a biannual rotation (legumes - cereals) with only one crop per year (Jendoubi, Hossain, and Giger 2020; GIZ 2014).

However, since the 1990s, Tunisia has been considering alternatives to intensive agriculture. Following the growing national and international demand for organic products (Blaise and Sbouai, 2015; Letaief

et al., 2016; Mtimet et al., 2020), organic agriculture emerged in Tunisia but is still struggling to take off (Blaise and Sbouai, 2015). Under incentives granted by the Tunisian government, both the area and the number of stakeholders involved in organic crops have increased (Laajimi and Ben Nasr, 2008). Through its organic development program, Tunisia seeks to promote the exporting of a few products that represent a comparative advantage, such as olive oil, dates and medicinal herbs (Mtimet, Souissi, and Mhamdi 2020). Indeed, a total of 48500 tons of organic products were exported in 2018 (including 38600 tons of olive oil) for an area of 370000 hectares [19]. Thus, while increased organic farming areas are reducing the negative environmental impacts of agriculture (Hattab et al. 2019), Tunisian agriculture remains high-yield and dedicated to the international market.

The study was carried out in the North-West region (Fig.1), the rainiest region in the country, bounded to the west by the Tunisian-Algerian border, to the east by the capital and to the north by the Mediterranean Sea. This region, 10.4% of the country's total surface area, is essentially agricultural, with 52% cultivated land, i.e. 19% of Tunisia's total agricultural surface area.

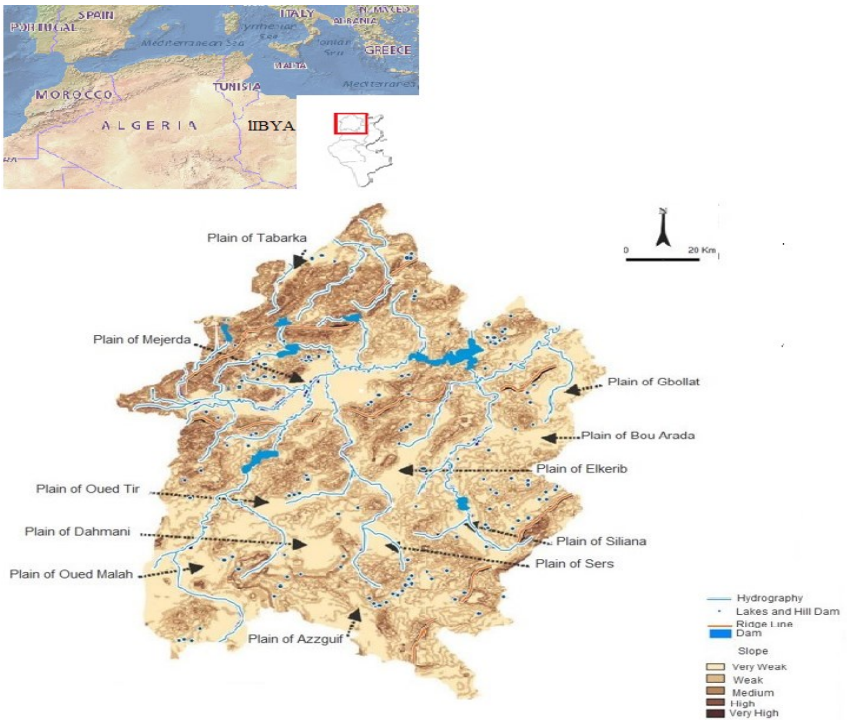


Figure. 1 : The North-west region of Tunisia

3. Methods and materials

To understand the factors preventing transition to more sustainable farming, we conducted semi-guided individual interviews in the study area, followed by a lexicometric analysis of their transcripts. We chose an open-ended method to explore unexpected dimensions of a subject never previously studied in this

[9] http://www.ctab.nat.tn/index.php/fr-fr/situation-du-secteur/tunisie/statistiques

situation. This type of interview gives the actors the opportunity to express their own understanding of their situation, and to argue for or justify their practices, thus highlighting the factors most important to them.

3.1. Field survey

Our interviews covered four main themes. The first was intended to gather identification data (age, gender, occupation, education level, etc.). The second was aimed at collecting data on farmers' use of pesticides. The third theme addressed farmers' opportunities to move away from intensive practices toward more sustainable agricultural systems. The fourth tackled structural problems facing the sector. Interviews were divided into sections per theme, each section including a combination of dichotomous, nominal, ordinal, and open-ended questions (see Appendix A). We conducted 111 interviews of between 15 and 50 minutes, largely with farmers and diverse stakeholders (Table 1). Respondents were selected using a snowball method to ensure qualitative diversity rather than statistical representation. The sample of farmers interviewed is diverse according to several criteria (see Tables 1 and 2): type of farm, size of farm, age, level of education, use of inputs, and land distribution on the territory (location).

We sampled respondents in several stages, as a complete list of farmers was not available for each commune in the region. First, in consultation with officials from the Regional Agricultural Development Commissariats, we identified farmers who lived in the districts. Within each district, we contacted local actors and other state officials to identify farmers to interview. Then, we asked each farmer interviewed to suggest others in the area that could be interviewed. Once the surveys were completed, we reviewed each of the questionnaire responses with the interviewees to ensure accurate interpretation of the data and responses. Recordings of the interviews, which were conducted in local Arabic, were kept in written form (note-taking), transcribed, and translated into French.

Table1. Statistical description of interviewee

Characteristic	Overall, N = 111[1]	Farm work?	
		no, N = 15[1]	yes, N = 96[1]
Age			
young [45<]	37 (33%)	4 (27%)	33 (34%)
medium [45-59]	44 (40%)	9 (60%)	35 (36%)
old [>59]	30 (27%)	2 (13%)	28 (29%)
Gender			
female	10 (9.0%)	2 (13%)	8 (8.3%)
male	101 (91%)	13 (87%)	88 (92%)
Is the respondent a farmer?	93 (84%)	0 (0%)	93 (97%)
Main occupation (11 farmers are pluriactive)			
administration	4 (3.6%)	4 (27%)	0 (0%)
doctor	1 (0.9%)	0 (0%)	1 (1.0%)
extensionist	14 (13%)	9 (60%)	5 (5.2%)
farmworker	3 (2.7%)	0 (0%)	3 (3.1%)
full-time farmer	85 (77%)	0 (0%)	85 (89%)
teacher	2 (1.8%)	1 (6.7%)	1 (1.0%)
union	2 (1.8%)	1 (6.7%)	1 (1.0%)
Level of education			
noanswer	2 (1.8%)	1 (6.7%)	1 (1.0%)
none	9 (8.1%)	0 (0%)	9 (9.4%)
primary	15 (14%)	0 (0%)	15 (16%)
secondary	51 (46%)	3 (20%)	48 (50%)
tertiary	34 (31%)	11 (73%)	23 (24%)

[1] n (%)

3.2. Lexicometric analysis of discourse: The Iramuteq approach

Our analysis was conducted using the Reinert method implemented in Iramuteq software (Ratinaud and Déjean 2009). This method makes it possible to find "lexical worlds" (or classes), also defined as a “coherent perceptual-cognitive frame” (Reinert, 1993), which reflects the latent and salient discursive structure of the interviews. Statistically, the lexical worlds are clusters of co-occurring terms in the same Elementary Context Units (ECUs), which are text segments of the size of an average sentence. In terms of semiotics, the lexical worlds can be interpreted as themes, social representations, or concerns that are repeated in a convergent manner by the various interviewees. Moreover, using metadata, specific links can be identified (according to χ^2 statistics) between lexical worlds and interviewees’ characteristics (Appendix B). In our case, all data on level of education, gender, age, and occupation were chosen as hypothetical sources of discourse differentiation. This method provides complementary representation of the classes through their most informative structures, i.e. the strongest connected graph of terms without circling (Appendix B). After 30 iterations, during which we varied the analysis parameters of the Reinert method (the types of active words, the number of classes, etc.) so as to tailor them to the

characteristics of the corpus, we chose a relevant clustering solution of 7 lexical worlds[10], most of which appeared recurrently through iterations and pertained to lock-in.

In the following section, we present the structuring of the interviewees' discourse on the questions asked. We then more closely interpret each lexical world identified, going back to the interviews to interpret the lexical worlds in a relevant way and illustrate them with verbatims.

4. Results

After the detection of expressions and lemmatization, the corpus of 111 interviews includes 1095 ECUs, 39229 occurrences of 3441 different lexical forms, and 1424 forms occurring once (41.4% of all forms). An average interview contains 353 occurrences. After many iterations to identify the most relevant classification of the corpus, we have chosen parameters allowing to classify 91% of the UCEs (text segments). This classification is considered to be a very good classification rate. Each of these classes has a number automatically attributed and is labelled according to its most associated terms (according to χ^2).

The results are discussed by groups of lexical worlds. Two classes stand out particularly (Fig. 2): Class 7 labelled the "*indispensable recourse to chemicals to combat pests*" and Class 1 the "*treadmill of hybrid seeds*", while the other classes are grouped into two subsets: one we entitled "*pesticides between rationalization and poison*" (Class 5 and 4), the others concerned the "*structural conditions of the lock-in*" (classes 2, 3, and 6).

[10] The final parameters are: types of words included (adjectives, supplementary adjectives, adverbs, supplementary adverbs, nouns, supplementary nouns, verbs and supplementary verbs); type of analysis: simple on text segments; maximum number of forms: 3000; number of final clusters of step 1: 10 class; minimum number of text segments per class: 70.

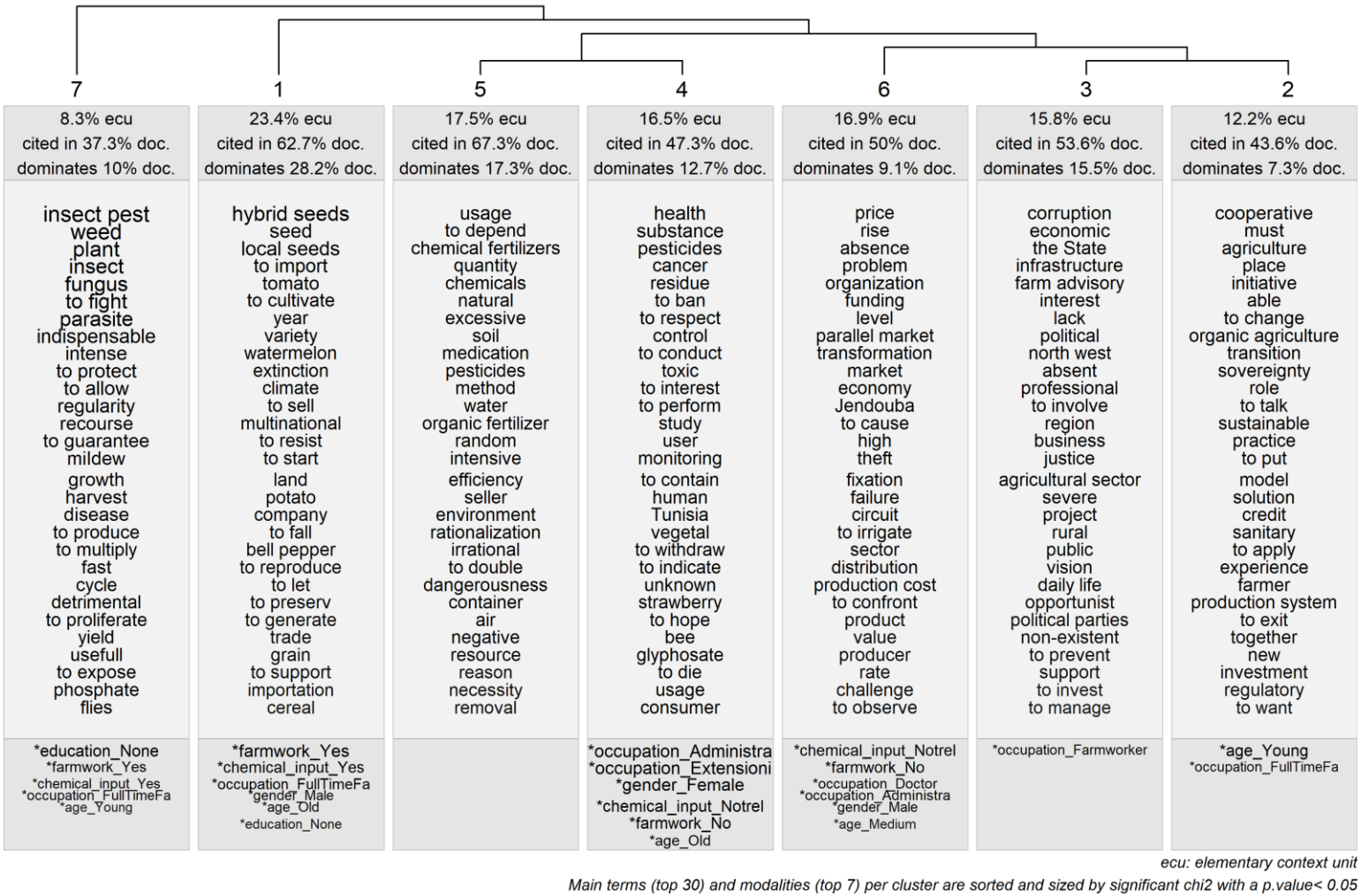


Figure. 2 : Lexical worlds emerging from actor interviews obtained with the Simple Reinert method on text segments and their main features

Class 7: The indispensable recourse to chemicals to combat pests

This class, representing 8.3 % of classified UCEs, cited in 37% of interviews and dominating 10% of them (fig. 2), is centered on the unavoidability of chemical inputs to combat pests and to ensure good yields, both in quantity and quality. This class is specifically linked to interviewees working on the *farm* (χ^2=9.14), particularly full-time farmers (χ^2=6.59), chemical input users (χ^2=6.95) and unskilled workers (χ^2=17.8)[11]. Table 2 details some features of practices according to farm worker interviewees (n=96), who are largely pesticide-reliant (89%), with only 7 declaring organic practices[12].

Table2. Characteristics of farm worker interviewees

Characteristic	N = 96[1]
Is s.he farm manager?	93 (97%)
Does s.he use chemical inputs (pesticides and fertilizers)?	
no	7 (7.3%)
noanswer	4 (4.2%)
yes	85 (89%)
What kind of irrigation does s.he use?	
mix	20 (21%)
noanswer	13 (14%)
rainfed	9 (9.4%)
yes	54 (56%)
What is the farm size?	
big	2 (2.1%)
medium	8 (8.3%)
noanswer	6 (6.2%)
small	80 (83%)
Is the production specialized or diversified?	
diversified	54 (56%)
noanswer	15 (16%)
specialized	27 (28%)

[1] n (%)

Interviewees linked to this class highlight the proliferation of *insects* (χ^2=239.25), *weeds* (χ^2=214) or *fungi* (χ^2=174) that threaten crops. As well as in Mhadhbi et al (2018) study, according to our survey results, 20 farmers reported using commercial pesticides, mainly fungicides , herbicides and insecticides , this use is due to the climatic nature of the explored area, which is a humid area, where fungal diseases (rust and mildew) develop easily, hence the intensive use of fungicides by the

[11] Words in italics are specific to the class and the χ^2values provided are statistically significant with a p-value <0,0001.

[12] The term 'organic', in Arabic عضوي ", corresponds in their discourse to certified practices and also traditional practices without pesticides.

farmers.The survey also revealed heavy use of herbicides to control weeds that compete with crops for access to water, light and soil nutrients. For instance, a farmer (id=93) notes: « *the intense recourse to pesticide allows me to fight the plant deseases, especially fungii, weeds, and insects pests and to grant a production* ».

This class mainly reflects the farmers' strong conviction that pesticides are "*indispensable*" (χ^2=124). They focus on the visible direct effectiveness of pesticides in meeting the subsistence requirements of a population in need. Thus, according to most farmers surveyed, the intensive system is a satisfactory way to improve their living conditions: "*Thanks to this model, I earn a good living and I don't want to change production systems*" (farmer, id=28). However, the few female farm laborers describe the deprivation that constrains them to accept risky work conditions. Some farmers are also critical: *"I'm trapped in this model of agriculture, either I use these toxic products or I starve"* (young educated farmer, id=12). Only seven intensive farmers appear open to change, but they consider there is no credible alternative so far: "*without fertilizer, it's not possible to get good yields (…) Harvests depend more and more on using great quantities of pesticides (…) I can't stop using these [chemical] inputs as long as there is no alternative*" (farmer, tertiary education, medium age, id=95).

Class 1: The treadmill of hybrid seeds

This class concerns the treadmill effect associated with the forced use of hybrid seeds and the correlated limited use of local seeds. This is an important topic for interviewees (23% of UCEs, cited in 63% and dominating 28% of interviews). This class is linked to farmers (χ^2=22), from medium farms (χ^2=312) and pesticide users (χ^2=15). The interviewees focus on Tunisian agricultural policies since independence, which have promoted a technological system based on the hybrid seed/pesticide combination reinforced by public *incentives* (χ^2=73.46). They deplore the many consequences of this public choice, ie the treadmill effect involving multiple dependencies:

- First, the farmers' dependence on corporate seed suppliers: "*the Tunisian agricultural administrations don't see any danger in seed procurement, their laws promote domination by multinationals*" (farmer, tertiary education, also extensionist, pesticide user, id=34).
- Second, the increasing dependence on technical solutions due to use of hybrid seeds, as a consequence of the inability of hybrid seeds to *resist* (χ^2=25) local agroecological conditions (*climate* χ^2=32; *drought* χ^2=15): "*these hybrid seeds, produced by the same multinationals, do not reproduce and are not adapted to our climate, these seeds are fragile, and can't withstand climate variations*" (farmer, id=15). As a consequence, many farmers (n=22) talk of a co-dependence between hybrid seeds and other technologies (pesticides, irrigation, fertilization), i.e. their use of hybrid varieties not adapted to local conditions forces them to employ significant amounts of pesticides : "*I have no choice, I'm forced to buy pesticides, without them my crop would not survive*

(…), I use hybrid seeds, which do not reproduce and are not always adapted to a different climate" (farmer, old, primary education, pesticide user, id=32).

According to most interviewees, this State policy of hybrid seeds has resulted in the *extinction* (χ^2= 33.92) of local seed varieties, which interviewees link to the issue of the peasantry and national sovereignty: *"the system of intensification is nothing more than a rope around the neck of peasants losing their independence and turning them into customers of foreign monopolies selling poisons and hybrid seeds*" (farmer and teacher, pesticide user, id=2). The national dimension associated with the seeds is expressed through the many oppositions contained in seed descriptions: *local, autochthonous, peasant or indigenous* seeds against *enhanced, modified, industrial, imported, foreign* seeds.

Classes 5 and 4: Pesticides between rationalization and poison

These classes share common features concerning pesticides but approach them from different angles. Class 5 focuses on the conditions of pesticide utilization, whereas Class 4 addresses the associated health risks and their management. The profiles of the interviewees describing these themes are very different. While Class 5 is not associated with any particular profile, Class 4 differs from all the other classes in being statistically associated with elderly interviewees, women, farmworkers, people with tertiary education, and non-farmers, especially from the administration.

Class 5: Rationality and irrationality in pesticide utilization

This class represents 17.5 % of UCEs, cited in 67% of interviews and dominating 17.3% of them. It focuses on the issue of *pesticides* (χ^2=30.6), *chemical fertilizers* (χ^2=45) or *chemical inputs* (χ^2=42.5) and their *usage* (χ^2= 78) and *application methods* (χ^2=28), particularly in describing the conditions of a *rational* or *irrational* (χ^2=21) use of pesticides. Arguments can also be found in this class for pesticide *efficiency* (χ^2=24), productivity, and their *necessity* (χ^2=16.5) for farmers (also put forward in Class 7). It shares a concern about dependence (*to depend* χ^2=53) on chemical inputs with Class 1 on hybrid seeds. In this class, some interviewees argue the possibility of an *efficient* (χ^2=24.03) use of pesticides and the way to promote it. Pesticides are thus positively described under a medical metaphor: "*agronomists follow protocols like doctors, the sicker you are, the more you need medication*" (old farmer & extensionist, primary education, pesticide user, id=88). But other interviewees advocate the need for *rationalization* (χ^2=21.38) while describing *excessive* (χ^2=36.42), *intensive* (χ^2=25.05), *alarming* (χ^2=16.02) pesticide uses and the *danger* (χ^2=21,38) of such situations, particularly for the *soil* (χ^2=36) and *environment* (χ^2=22). They give multiple *reasons* for these detrimental situations:

- lack of *information* (χ^2=15.5) and training on products, on their *quantity* (χ^2=46) or conditions of use: "*some farmers ignore the recommendations for use, or don't respect the*

dose, the mode, or the frequency of application provided by the supplier" (extensionist, Id=9). Indeed, during the interviews, most farmers were not able to provide the names of the substances used to treat the field crops grown.

- lack of waste management, invoking personal and collective responsibility: "*the irrational use of pesticides and the random dumping of waste, containers and empty cans, in the complete absence of a clear disposal strategy (...) after emptying the chemicals into the sprinkler, the farmer throws empty containers and plastic boxes into the countryside next to the cattle and birds grazing on his farm.*" (id=71, secondary education, pesticide user).
- the responsibility of other actors in the sector, the *sellers* (χ^2=22), the agricultural *supervision* system (χ^2=6), in the "irrational" use of pesticides. Only one interviewee cited extensionist extension agents as sources of information on pest management, whereas 12/85 pesticide users explicitly cited vendors as a source of information and guidance.

Class 4: Health risk regulation - awareness and failures

This class concerns 16.5% of UCEs, mentioned in 47.3% of interviews and dominating 12.7% of them, and consists mainly of people from the administration (χ^2=24), extension (χ^2=22.5), women (χ^2=22), non-farmers (χ^2=20), or tertiary-educated people (χ^2=17). People with these profiles particularly expressed their awareness of health as well as the environmental risks of pesticides. This contrasts sharply with the farmers, who had less to say on the subject, even though they are in direct contact with these substances. The words most specific to this class concern the semantic field of *health* (χ^2=101), diseases (e.g. *cancer* χ^2=51; *harmful* χ^2=86, *toxicity* χ^2=17) and death (*to die* χ^2=22.27), as well as chemicals: *pesticides* (χ^2=63.69), *substance* (χ^2=84.73), *residue* (χ^2=50.42). The class also mentions terms related to regulation and management of risk - *prohibit* (χ^2=46.26), *respect* (χ^2=39.16), *control* (χ^2=53.33), *or contain* (χ^2=26.84) – as well as *monitoring* (χ^2=22.84) and *study* (χ^2=28.28). It also tackles these issues from producers (*users* χ^2=86) to consumers (χ^2=22), as well as the environment (e.g. bees χ^2=23). These interviewees generally recognize a link between pesticides and cancer. For instance, the 3 female farmworkers interviewed mentioned their own exposure to skin diseases, cancer, and respiratory problems due to the use of pesticides. Only one interviewee, a civil servant, explicitly contested this link (id=25). Interviewees also deplore the distortion and time gap between Tunisian and foreign regulations, the many failures of the Tunisian risk management system and the lack of market control: "*marketing and use of pesticides are out of control and open the way to the use of toxic products that are banned according to European standards but registered in our country*" (id=48, farmer). One interviewee even reported warehouses containing obsolete types of pesticides stored for forty years under inappropriate conditions (administration, id=26). At this stage, as in the previous class, many interviewees report a lack of protection and training of pesticide users as well as a lack of monitoring and control.

Classes 6, 3, and 2: The structural conditions of lock-in

This group of classes share some structural and institutional factors affecting farming conditions in the region and opportunities for change. The profiles associated with each of these classes are slightly different. Class 6, concerning the economics of agricultural markets, is relatively more related to younger people (χ^2=11), not working on a farm (χ^2=15), particularly from the administration (χ^2=8) and a union (χ^2=27). Class 3, which concerns lack of political support for the region, is mainly associated with people working on a farm (χ^2=7) and, to a lesser extent, educated people (χ^2=5) and farmers that are not pesticide users. Finally, Class 2 on transition is mainly associated with *young people* (χ^2=17) and full-time farmers.

Class 6: Framing of formal and informal input market

This class representing 16.9% of UCEs is cited in 50% of interviews and dominates 10% of them. It focuses on markets, and more generally on the issue of economic difficulties, from market supply to marketing. First, interviewees evoke the issue of the *rise* (χ^2=50) of *input prices* (χ^2=52) and *production cost (*χ^2=19). They note their dependence on the fluctuations of international markets: "*I am highly dependent on these products, whose prices are generally subject to upward variations due to the parity of the local currency in relation to foreign currencies and increases in the price of inputs on the physical market*" (farmer, pesticide user, id=69). Thus, they point out the gaps between production costs and market value of their agricultural products, deploring the lack of State regulation: "*the rise in production costs has not been followed by a proportional increase in the selling prices of agricultural products, this being partly due to the regulatory role of the State in setting the prices of certain products"* (young teacher, tertiary education, id=66). Many interviewees complain of lack of *organization* (χ^2=39) of access to the different components of agricultural markets: "*the weak coordination between sector actors at regional and national levels as well as the absence of a system of protection, control, and certification*" (id=95, tertiary education, pesticide user). In addition, many farmers mention difficulty accessing *credit* (χ^2=38), which "*constitutes a barrier to the expansion of the sector*" (farmer, not pesticide user, tertiary education, id=38), particularly because of their "*inability to provide a personal contribution or even a joint guarantee, and the rigidity of the banking system"* (id=19), leading to a situation where "*over-indebtedness and difficult access to finance are the main problems faced by farmers*" (farmer, id=74).

Second, interviewees list the *problems* (χ^2=44), *failure* (χ^2=22) and *challenge*s (χ^2=17) of regional agriculture at each step of the value chain. Concerning the input supply market with its rising prices, interviewees (n=6), as in Class 4 on risk regulation, mention the existence of a parallel market (χ^2=33) of chemical inputs, sometimes counterfeit or obsolete:*"I can confirm that there are counterfeit chemical fertilizers coming mainly from smuggling networks between Tunisia and*

Algeria circulating on the formal Tunisian market and marketed in legal and recognized points of sale" (farmer, pesticide user, id=51).

Class 3: Weakness of political support for regional agriculture

This class, representing 18.8% of UCEs, cited by 53.6% of interviews and dominating 15.5% of them, echoes previous statements on lack of public intervention. Here too, many interviewees strongly criticize the Tunisian State (governments, authorities, administration) (χ^2=46), local politicians, and their role in regional agriculture. This is particularly expressed through the use of many negative words, e.g. *corruption* (χ^2=61), *never* (χ^2=37), *lack* (χ^2=34), *not* (χ^2=22.5), *absent* (χ^2=30), *severe* (χ^2=23). Through these words, interviewees express their disappointment with and feeling of abandonment by the Tunisian State and its local representatives, who are said to be "*completely absent*" (id=6, 19 63, 30), *non-existent* (id=19), *incapable* (id=17, 55, 63), *incompetent* (id=19, 38, 103), *weak* (id=38), *indifferent* (id=36), *careless* (id=38) or *corrupt* (id=55). Some farmers feel they are considered as second-class citizens (id=12, 36). Without rejecting the State itself, they expect more efficient public action (id=65, 84, 107): "*regional and national authorities need to find urgent solutions to those old structural problems*" (farmer, id=30). But, for the moment, interviewees highlight a crisis of confidence between farmers and the State: "*this mistrust in the State is due to the lack of guidance, support, and encouragement*" (id=80, farmer). The argument of State weakness, already put forward in Class 4, crops up again: for instance, "*to know which product to buy, I rely on the pesticide seller or sometimes I ask the neighbors for advice, these State representatives are completely absent, they never come!*" (old farmer, secondary education, pesticide user, id=6).

This situation is partly attributed to regional politics characterized by "*conflicts of interest between political parties (…) a lack of communication and opportunist behaviors, which hinders dialogue on the issue of agricultural development in terms of basic infrastructures*" (farmer, old, secondary education, id=78). A farmer explains: "*this is not a problem of organization but rather a lack of vision and autonomy of the current government (…) [which] represents an extension of the previous regime in terms of continued looting of public funds*" (farmer, education secondary education, id=44). More precisely, many interviewees (n=25) evoke the *corruption* (χ^2=61) involving State representatives, and "*maintained by lobbies from each sector*" (farmer, id=84): "*the priority I see for this period is to fight the administrative corruption that permeates the pillars of the State, post-revolution governments have deepened this phenomenon; there is almost no economic sector or aspect of the daily life of the Tunisian citizen that is not affected by many forms of corruption*" (farmer, pesticide user, id=48). For instance, this statement by a farmer, also an extensionist (id=11): "*subsidies for intensification were preferentially attributed to people affiliated to the State*

system" thereby leading to the "*monopolization and privatization of marketing channels by people who take advantage of the system*" (farmer and teacher, tertiary education, pesticide user, id=2)".

In this context, many farmers consider that small-scale farmers are particularly harmed by policies: "*the State supports large farmers with loans, subsidies, and seeds while excluding small farmers*" (farmer, secondary education, pesticide user, id=42). This *"policy of exclusion reflects the lack of harmony between State institutions, and a lack of knowledge of rural realities, particularly the problems of small farmers*" (old farmer, no education, pesticide user, id=100).

Class 2: Proposals for transition

This class is evoked least, representing 12% of UCE, cited in 43.6% of interviews and dominating 7.3 of them. As it concerns what should be done to change the agricultural system in the region, the significant terms are related to prescription, will or action: *should* (χ^2=53), *to want* (χ^2=16), *to will* (χ^2=9) -, *change* (χ^2=40 for the verb and *12* for the noun), *initiative* (χ^2=49), *transition* (χ^2=36), *solution* (χ^2=25), *to exit* (χ^2=19). These interviewees, especially the young ones (χ^2=16.74), identify both solutions and constraints for change: *investment* (χ^2=18), *support,* and *encouragement* (χ^2=3.07) from the State through infrastructure, organization, and advice. For now, the majority of interviewees do not envisage any alternative production system, but rather see room for improvement either in adjusting chemical input use, or in better political and material support for agriculture: *"the political situation must be stabilized and a real balance must be found to restore confidence in the State and put an end to corruption, implement an incentive and regulatory policy, and make investments in infrastructure*" (young farmer, tertiary education, pesticide user, id=12). Two change options are nevertheless more specifically detailed by interviewees:

- Cooperation (11 interviewees), sometimes mentioning foreign experiences (France, Morocco, or Italy): "*farmers are able to change their practices toward more ecofriendly systems, and even ensure social cohesion, the solution to save Tunisian agriculture is to create cooperatives"* (farmer & union, secondary education, pesticide user, id=50). However, the cooperation option is often cited negatively: "*the State wants to revive collectivism, the country of thieves and corrupt people wants to strip us of our goods (…), it's a new Ben Saleh!*" (the minister in charge of cooperative policy in the 1960s, remembered bitterly by many peasants) (old farmer, id=44).
- Conversion of the production system (29 interviewees) into *permaculture* (n=2), *sustainable agriculture* (=1), *agroecology* (n=3), *biological control* (n=2), or *organic farming* (χ^2=37, n=21including 7 organic farmers).

Organic farming (OF) is mentioned in our questions, and although only 7 interviewees are organic farmers, this appears to be the most promising, while not consensual, model for transition (OF refers to certified practices as well as traditional ones). Interviewed organic farmers mention their multiple conversion motivations, e.g. awareness of pesticide danger as well as using OF in response to a

financial crisis (id=88), or to health problems (id=91). *More interestingly from a lock-in perspective,* interviewees also mention their perceived, sometimes experienced, barriers to conversion. For conventional farmers, one barrier is the time and the effort or sacrifices required (young farmer, pesticide user, id=47). Moreover, as expected, they appear to be risk-averse: for an old conventional farmer (secondary education, id=22) *"abandoning chemical fertilizers can lead to a significant drop in yields and a poorly diversified rotation increases the presence of disease (…) since herbicides are banned in organic farming, the farmer is forced to increase the workforce for weeding".* Moreover, "*the transition to organic is possible for large farmers, but not for small ones who are not able to diversify their farm*" (id=76, pesticide user). A member of the board of the Union of Organic Farmers (id=66) highlights the many institutional obstacles to conversion: "*the criteria in the specifications are so fierce that sometimes farmers spend two or three years looking for a plot of land with water and a clean neighborhood*". Many interviewees, as for regional agriculture in general (as in Class 3), cite structural obstacles to the organic sector that are primarily related to market organization and certification. Despite the promising prospects of the sector, they note numerous marketing problems due to "*lack of coordination between sector actors at local and national level* (…) *there is a need to widen the distribution channels for organic products on foreign and national markets, but the labelling process faces several constraints, in particular the low level of organization of producers*" (id=66). Indeed, "*the export prospects are very narrow due to the difficulty of accessing markets that want organic products and the strict specifications imposed by the markets*" (id=66). *Moreove*r, "*obtaining approval from the European Specifications Bureau is expensive, which explains the reluctance of farmers to turn to this type of activity*", whereas "*the subsidies to cover the costs of certification for five years have been abolished for budgetary reasons, now it's up to the farmer to pay and it's a huge obstacle*" (id=66).

A reliable and accessible certification and control system is also a priority (47,66, 75) to "*ensure product traceability and the rise in production value chains that will strengthen the positioning of national production on international markets*" (id=75, farmer, pesticide user). To remove these obstacles, in addition to the structuring of producers into cooperatives, the interviewees would like the State to provide conversion subsidies (id=37,66), "*an incentivizing regulatory framework*" (id=47, young farmer, pesticide user), as well as information and training to encourage people to convert to organic production and consumption (id=66, 82, 37, 9,87,109). Thus, interviewees believe that transition faces the challenges of ensuring a coherent and efficient State, the disappearance of corruption and the self-organization of farmer's cooperatives.

5. Discussion and conclusion

Despite the positive effect of chemical inputs on yields, intensive agriculture has a negative impact on the environment, resources, and farmers' health (Rossi and Garner, 2014; Sumberg et al., 2013; Temple, 2015). However, in our setting, this agriculture seems to be supported by both public policies and most farmers' practices (85% of farmers use chemical inputs and hybrid seeds). Although decades of studies have analyzed resistance to change in agricultural systems in developing countries (Flor et al. 2020; C. H. Wagner and , Michael Cox 2016; Flor et al. 2019), the question of which of the lock-in factors identified best explain developing country agricultural dynamics remains open. In this perspective, our analysis focuses on the salient arguments of interviewees with respect to the lock-in issue. We show that only 8% of farmers appear satisfied with their current production process and a majority express no awareness of risk, nor any will to modify their practices. Other interviewees (all the farmworkers and some farmers) are critical despite the intensive practices they are obliged to apply, as they feel they are stuck in an unsatisfactory system that merely allows them to survive, consistent with previous findings by Hu (2020) for instance. The table below summarizes the barriers and levers mentioned in interviews, identifying those capable of affecting individual and regional agricultural systems and their ability to change (table 3).

Table 3. Synthesis of the discourse analysis organized by types of factors affecting opportunities for change

Drivers	Barriers to change	levers for change
Technical	- Hybrid seeds and pesticide treadmill ++ - Lack of knowledge on alternatives - Farm size	- Inappropriacy of seeds for local agroecological conditions - Seeds as vectors of disease
Behavioral	- Chemical inputs are required to ensure yield and revenue ++ - The need for subsistence leads people to accept "poor working conditions" - limited information on pesticide use and awareness of health or environmental risk among users -Short-term thinking - Individualism - Lack of access to credit	- Rising cost of inputs, but what about comparative cost of conventional and agroecological methods? - Increased information on risks - Increased information on alternatives
Collective/territorial	- Local politics - Lack of investment in productive infrastructure (irrigation, transformation units, etc.) - Land availability - Rural exodus and old population - Lack of value chain organization - Bad experience of previous cooperativism - Demand for organic products is limited to elite urban population	- Invest in, develop, and coordinate the agricultural sector in general, and organic supply chains in particular - Favor cooperatives - Widen distribution channels and develop demand for organic products, on export and domestic markets
Institutional	- Failure of State: no political vision for agriculture, no effective control, dependence on international market, corruption - A regulatory framework impeding change (e.g. seed regulation) - Competition between formal institutions (e.g. pesticide control) and informal institutions (parallel market for forbidden or altered products)	- Fight corruption - Enhance pesticide control and information on pesticides - Support extension services, education of farmers - Better organization of agricultural sector - Grant a robust certification system - Lower certification costs

Some of the factors identified are well-documented in the literature. A prominent issue for interviewees was the technological treadmill and technological dependency (class 1) between hybrid seeds, pesticide use and farmer dependence (see Luna, 2020 for another example), threatening climate adaptation, together with their aversion to the risk of loss of production or income in the short term (Chèze, David, and Martinet 2020). Other interviewees mentioned a lack or asymmetry of information (class 2) on pesticide use and risks or on alternative practices and their efficiency. As shown by Flor et al. (2020) or Hu (2020), this indicates unbalanced relations between farmers, extension agents, the administration, and input suppliers, particularly due to the weakened position of the State. It should also be noted that not all pesticide vendors receive formal training on pesticides or alternative technologies, and therefore also depend on information provided by pesticide companies and technicians (Norton et al., 2015). Our findings thus confirm that the lock-in situation is strongly related to cognitive aspectsdue to the low level of knowledge about the

environmental and health effects of excessive pesticide use, coupled with a low level of education, reinforced by the socio-cultural environment (neighborhood effect, farming advice, personal experiences, etc.), makes it more difficult for farmers to change their behavior (Khan et al, 2015; Ntow et al, 2006; Stadlinger et al, 2011), especially since sustainable alternatives are knowledge intensive (J. L. Wagner et al. 2016) and require retraining of farmers (Hu 2020). A transition thus requires investments in knowledge dissemination and training for all actors, from farmers to consumers.In addition, our analysis reveals some undocumented and Global-South-oriented factors, particularly concerning institutional issues in regulating individual behaviors and the agriculture sector and its transitions. A factor little considered in the literature on the transition to sustainability is the role of informal institutions (Hansen,et al.,2018; Ramos-mejía et al., 2018). According to Helmke and Levitsky (2004), institutions are "rules and procedures (both formal and informal) that structure social interaction by constraining and enabling actors' behavior"–*including illegal forms like corruption, clientelism,…- which can become stronger drivers of behaviors than formal ones*. In our case, the weakness of formal institutions is strongly evoked by interviewees. The State appears to fail in the support to agriculture and regional development, in terms of subsidies (class 6), infrastructure investment (class 3), and extension and training capacities, as well as in the regulation of pesticides (class 4 and 5). Moreover, they note the strength of informal institutions, such as corruption, in the attribution of loans, smuggling, and parallel markets for inputs. Corruption is a worldwide and multifaceted phenomenon. In developing countries, van den Bersselaar and Decker (2011) show that it emerged historically as a response to colonial systems which super-imposed an institutional system on an existing and often conflicting one, even after decolonization. In Tunisia, "*the newly emerging "democratic" institutions struggle to establish themselves, while the informal practices of political clientelism prove exceptionally resilient*" (Paquin 2020). Corruption stems from the structural weakness of formal institutions and affects human capital development (Mtiraoui, 2014). It is associated with the growth of social and regional disparities characterizing development dynamics based on liberalization and export-oriented strategies (Gana, 2012). In Tunisia, the privatization of marketing and supply channels contributed to the emergence of parallel markets (Gana 2008). Corruption is a factor in pesticide overuse (Marcoux and Urpelainen 2011; Van Hoi, Mol, and Oosterveer 2013), agricultural productivity (Ahmed and Michael 2010), and environmental performance (Wang et al. 2020). Counterfeit chemical inputs, mainly obtained from smuggling networks between Tunisia and Algeria, circulate on the official Tunisian market and are marketed through legal outlets (with false packaging and labelling indicating that these pesticides comply with national and international standards). In the post-Revolution era, rural outmigration and non-farm employment opportunities have been declining. Small farms have thus become survival spaces for jobless household members, who increasingly need to access chemical inputs cheaply.

This situation, combined with ill-functioning institutions, is a loose scenario for sustainability transitions (Ramos-mejía, Franco-garcia, and Jauregui-becker 2018). According to the MLP model, transitions are mainly induced by innovative niches able to influence the dominant socio-technical regime (Elzen et al. 2011). Thus, in a situation with corruption or "informal insecurity", niches lack protection from formal institutions and at the same time suffer from limited social trust and actor capacities (Ramos-mejía, Franco-garcia, and Jauregui-becker 2018). For instance, OF, mentioned as being of interest by interviewees, strongly depends on stakeholder trust in a State-granted control and certification system created to resolve information asymmetries on the quality of products and justifying their price premium. Currently, the organic sector, although promising, still suffers from a lack of public support and structure, and is undervalued on the domestic market, particularly among rural and lower class people (Callieris, Brahim, and Roma 2016; Blaise and Sbouai 2105). Moreover, official representatives are somewhat disconnected from this population's needs and realities (outmigration, poverty), in spite of the demands of the 2011 revolution (Gana, 2016). The political system is rigid in its functioning and its aims, with, for instance, the perpetuation of shortsighted policies in support of intensification and exportation. Any public decisions pursuing virtuous aims that may run counter to the dominant private interests have little chance of success.

Another undocumented developing country factor is the particular historically-determined conditions of implementation of collective solutions. In our survey, there is a sharp divide between interviewees who support cooperatives as a solution to the lack of coordination in the local agricultural sector and interviewees who are opposed to them. Our survey reveals an original and salient lock-in factor in institutional path dependency concerning the State or collective action. First, there is the remembered trauma of past cooperative experiences, which are considered rigid and authoritarian and contribute to "particular collective imaginaries" (Yousfi 2019). More recently, the experience of collective action has been mixed. Only a few grassroots experiments have taken place in Tunisia. The Jemna oasis is an emblematic exception where institutional entrepreneurs try to frame commons logic as an alternative between market and State. This also enables the extent of opposition to cooperativism to be measured (Ben-Slimane et al , 2020). There is thus work to be done on the development of new forms of cooperation between actors. The revolution provided a forum for demands, but translating them into action is taking time.

To conclude, as noted by Yousfi (2019), agricultural transformation in the developing country will require taking into account the cultural framework structuring the relations between individuals and institutions, rather than applying standard recipes for reform. Our study highlights the need for further global governance change, to strengthen or create supporting institutions and enhance social trust, on two major issues: corruption and society's attitude toward collective solutions. This is consistent with recent work considering corruption as a collective action problem (Carson and Prado 2016; Tacconi and Aled Williams 2020). In addition, collective actions are often advanced

as facilitators of sustainable transition, either in general (Bebbington 1996; Chiffoleau 2005; Emery, Forney, and Wynne-Jones 2017; Pretty 2003; Warner 2006) or via specific forms such as Campesino-a-Campesino (Holt-Gimenez 2001), Farmer Field School (Waddington et al. 2014), or Cooperatives (De Herde, Baret, and Maréchal 2020; Lucas et al. 2018), providing some cost, risk, and resource-sharing capabilities (material, labor, knowledge, moral support, reputation).

Appendix A. The interview guide and variables

Variable name	Description	Categories
Age	Category of respondent age	Young [<45], adult [45-59], old [>59]
Education	Education level of respondent	none; primary; secondary, tertiary
Gender	Gender of respondent	Male; female
Occupation	Main professional occupation	Full-time farmer, agricultural worker, extensionist, administration, doctor, teacher, union member
Chemical input	Use of chemical inputs (synthetic pesticides and chemical fertilizers)	No; yes
State		Absent, frequent
Productive specialization		Specialized; Diversified
Market	Market, Low storage capacity in silos in the area, processing units	Limited

Open-ended questions

1- What do you think about agricultural intensification and the use of chemical inputs?
2- Are you thinking of stopping the use of chemical inputs and moving toward environmentally- and health-friendly practices?
3- How do you assess the issue of chemical input residues in agricultural products and the effect of these inputs on the environment and human health?
4- What are the main issues affecting farmers specifically and the region in general and what are the solutions?
5- Cooperation with local actors: what do you think of agricultural cooperatives?
6- What are the reasons that prevent you from joining these collective structures?
7- What problems do you face?

Appendix B. Methodological details on Iramuteq methods

The Reinert method is used to identify lexical worlds which corresponds to clusters of terms frequently co-occurring and semantically coherent. While some methods approximate terms or textual segments according to rules (e.g. grammatical) or according to an a priori defined meaning (e.g. by means of dictionaries), the Reinert method starts from the well-known postulate: "You shall know a word by the company it keeps" (Firth 1957), i.e. the meaning can be captured from the association of words co-occurring in the same context of enunciation.

Following data collection, the corpus of transcribed interviews is cleaned and entered into Iramuteq. Then, each interview is partitioned into text segments (Elementary Context Units, ECUs) of several consecutive words – generally marked off by punctuation – that should contain almost 40 words, corresponding to the average size of a sentence, i.e. the functional unit of meaning when reading a text.

Iramuteq operates additional editing. First, it replaces all terms by their canonical form (lemmatization step): plural by singular, verbal forms by the infinitive, elided words by corresponding non-elided words. The lemmatization is driven by a dictionary, fed and adjusted by the analyst. A dictionary of multi-word expressions is compiled to increase semantic specificity (here, for example, we identified terms like "organic farming" – see Appendix C for details). Then, the software identifies terms either as "active forms" (i.e. full content words like nouns, verbs, adjectives, adverbs) or as "supplementary forms" (i.e. function words such as prepositions, articles, pronouns), the former being considered first in the analyses.

After these operations, the software builds a matrix composed of active words and text segments. This matrix is decomposed using a descending hierarchical classification method, which is an iterative procedure, the supplementary forms being reprojected after the analysis. The metadata are taken into account after analysis of the ECU-term matrix; using chi2, the "lexical worlds" can thus be statistically linked to the sociographic characteristics of interviewees.

Appendix C. Encoded multi-term expressions and synonyms (source : authors)

Aliases of form	Encoded translated form
produits phytosanitaires|traitements chimiques|traitement chimique|produits_phytosanitaires|produit phytosanitaire|produits phyto|produits phytopharmaceutiques | traitements phytosanitaires|traitement phytosanitaires|traitement phytosanitaire|phytosanitaires|produits phytos	Pesticides
pesticides|pesticide	Pesticides
produits chimiques|produit chimique|produits chimique|produit chimiques|substances chimiques	chemical products
intrants chimiques|intrant chimique	chemical inputs
produit agricole|produits agricoles	agricultural products
insectes ravageurs|ravageurs	insect pest
engrais chimiques|engrais chimique|engrais minéral	chemical fertilizer
engrais organiques|engrais organique|amendement organique|amendements organiques|compost|matières organiques	organic fertilizer
semences importées|semences améliorées|variétés améliorées|semences modifiées|semences hybrides|semences étrangères|semences industrielles|semences importées	hybrid seeds
semences locales|semences tunisiennes|semences nationales|semences classiques|semences authentiques|semences locaux|semence locale|variété autochtone|variétés autochtones|variétés locales|semences paysannes|variétés paysannes|semences indigènes	local seeds
sécurité alimentaire	Food security
petits agriculteurs|petits paysans|petit paysan	small farmers
conditions climatiques	climatic conditions
secteur agricole	agricultural sector
ministère de l'Agriculture	ministry of agriculture
développement agricole	agricultural development
changement climatique|changements climatiques|dérèglement climatique	climate change
main d'oeuvre|main-d'oeuvre|main d'œuvre|main d'œuvre	labour force
Ben Ali|Ben ali	Ben Ali
Commissariat régional de développement agricole (CRDA)|Commissariat régional de développement agricole|CRDA	Agricultural Development Commission
culture biologique|production "bio"|production biologique|production bio|agriculture biologique|au bio|mode biologique|production biologique|agriculture bio|système biologique|le bio| en bio| du bio	organic agriculture
Programme alimentaire mondial|Programme alimentaire mondiale|Programme d'aide alimentaire mondial|Programme d'Aide Alimentaire Mondial	World Food Programme
cahier des charges|cahiers des charges	specification
Fonds monétaire international|FMI	International monetary Fund
marché parallèle|marché noir|marché illégal|commerce parallèle|circuit informel|circuit parallèle	parallel market
Organisme Génétiquement Modifié|OGM|Organismes Génétiquement Modifiés|génétiquement modifié|génétiquement modifiés|génétiquement modifiées|plantes génétiquement modifiées	GMO
mauvaises herbes|herbes parasites|mauvaise herbes	Weed
effets secondaires	Secondary effects
perturbateurs endocriniens|perturbateur endocrinien	endocrine disruptor
coûts de production|coût de production|couts de production|couts de productions|coût de la production	production cost

points de vente|point de vente	point_of sale
agriculture intensive|agriculture conventionnelle	intensive agriculture
dépendance alimentaire	Food dependence
couverture sociale|protection sociale	social protection
produits biologiques|produit biologique|produits bio|produit bio	Organic products
consommation bio|consommation du bio|consommation biologique	Organic consumption
unités de transformation	Processing units
Ressources hydrauliques|Ressources en eau|Ressource hydraulique|eau	Water
zones rurales|monde rural|société rurale	rural society
activité agricole|agriculture	Agriculture
système nerveux	nervous system
équipements de protection|équipement de protection|combinaison de protection|équipements de protection individuelle (EPI)	protective_equipment
normes européennes|norme européenne|réglementation européenne|réglementations européennes	European norms
Union européenne|Europe|parlement européen	Europe
Nations Unies|ONU|Nations-Unies	United Nations
CMR|cancérogènes, mutagènes ou toxiques pour la reproduction|mutagène|reprotoxique|CMRs	CMR
UTAP|Union des paysans|Union tunisienne de l'agriculture	UTAP
structure administrative|agences étatiques|Etat|organisations étatiques|organisation étatique|gouvernement|administration|autorités|autorité publique|bureaucratie	State
gagne-pain|le revenu	Revenue
groupements de développement agricole|groupement de développement agricole|GDA	GDA
BNA|Banque Nationale Agricole	National Agricultural Bank
ben Saleh	ben_Saleh
pays étrangers	foreign countries
DDT|Dichlorodiphényltrichloroéthane	DDT
ALECA|accord de libre-échange|accord de libre-échange complet et approfondi|Accord de libre d'échange	Free trade agreement
nappes phréatiques|nappe phréatique	Groundwater
Etats-Unis|Etats Unis	USA
classe bourgeoise	Bourgeoisie
système de production|systèmes de production|système agricole|systèmes agricoles	production system
pomme de terre|pommes de terre	Potato
conseil technique|extension agricole|vulgarisation|vulgarisation agricole|vulgarisateur|vulgarisateurs|conseil agricole|conseiller agricole|conseillers agricoles	agricultural advisors
ouvriers|travailleurs|ouvrières|travailleuses|ouvrier|travailleur	Workman
partis politiques|parti_politique	political party
conditions de travail	Working conditions
conditions de vie	Living conditions

6. Reference

Adnan, N., Nordin, S., Ari, M., Hussen, A., 2019. Trends in Food Science & Technology A state-of-the-art review on facilitating sustainable agriculture through green fertilizer technology adoption : Assessing farmers behavior. Trends Food Sci. Technol. 86, 439–452. https://doi.org/10.1016/j.tifs.2019.02.040

Aguilera, E., Díaz-gaona, C., García-laureano, R., Reyes-palomo, C., Guzmán, G.I., Ortolani, L., Sánchez-rodríguez, M., Rodríguez-estévez, V., 2020. Agroecology for adaptation to climate change and resource depletion in the Mediterranean region . A review. Agric. Syst. 181, 102809. https://doi.org/10.1016/j.agsy.2020.102809

Ahmed, N., Michael, P., 2010. Analysing agricultural productivity growth in a framework of institutional quality.

AJZEN, I., 1991. The Theory of Planned Behavior. Organ. Behav. Hum. Decis. Process. 50, 179–211.

Altieri, M.A., 2009. Agroecology, Small Farms, and Food Sovereignty. Mon. Rev. 61, 102–113. https://doi.org/10.14452/MR-061-03-2009-07_8

Arthur, W.B., 1989. Competing Technologies, Increasing Returns, and Lock-In by Historical Events. Econ. J. 99, 116. https://doi.org/10.2307/2234208

Avelino, F., Wittmayer, J.M., 2016. Shifting power relations in sustainability transitions: A multi-actor perspective. J. Environ. Policy Plan. 18, 628–649. https://doi.org/10.1080/1523908X.2015.1112259

Ayeb.H et Bush.R, 2019. Food Insecurity and Revolution in the Middle East and North Africa.

Bakker, L., Sok, J., Werf, W. Van Der, Bianchi, F.J.J.A., 2021. Kicking the Habit : What Makes and Breaks Farmers ' Intentions to Reduce Pesticide Use ? Ecol. Econ. 180, 106868. https://doi.org/10.1016/j.ecolecon.2020.106868

Bakker, L., Werf, W. van der, Tittonell, P., Wyckhuys, K.A.G., Bianchi, F.J.J.A., 2020. Neonicotinoids in global agriculture: Evidence for a new pesticide treadmill? Ecol. Soc. 25, 1–22. https://doi.org/10.5751/es-11814-250326

Bebbington, A., 1996. Organizations and Intensifications : Campesino Federations , Rural Livelihoods and Agricultural Technology in the Andes and Amazonia. World Dev. 24, 1161–1177. https://doi.org/10.1016/0305-750X(96)00028-9

Ben-Slimane et al, 2020. Institutional Entrepreneurship in a Contested Commons : Insights from

Struggles Over the Oasis of Jemna in Tunisia. J. Bus. Ethics 166, 673–690. https://doi.org/10.1007/s10551-020-04601-6

Benoit, M., Tchamitchian, M., Penvern, S., Savini, I., Bellon, S., 2017. Potentialités, questionnements et besoins de recherche de l'Agriculture Biologique face aux enjeux sociétaux. Économie Rural. Rev. française d'économie Sociol. Rural. 49–69. https://doi.org/10.4000/economierurale.5287

Blaise and Sbouai, 2105. Organic food in Tunisia: A sector with great potential struggles to take off.

Burton, R.J.F., 2014. The influence of farmer demographic characteristics a review. J. Environ. Manage. 135, 19–26.

Callieris, R., Brahim, S., Roma, R., 2016. Organic agriculture in Tunisia 53–62.

Carson, L.D., Prado, M.M., 2016. Using institutional multiplicity to address corruption as a collective action problem: Lessons from the Brazilian case. Q. Rev. Econ. Financ. 62, 56–65. https://doi.org/10.1016/j.qref.2016.07.009

Chebbi, H.E., Khechimi, W., 2019. Rapport de synthèse sur l'agriculture en Tunisie. [Rapport de recherche] CIHEAM-IAMM.

Chèze, B., David, M., Martinet, V., 2020. Understanding farmers ' reluctance to reduce pesticide use : A choice experiment. Ecol. Econ. 167, 106349. https://doi.org/10.1016/j.ecolecon.2019.06.004

Chiffoleau, Y., 2005. Learning about innovation through networks: The development of environment-friendly viticulture. Technovation 25, 1193–1204. https://doi.org/10.1016/j.technovation.2004.04.003

Cowan, R., Gunby, P., 1996. Sprayed to Death: Path Dependence, Lock-in and Pest Control Strategies. Econ. J. 106, 521–542. https://doi.org/10.2307/2235561

Darnhofer, I., Gibbon, D., Dedieu, B., 2012. Farming systems research into the 21st century: The new dynamic. Farming Syst. Res. into 21st Century New Dyn. 1–490. https://doi.org/10.1007/978-94-007-4503-2

De Herde, V., Baret, P. V., Maréchal, K., 2020. Coexistence of Cooperative Models as Structural Answer to Lock-Ins in Diversification Pathways: The Case of the Walloon Dairy Sector. Front. Sustain. Food Syst. 4. https://doi.org/10.3389/fsufs.2020.584542

Debray, V., Wezel, A., Lambert-Derkimba, A., Roesch, K., Lieblein, G., Francis, C.A., 2018. Agroecological practices for climate change adaptation in semiarid and subhumid Africa.

Agroecol. Sustain. Food Syst. 43, 429–456. https://doi.org/10.1080/21683565.2018.1509166

Dedieu, F., Jouzel, J., Prete, G., Dedieu, F., Jouzel, J., Prete, G., The, I., 2015. Governing by Ignoring To cite this version : HAL Id : hal-02161788 Governing by ignoring The production and the function of. Handb. Ignorance Stud. Routledge 297-307.

Dessart, F.J., Barreiro-hurlé, J., Bavel, R. Van, 2019. Behavioural factors affecting the adoption of sustainable farming practices : a policy- oriented review 46, 417–471. https://doi.org/10.1093/erae/jbz019

Drechsler, M., Wätzold, F., 2020. Biodiversity conservation in a dynamic world may lead to ine ffi ciencies due to lock-in e ff ects and path dependence 173. https://doi.org/10.1016/j.ecolecon.2020.106652

Duru, M., Therond, O., 2014. Livestock system sustainability and resilience in intensive production zones: which form of ecological modernization? Reg. Environ. Chang. 15, 1651–1665. https://doi.org/10.1007/s10113-014-0722-9

Ecobichon, D.J., 2001. Pesticide use in developing countries 160, 27–33. https://doi.org/10.1016/S0300-483X(00)00452-2

El Bilali, H., 2019. The multi-level perspective in research on sustainability transitions in agriculture and food systems: A systematic review. Agriculture 9. https://doi.org/10.3390/agriculture9040074

Elzen, B., Geels, F.W., Leeuwis, C., Mierlo, B. Van, 2011. Normative contestation in transitions ' in the making ': Animal welfare concerns and system innovation in pig husbandry. Res. Policy 40, 263–275. https://doi.org/10.1016/j.respol.2010.09.018

Emery, S.B., Forney, J., Wynne-Jones, S., 2017. The more-than-economic dimensions of cooperation in food production. J. Rural Stud. 53, 229–235. https://doi.org/10.1016/j.jrurstud.2017.05.017

FAO, 2018. Guiding the Transition To Sustainable Food and Agricultural Systems the 10 Elements of Agroecology.

Fares M, Magrini MB, T.P., 2012. Transition agroécologique, innovation et effets de verrouillage : le rôle de la structure organisationnelle des filières. Le cas de la filière blé dur française. Cah. Agric. 21, 34–45. https://doi.org/10.1684/agr.2012.0539

Firth, J.R., 1957. A synopsis of linguistic theory, 1930-1955. Stud. Linguist. Anal.

Flor, R.J., Maat, H., Asmara, B., Hadi, R., Kumar, V., Castilla, N., 2019. Field Crops Research Do fi eld-level practices of Cambodian farmers prompt a pesticide lock-in ? F. Crop. Res. 235,

68–78. https://doi.org/10.1016/j.fcr.2019.02.019

Flor, R.J., Maat, H., Hadi, B.A.R., Then, R., Kraus, E., Chhay, K., 2020. How do stakeholder interactions in Cambodian rice farming villages contribute to a pesticide lock-in? Crop Prot. 135, 104799. https://doi.org/10.1016/j.cropro.2019.04.023

Gafsi , S., and Roe, T., 1979. Adoption of Unlike High-Yielding Wheat Varieties in Tunisia. Econ. Dev. Cult. Change 28, 119–133. https://doi.org/10.1086/451156

Gafsi , S., and Roe, T., 1977. Adoption Of Unlike High Yiekding Wheat Varieties in Tunisia. Staff Pap. Ser. Univ. Minnesota Instituteof Agric. Home Econ.

Gana, A., 2012. The Rural and Agricultural Roots of the Tunisian Revolution: When Food Security Matters. Int. J. Sociol. Agric. Food 19, 201–213.

Gana, A., 2008. Restructurations agricoles en Tunisie : adaptations et différenciation. Autrepart 46, 81. https://doi.org/10.3917/autr.046.0081

GIZ, 2014. Etude de la filière Légumineuse alimentaire et fourragère dans le Gouvernorat de Béja.

Handford, C.E., Elliott, C.T., Campbell, K., 2015. A review of the global pesticide legislation and the scale of challenge in reaching the global harmonization of food safety standards. Integr. Environ. Assess. Manag. 11, 525–536. https://doi.org/10.1002/ieam.1635

Hansen U.E., Nygaard I., Romijn H., Wieczorek A., K.L.M. et K.L., 2018. Sustainability transitions in developing countries : Stocktaking , new contributions and a research agenda. Environ. Sci. Policy 84, 198–203. https://doi.org/10.1016/j.envsci.2017.11.009

Hattab, S., Bougattass, I., Hassine, R., Dridi-al-mohandes, B., 2019. Metals and micronutrients in some edible crops and their cultivation soils in eastern-central region of Tunisia : A comparison between organic and conventional farming. Food Chem. 270, 293–298. https://doi.org/10.1016/j.foodchem.2018.07.029

Helmke, G., Levitsky, S., 2004. Informal Institutions and Comparative Politics: A Research Agenda. Perspect. Polit. 2, 725–740.

Hendrickson, J.R., Hanson, J.D., Tanaka, D.L., Sassenrath, G., 2008. Principles of integrated agricultural systems: Introduction to processes and definition. Renew. Agric. Food Syst. 23, 265–271. https://doi.org/10.1017/S1742170507001718

Holt-Gimenez, E., 2001. Scaling up sustainable agriculture. Lessons from the Campesino a Campesino movement. 3.

Hu, Z., 2020. What Socio-Economic and Political Factors Lead to Global Pesticide Dependence ?

A Critical Review from a Social Science Perspective.

Jendoubi, D., Hossain, S., Giger, M., 2020. Local livelihoods and land users ' perceptions of land degradation in northwest Tunisia. Environ. Dev. 33, 100507. https://doi.org/10.1016/j.envdev.2020.100507

Jouili, M., 2016. Changements structurels, politiques publiques et petite agriculture familiale en Tunisie, in: International Conference of the African Association of Agricultural Economists, September 23-26, 2016, Addis Ababa, Ethiopia.

Jouili, M., 2015. Tunisian agriculture : Are small farms doomed to disappear ?, in: 111 EAAE-IAAE Seminar 'Small Farms: Decline or Persistence' University of Kent, Canterbury, UK 26th-27th June 2009.

Jouili, M., 2009. Problématique de financement de l ' investissement agricole en Tunisie 28–35.

Jouzi, Z., Azadi, H., Taheri, F., Zarafshani, K., Gebrehiwot, K., Passel, S. Van, Lebailly, P., 2017. Organic Farming and Small-Scale Farmers : Main Opportunities and Challenges. Ecol. Econ. 132, 144–154. https://doi.org/10.1016/j.ecolecon.2016.10.016

Kallis, G., Norgaard, R.B., 2010. Coevolutionary ecological economics. Ecol. Econ. 69, 690–699. https://doi.org/10.1016/j.ecolecon.2009.09.017

Kuokkanen .A , Mikkila .M , Kuisma. M, Kahiluoto .H, L.. ., 2017. The need for policy to address the food system lock-in : A case study of the Finnish context. J. Clean. Prod. 140, 933–944. https://doi.org/10.1016/j.jclepro.2016.06.171

Laajimi. A et J.Ben Nasr, 2008. Déterminants économiques de l ' adoption de l ' agriculture biologique en Tunisie :

Lacour, C., Seconda, L., Allès, B., Hercberg, S., Langevin, B., Pointereau, P., Lairon, D., Baudry, J., Kesse-Guyot, E., 2018. Environmental Impacts of Plant-Based Diets: How Does Organic Food Consumption Contribute to Environmental Sustainability? Front. Nutr. 5, 1–13. https://doi.org/10.3389/fnut.2018.00008

Letaief, H., Zemni, H., Mliki, A., Chebil, S., 2016. Composition of Citrus sinensis (L .) Osbeck cv « Maltaise demi-sanguine » juice . A comparison between organic and conventional farming. FOOD Chem. 194, 290–295. https://doi.org/10.1016/j.foodchem.2015.08.025

Lucas et al., 2018. Local inter-farm cooperation : A hidden potential for the agroecological transition in northern agricultures. Agroecol. Sustain. Food Syst. 00, 1–35. https://doi.org/10.1080/21683565.2018.1509168

Luna, J.K., 2020. ' Pesticides are our children now ': cultural change and the technological treadmill

in the Burkina Faso cotton sector. Agric. Human Values 37, 449–462. https://doi.org/10.1007/s10460-019-09999-y

Magrini, M., Nicolas, B., 2019. Technological Lock-In and Pathways for crop Diversification in the Bio-Economy, in: Agroecosystem Diversity. pp. 375–388. https://doi.org/10.1016/B978-0-12-811050-8.00024-8

Marcoux, C., Urpelainen, J., 2011. Special Interests , Regulatory Quality , and the Pesticides Overload. Rev. Policy Res. 28, 585–612. https://doi.org/10.1111/j.1541-1338.2011.00528.x

Max Reinert, 1993. Les " mondes lexicaux " et leur ' logique " à travers l ' analyse statistique d ' un corpus de récits de cauchemars 66, 5–39. https://doi.org/10.3406/lsoc.1993.2632

Mhadhbi, T., Pringault, O., Nouri, H., Spinelli, S., Beyrem, H., Gonzalez, C., 2018. Evaluating polar pesticide pollution with a combined approach : a survey of agricultural practices and POCIS passive samplers in a Tunisian lagoon watershed. Environ. Sci. Pollut. Res. https://doi.org/10.1007/s11356-018-3552-3

Mialon, M., Mialon, J., 2018. Analysis of corporate political activity strategies of the food industry: Evidence from France. Public Health Nutr. 21, 3407–3421. https://doi.org/10.1017/S1368980018001763

Mtimet, N., Souissi, A., Mhamdi, N., 2020. Tunisian consumers perception and behaviour towards organic food products. New Medit 19, 3–18. https://doi.org/10.30682/nm2001a

Mtiraoui, A., 2014. Control of corruption, economic growth and human capital: MENA-OECD benchmarking.

Mzoughi, N., 2011. Farmers adoption of integrated crop protection and organic farming: Do moral and social concerns matter? Ecol. Econ. 70, 1536–1545. https://doi.org/10.1016/j.ecolecon.2011.03.016

Nicholls, C.I., Altieri, M.A., 1997. Conventional agricultural development models and the persistence of the pesticide treadmill in Latin America. Int. J. Sustain. Dev. World Ecol. 4, 93–111. https://doi.org/10.1080/13504509709469946

Norton, G.A., Heong, K.L., Cheng, J., 2015. Future planthopper management: increasing resilience of rice systems. In: Heong, K.L., Cheng, J., Escalada, M. (Eds.), Rice Planthoppers: Ecology, Management, Socioeconomics, and Policy. Zhejiang Univ. Press. Hangzhou Springer Sci. Media Dordrecht. 209–226. https://doi.org/10.1007/978-94-017-9535-7

Ollivier, G., Bellon, S., 2013. Dynamiques paradigmatiques des agricultures écologisées dans les communautés scientifiques internationales. Natures Sci. Soc. 21, 166–181.

https://doi.org/10.1051/nss/2013093

Ollivier, G., Magda, D., Mazé, A., Plumecocq, G., Lamine, C., 2018. Agroecological transitions: What can sustainability transition frameworks teach us? an ontological and empirical analysis. Ecol. Soc. 23. https://doi.org/10.5751/ES-09952-230205

Paquin, B.C., 2020. Clientélisme et corruption en Tunisie, de Ben Ali à la période contemporaine (1987- 2017) : résilience et transformations d'une institution informelle. https://doi.org/http://dx.doi.org/10.20381/ruor-24319

Perkins, R., 2003. Technological " lock-in ." Online Encycl. Ecol. Econ. 1–8.

Pingali, P.L., 2012. Green Revolution: Impacts, limits, and the path ahead. Proc. Natl. Acad. Sci. 109, 12302–12308. https://doi.org/10.1073/pnas.0912953109

Pretty, J., 2003. Social Capital and the Collective Management of Resources. Science (80-.). 302, 1912–1914. https://doi.org/10.1126/science.1090847

Purvis, M.J., 1972. The Adoption of High Yielding Wheats in Tunisia. Staff Pap. 13677, Univ. Minnesota, Dep. Appl. Econ. https://doi.org/10.22004/ag.econ.13677

Ramos-mejía, M., Franco-garcia, M., Jauregui-becker, J.M., 2018. Sustainability transitions in the developing world : Challenges of socio- technical transformations unfolding in contexts of poverty. Environ. Sci. Policy 84, 217–223. https://doi.org/10.1016/j.envsci.2017.03.010

Ratinaud, P., Déjean, S., 2009. IRaMuTeQ: implémentation de la méthode ALCESTE d'analyse de texte dans un logiciel libre. Modélisation Appliquée aux Sci. Hum. Soc. Toulouse - Le Mirail 8–9.

Reijntjes C., H.B. et W.-B.A., 1992. Farming for the Future: An Introduction to Low-External-Input and Sustainable Agriculture. Macmillan Press, New York,, NY, USA.

Richard, J.-F., 2006. Le devenir de l'agriculture tunisienne face à la libéralisation des échanges. Afr. Contemp. 219, 29–42. https://doi.org/10.3917/afco.219.0029

Rogério, C., Augusto, J., Borges, R., Armando, J., Machado, D., 2020. Science of the Total Environment A review and some re fl ections on farmers ' adoption of sustainable agricultural practices worldwide. Sci. Total Environ. 729, 138831. https://doi.org/10.1016/j.scitotenv.2020.138831

Rogers, E.M., 1962. Diffusion of innovations, The Free P. ed, An Integrated Approach to Communication Theory and Research, Third Edition. New York.

Rossi, J., Garner, S.A., 2014. Industrial Farm Animal Production: A Comprehensive Moral

Critique. J. Agric. Environ. Ethics 27, 479–522. https://doi.org/10.1007/s10806-014-9497-8

Schut, M., Rodenburg, J., Klerkx, L., Ast, A. Van, Bastiaans, L., 2014. Systems approaches to innovation in crop protection . A systematic literature review. Crop Prot. 56, 98–108. https://doi.org/10.1016/j.cropro.2013.11.017

Sumberg, J., Thompson, J., Woodhouse, P., 2013. Why agronomy in the developing world has become contentious. Agric. Human Values 30, 71–83. https://doi.org/10.1007/s10460-012-9376-8

Tacconi, L., Aled Williams, D., 2020. Corruption and anti-corruption in environmental and resource management. Annu. Rev. Environ. Resour. 45, 305–329. https://doi.org/10.1146/annurev-environ-012320-083949

Temple, 2015. Comparaison des trajectoires d'innovation pour la sécurisation alimentaire des pays du Sud. Biotechnol. Agron. Société Environ. 19, 53–61.

van den Bersselaar, D., Decker, S., 2011. "No longer at ease": Corruption as an institution in West Africa. Int. J. Public Adm. 34, 741–752. https://doi.org/10.1080/01900692.2011.598272

Van Hoi, P., Mol, A., Oosterveer, P., 2013. State governance of pesticide use and trade in Vietnam. NJAS - Wageningen J. Life Sci. 67, 19–26. https://doi.org/10.1016/j.njas.2013.09.001

Vanloqueren, G., Baret, P. V., 2008. Why are ecological, low-input, multi-resistant wheat cultivars slow to develop commercially? A Belgian agricultural "lock-in" case study. Ecol. Econ. 66, 436–446. https://doi.org/10.1016/j.ecolecon.2007.10.007

Villemaine, R., 2018. Fidéliser, servir, rendre dépendant. Le travail d'attachement au sein d'une grande coopérative agricole. Sociol. Trav. 60. https://doi.org/10.4000/sdt.2756

Waddington, H., Snilstveit, B., Hombrados, J.G., Vojtkova, M., Anderson, J., White, H., 2014. PROTOCOL: Farmer Field Schools for Improving Farming Practices and Farmer Outcomes in Low- and Middle-income Countries: A Systematic Review. Campbell Syst. Rev. 10, 1–48. https://doi.org/10.1002/cl2.90

Wagner, C.H., , Michael Cox, J.L.B.R., 2016. Pesticide lock-in in small scale Peruvian agriculture. Ecol. Econ. 129, 72–81. https://doi.org/10.1016/j.ecolecon.2016.05.013

Wagner, J.L., Ferguson, P.L., Kellermann, T., Smith, G., Brooks, B., 2016. Behavioral health referrals in pediatric epilepsy. Epilepsy Res. 127, 72–77. https://doi.org/10.1016/j.eplepsyres.2016.08.017

Wang, C., Cardon, P.W., Liu, J., Madni, G.R., 2020. Social and economic factors responsible for environmental performance: A global analysis. PLoS One 15, 1–12.

https://doi.org/10.1371/journal.pone.0237597

Ward, N., 1993. THE AGRICULTURAL TREADMILL AND THE RURAL ENVIRONMENT IN THE POST-PRODUCTIVIST ERA XXXIII, 348–361.

Warner, K.D., 2006. Agroecology in Action.Extending alternative agriculture through social networks, MIT Press, w. https://doi.org/10.7551/mitpress/1164.001.0001

Wilson, C., Tisdell, C., 2001. Why farmers continue to use pesticides despite environmental, health and sustainability costs. Ecol. Econ. 39, 449–462. https://doi.org/10.1016/S0921-8009(01)00238-5

Yousfi, H., 2019. Reshaping state/local communities relations in Tunisia: The socio-cultural and institutional challenges of the decentralization project. Eur. Manag. J. 37, 625–636. https://doi.org/10.1016/j.emj.2019.05.002

Zarai, T., 2017. LES PESTICIDES à usage agricole EN TUNISIE « Cadre réglementaire& proCédure d'homologation», in: Séminaire « Utilisation Des Pesticides Dans La Production Agricole: Entre Enjeux Économiques et Santé Humaine».

Article 3: Farmer' hability to adapt to the "social and solidarity economy" in Tunisian rural areas: A descriptive exploratory qualitative study

Target review : Journal International Journal of Sustainable Development & World Ecology (work in progress)

Fatma Mhadhbi[a*]

[a] Ecodeveloppement, INRAE, 84000 Avignon, France

*corresponding author

Abstract: The aim of this article is to study farmers' preferences towards collective institutions in order to highlight factors that block or favor the integration of farmers in collective groups that aim to enhance rural wellbeing. To achieve this aim, we applied a directive questionnaire with open-ended questions, interviewing 136 interlocutors, mainly farmers and local actors (farm workers, farm advisors, representatives of SSE organizations). Our analysis reveals the strong transformations of rural society due to the system of agricultural intensification, which has become increasingly complex and characterized by the individualization of land ownership and labor, leading to the destruction of the social character of rural communities through the use of new labor-saving technological trends (e.g., GMOs and pesticides), and the weakness of public institutions: constraints (bureaucracy, lack of financial incentives) that hinder the regional development of the agricultural sector and, in particular, of collective structures. Without forgetting the trauma of the collectivist experience of the 1960s.

Keywords: collective action, Social and solidarity economy, Local food System, rural areas

1. Introduction

The dominant agricultural production system appears locked around a technological paradigm based on the intensive use of chemical inputs (fertilizers, herbicides, pesticides, etc.) (Magrini et al, 2017) whose impacts on the environment, resources, and farmers' health is negative (Altieri, 2009). To minimize the lock-in of the global agrifood production system, several scholars called for "localized agrifood systems" (LAS) (Bele et al., 2018; Hinrichs, 2003, 2000; Mtiraoui, 2014; Muchnik, 2008) inspired by regional science research on local productive systems. This approach is based on the combination of the notions of territory and agrifood chain, on one hand, and the integration of a double objective of societal responsibility (of producers as well as consumers, i.e. food ethics) and sustainable development, on the other hand. However, this process depends on the capacity of local actors to act collectively and to enhance the territory's resource (Torre and Vollet, 2016). In particular, the LAS focuses on the three points related to food identity, preservation of territorial resources and farmers, and other uses of the rural territory (e.g. tourism) (Pachoud et al., 2019).

In order to assess rural communities' opportunity to shift for LAS, the social and solidarity economy (SSE) approach aims to generate values for local communities based on the principles of equity, inclusion, cooperation, solidarity and democracy (Utting, 2017). Its activities are primarily focused on meeting the needs of communities and creating an inclusive and sustainable society where socially vulnerable groups are also empowered (Lee, 2020). In recent years, considerable attention has been given to the SSE. This term is characterized by a wide variety of structures: cooperatives, mutuals, associations, foundations, social enterprises, self-help groups, community-based savings and credit systems, complementary currency systems, alternative food and fair trade networks, associations of informal economy workers, and NGOs that are shifting from donor dependency to earned income (Utting, 2015). All these SSE organizations are characterized by their autonomy from the state and are guided by goals and standards that prioritize social welfare, cooperation and solidarity. They can be either communal or cooperative in nature, or even a mix of the two, to take up the distinction proposed by Haubert (1981). Haubert (1981), in line with the Tönnies' work on community (Gemeinschaft) and society (Geselschaft), and Durkheim (1967) on "mechanical solidarity" and "organic solidarity". From a theoretical point of view, SSE is a broad and plural concept that covers various economic models and approaches based on social objectives, socially-oriented work organizations, shared core values such as redistribution of resources, reciprocity, solidarity practices and self-management (Moulaert and Ailenei, 2005).

Understanding SSE dynamics leads us to mobilize three types of proximity: spatial, organizational and institutional (Rallet and Torre 2005; Polge 2016; Colletis and al.2005). The second proximity is based on two types of logic, a logic of degree of attachment, i.e. the emotional relationship between an individual and a given place (Altman and Low 1992; Shamai, Qazrin 1991), and the logic of neighbourhood, which is linked to the proximity of actors in terms of representations and values. So, the establishment of SSE-specific collective structures, such as cooperatives, mutual societies, self-help groups, and farm groups, is thus seen as a tool for small-scale farmers to pool their resources and market their products collectively, which could help to overcome the high transaction costs resulting from their small size (Kruijssen et al., 2009; Raimbert et Rebaï, 2017), increase their bargaining power (Bosc et al.,2002), reducing transport or facilitate certification and labeling. Farmers' groups can also increase the productivity of their members by providing access to resources (inputs, credit, training, transport, information and technical assistance) that are difficult to obtain individually (Chiputwa, Spielman and Qaim 2015; Fischer, Qaim and Goettingen 2012; Abebaw and Haile 2013). Collective action through agricultural cooperatives societies can contribute to improving the well-being of smallholders and thus to rural economic growth, reducing poverty and improving food security in rural areas (Simmons and Birchall, 2008; Thorp et al., 2005; Verhofstadt and Maertens, 2014). The literature widely recognizes that the expected outcomes of some SSE entities depend on the existence and strength of social capital (Eschweiler and Hulgård, 2018) in the community concerned . The essential meaning of social capital is related to trust and the ability to cooperate, shared norms, a particular form of local culture, the network of relationships, all of which are crucial for the development and success of collective actions (Crespo, Réquier-Desjardins and Vicente 2014; Koutsou, Partalidou, and Ragkos 2014). Social capital and formal institutions are substitutes in development, so social capital is particularly important for the poorest countries where formal institutions are of low quality (Ahlerup, Olsson, and Yanagizawa 2009).

So, SSE, as a localized social system (Demoustier, 2010), is a system capable of accompanying and influencing territorial regulation, maintaining economic activities and protecting its natural resources, but also maintaining a minimum of economic and social cohesion. The question is "how" can SSE act as a "*collective actor*" of a *"socially constructed territory"* and thus participate in the conception of an alternative agricultural production system likely to strengthen the productive capacity of local communities?

In this context, this paper explores the possibility of developing a local approach based on specific characteristics and territorial particularities, which empower local communities and contribute to the improvement of livelihoods and social cohesion through SSE organizations designed around a collective approach. The concept of collective as we present it in this article is distilled by the

group of individuals involved in formal cooperative organizations without neglecting the customary organizations or mutual aid[13] societies that distinguish rural communities. The rural community is concentrated around culturally, religiously and socially monolithic tribes. This solidarity is embodied in mutual inheritance at the family or village level. These tribal organizations also allowed for harmonious relations between the inhabitants of the same village: even today, a large part of the agricultural work is carried out within the framework of mutual aid relations involving the members of several production units - neighbors, relatives or allies - or even the entire village community (Sabourin, 2007).

Following the literature (Chèze et al., 2020; Hardin, 1968; Luna, 2020), we assume that the individualistic behavior of farmers is a major obstacle to the establishment of SSE entities and that the motivations of collective projects are not necessarily economic and that it is essential to understand the social, cultural and identity motivations to help and accompany collective projects in the framework of social and solidarity economy. Our objective is to understand the attitudes of farmers towards collective structures in order to determine the factors that block and promote the integration of farmers into collective groups in order to find solutions.

To test our hypothesis, we use survey data among a sample of farmers and stakeholders in Tunisia (North Africa). We focused on the plains of the North-West region (Figure. 1), where cereal and vegetable crops are concentrated and generally depend on intensive systems. In addition to one of the most well-known factors, the memorial trauma of the collectivist experience of the 1960s. Another unexplored factor must be taken into account in our analysis, especially for certain situations in the South: the numerous transformations of rural society due to the system of agricultural intensification, which has become increasingly complex and characterized by the individualization of land ownership and labor, leading to the destruction of the social character of rural communities through the use of new labor-saving and profitable technological trends (e.g., GMOs and pesticides), in spite of their negative effects on the environment and on health.

The remainder of the article is divided into four sections. Section 2 outlines the situation prevailing in the agricultural sector in Tunisia. Section 3 describes our survey and analysis methodologies. The results of our field survey are presented in section 4. We provide a discussion and conclusion in section 5.

[13] In most rural societies, there is a specific term for mutual aid and often a variety of terminologies: jmaâ, Twiza and Farga in the Maghreb countries, tapaï in the Canaque xaraaçu language of New Caledonia, musada in the Mahorais language of Mayotte, kihuate in the Kibundo language of Angola, tsikumu in the Banga language and kudzimissana in the Massoan language of Mozambique, mwethia in Kenya, gotong royong in Indonesia,

2. The genesis of the social and solidarity economy in Tunisia

At independence, Tunisia established a "socialist policy[14]" or collectivist policy from 1962 to 1969 initiated by Minister of planning Ahmed Ben Salah: This period is marked in particular by the Generalization of the cooperative system. In the agricultural field, this has resulted in the creation of production cooperatives from the former farms of the colonists, to organize collectively the integration of farmers with small farms in order to constitute viable farms, with a strong commitment from the State, with the sole aim of modernizing and intensifying agriculture to serve the other economic sectors. This collectivist policy ended in failure.

At the beginning of the 1980s, the government moved towards a liberal option, which was marked by the implementation of the structural adjustment program (PAS) and its agricultural component (PASA). The structural adjustment policies have reinforced the State's disengagement from agricultural economic activities and the dismantling of agricultural cooperatives and their transfer to private actors (Gana, 2008). This disengagement has reinforced individualism at the expense of communitarianism. Tunisia remains a country where the culture of solidarity, mutual aid and collective work has always been part of the traditions and practices of local populations (Elachhab, 2018), which is strongly marked by the debris of the cooperative experience (El-Idrissi, 2017).

The various donor-supported economic reforms have reinforced regional dualism by deepening selective development trends through increasing metropolization, maintaining the marginal status of inland regions, reducing them to a mere reservoir of labour and natural resources(Dhaher, 2010; Salman, 2017) , thus encouraging rural exodus and generating socio-political tensions.

In order to alleviate these tensions, public policies have been oriented towards "controlling rural spillovers" and reinvesting in the organization of the rural sector. In the mid-1980s, cooperatives timidly resumed to ensure the continuity of certain strategic activities such as the dairy sector, the State granted various advantages to new public dairy cooperatives with their equipment, payment facilities for the acquisition of new equipment, technical support (El Harizi et al., 2019) .

At the end of the 1990s, Tunisia embarked on a restructuring of rural institutions(Canesse, 2009) with a focus on collective action through the creation of associations of irrigators who manage public irrigated areas under the status of agricultural development group[15] (GDA) (Mustapha et al., 2015) . Through the GDA, members are now involved in local development (Elloumi, 2006). The groups are in charge of protecting, rationalizing and safeguarding natural resources and equipping the areas. They take over the activities of the administration (supervision of members;

[14] Socialist policy" or collectivist policy from 1962 to 1969 initiated by Ahmed Ben Salah: This period is marked in particular by the promulgation of Law No. 64-5 of May 12, 1964 relating to the nationalization of land expropriated from settlers (Attia, 1986; Poncet, 1963)

[15] The GDAs are associative entities with voluntary and non-profit

dissemination of techniques to improve productivity; improvement of rangeland and livestock systems; assistance in clearing up agrarian situations). This top-down policy served primarily to strengthen local control of the ruling party until the Jasmine Revolution in 2011(Canesse, 2010).

manifested a will to revive the cooperative model through the creation of the agricultural service mutual society[16] (SMSA) specialized in the provision of agricultural services entered into force in accordance with the law n° 2005-94 of October 18, 2005, and of the Groups of agricultural development and fishing (GDAP) in the provision of agricultural services and access to drinking water and irrigation.

A decade after the Jasmine Revolution, Tunisia is still teetering between economic recession (El-Idrissi, 2017) and socio-economic demands around the issues of employment, development and justice, in the so-called marginalized rural areas that were excluded by the economic and social development policies. This model for the development of SSE in Tunisia has been a bottom-up approach where civil society actors have initiated SSE entities such as associations that have tried to implement new ways of doing development, in the face of the state's inability to meet the needs of the population(El-Idrissi, 2017; Mouelhi et al., 2021). In order to consolidate the dynamics underway, several economic initiatives of a social and solidarity nature are emerging, from small craft enterprises to social entrepreneurship experiments, including self-managed villages (experience of Jemna, Henchir Still, the fig of Djebba), some of them have been initiated in the framework of cooperation projects as is the case of SMSA "Djebba Fruits" and the grouping of agricultural development femenin "Knouz Djebba"[17], others have emerged in a more spontaneous manner as is the case of the farm of Jemna, (Abaza, 2020; Ben-Slimane et al, 2020; El-Idrissi, 2017; Gammar, 2019). Other SMSAs have succeeded in their activities thanks to a dynamic partnership with the public authorities and the private sector, such as the experience of the "Elhouda" SMSA in Mahdia. It has 1551 members and a turnover of 24.2 million dinars. Similarly, the cooperative is a shareholder of 4.21% in the capital of a private company, the central Vitalait Mahdia[18].It is in this context that the social and solidarity economy (SSE) appears as a socio-economic alternative to the development strategies of the State and as a legitimate model of participatory and collective action

[16] SMSAs are associative entities with voluntary and profit

[17] https://www.mangeonsbien.com/outdoor/tiroirs-du-terroir/figues-djebba-aoc-dynamise-region/

[18] Estimations de l'année 2017 selon les sources de la SMSA « Elhouda ». Cf. Akram Belhaj Rhouma, Les sociétés mutuelles de services agricoles (SMSA) en Tunisie: Cadre juri- dique et Partenariat Public-SMSA, Étude pour le compte du MARHP et CIHEAM-Institut Agronomique Méditerranéen de Montpellier: https://www.iamm.ciheam.org/ress_doc/opac_css/doc_num.php? explnum_id=18219

also after the vote of the law[19] 2020/30 relating to the social and solidarity economy (Journal Officiel de la République Tunisienne, 2020).

The latter defines*:"any legal person of private law provided that it respects the provisions of the present law and has the label "Entre- prise de l'économie sociale et solidaire"*. This new conception of SSE offers an alternative towards a local, collective, responsible and citizen economy, respectful of people and resources, creating economic and social value in the territories. Likely to meet both the challenges of job creation and social cohesion (Tibollo et al, 2014).

3. Materials and Methods

3.1. Field survey

The study was carried out in the North-West region, the rainiest region in the country, bounded to the west by the Tunisian-Algerian border, to the east by the capital and to the north by the Mediterranean Sea. This region, 10.4% of the country's total surface area, is essentially agricultural, with 52% cultivated land, i.e. 19% of Tunisia's total agricultural surface area. In the situation of the North-West region, which is essentially agricultural, it hosts only 9% of the SSE organizations present on the national territory, with a membership rate that does not exceed 5% (Haddar et al., 2017).

3.1. Methods

Given the lack of knowledge about farmers' perceptions of collective structures, we conducted an exploratory and qualitative study based on a set of semi-structured interviews. Several interviews be conducted online because of the Corona pandemic travel and contact restrictions starting in March 2020. This method aimed to collect farmers' narratives in order to gain an in-depth understanding of how they perceive the issues of collective action. We therefore relied on the deductive method to test our hypotheses and answer our research questions.
However, before conducting these interviews, we used a methodological device that articulates quantitative and qualitative research. This research relies on three different but complementary methodological tools: a bibliographic analysis, a database listing all the entities (assets) of the social

[19] This law, is composed of 24 articles divided into 6 chapters, which aims to support collective activities based on the principle of solidarity and social utility implemented by cooperatives, mutuals, associations and foundations and of the Groups of agricultural development and fishing (GDAP).

and solidarity economy in the Northwest region, and a dozen studies on collective action over the past decades.

The first was to gather identification data (age, gender, occupation, education level, etc.). The second was to collect data about farmers' attitudes towards SSE organizations such as agricultural cooperatives, farmers' groups, etc. The third theme focused on the conditions that prevent farmers from becoming involved in collective structures. The fourth theme focused on the structural problems facing the sector. The interviews were divided into sections by theme, with each section

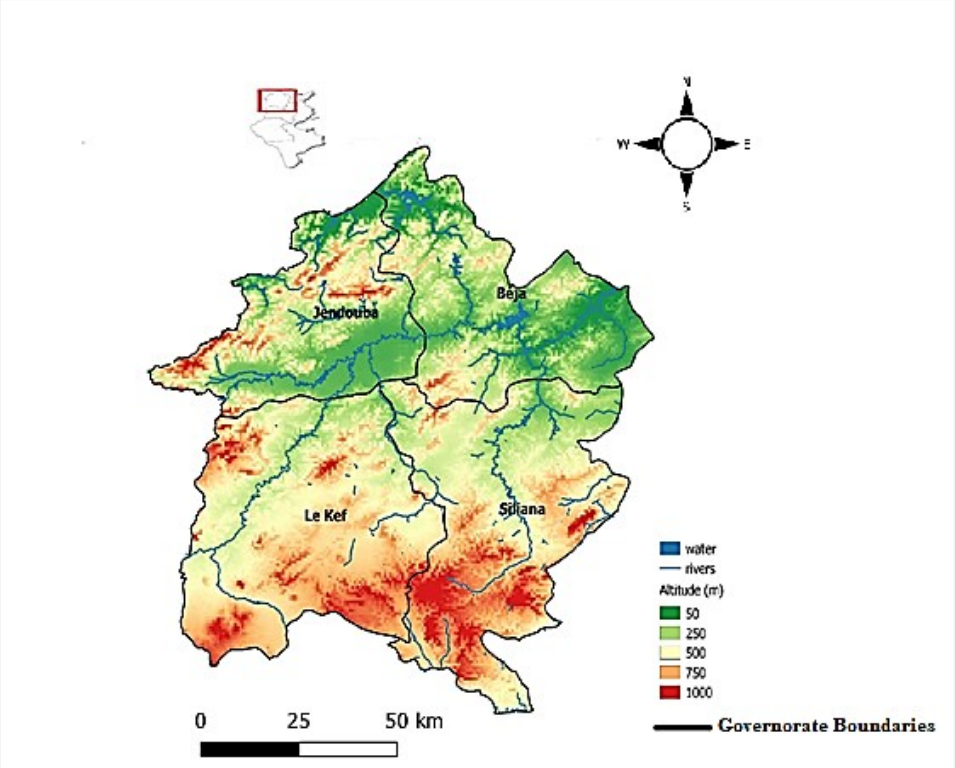


Figure 1. The North-west region of Tunisia

consisting of a combination of dichotomous, nominal, ordinal and open-ended questions (see Appendix A).

We conducted 136 interviews with farmers and stakeholders (farm workers, farm advisors, trade unionists, bureaucrats), ranging in length from 15 minutes to 2 hours depending on the case.

We sampled the interviewees in several stages, as a complete list of farmers was not available for each municipality in the region. First, in consultation with the heads of the regional agricultural development commissariats, we identified the SSE entities present in the region in order to know the active members of these collective structures (GDA and SMSA). We then contacted local stakeholders and other officials to identify currently active farmers and farmer groups to interview and asked them to suggest other farmers or indicate other names of collective structures to interview in the region (see table.1, 2).

Table 1: lists of SSE entities that participated in the study

Name of coop	City	Date of formalisation	Total number of members	Women	Men	Main activities
SMSA Apiservices	Fernana	2019	45	2	43	Offers advice and training to beekeepers in the region The marketing of honey Collection and recycling of wax from beekeepers supply of equipment
GDA Dar_Mhenia	Krib	2017	20	20		Valorization of agricultural and forestry products and artisanal weaving
GDA ElHayet	Kalaat Senane	2015	58	58		Valorization of local products: the wild artichoke. The breeding of quails
GDA Falahat	Sers	2017	50	50		Valorization of local products
GDA Sendiane	Nefza	2006	8	6	2	Production of lentisk oil
GDA Elbarka	Ain Draham	2010	45	45		Production of organic pomegranates Specialization in the distillation of aromatic and medicinal plants.
GDA Sra Ouertane	Ksour	2017	85		85	Production of potatoes in the highlands
SMSA Kalaat Kesba	Kalaat Kesba	1994	35			Fodder supply and crop harvesting
SMSA Ennajah jaza	Tejerouine	2000	219			Fodder supply and crop harvesting
SMSA El Amen	Fernana	2013	30			All agricultural services
GDA Ennour	Krib	2017	12	12		Specialized in the distillation of medicinal and aromatic oils and the drying of plants. Processing of local food products such as couscous, jam and carob molasses.
SMSA Elmahassen	Nebeur	1989	810			Collection of dairy products - artificial insemination - storage of cereals -agricultural supplies - agricultural mechanization
GDA Bionor	Testour	2019	40	13	27	Production of organic pomegranates and distillation of medicinal plants
SMSA Djebba Fruit	Thibar	2016	140			Specialized in the valorization of the fig *Bouhouli"*

In the second stage, individual interviews were conducted with farmers who did not belong to collective structures. These farmers were asked to express their views on the need for agricultural cooperatives in order to assess the reasons that prevent them from engaging in collective action. Interviews were conducted in arabic. All our interviews conducted in 2018 (N=111) took place at the workplace of the interviewees. Due to the covid-19 health crisis, other interviews (N=25) conducted in 2021 were organized by telephone, audiovisual and other actors have asked us to send them the questionnaires so they can complete and send it by email. Once the surveys were

completed, we reviewed each of the questionnaire responses with the interviewees to ensure accurate interpretation of the data and respo

Table2.Statistical description of interviewees

Variables modalities	Total N prop(100%)	Yes N prop(100%)	No N prop(100%)
Manager Farmer?	136	109(80.1%)	27(19.9%)
Age			
Young [45<]	34(25%)	26(23.86%)	8(29.6%)
Medium [45-59]	31(25%)	23(21.10%)	8(29.6%)
Old <59	71(52.2%)	60(55.04%)	11(40.7%)
Genre			
Female	17(12.5%)	11(10.09%)	9(33.3%)
Male	119(87.5%)	101(92.66%)	18(66.7%)
Level Education			
None	9(6.6%)	9(8.26%)	0.0
Primary	19(14%)	19(17.34%)	0.0
Secondary	58(42.6)	53(48.62%)	5(18.5)
Tertiary	50(36.8%)	28(25.69%)	22(81.5)
Main occupation (19 farmers are pluriactive)			
Administration	22(16.17%)	4 (3.67%)	18 (66.66%)
Doctor	1(0.7%)	1(0.7%)	0.0
Extensionist	14(3.7%)	5(4.59%)	9(33.33%)
Farmworker	3(2.20%)	0.0	3(11.11%)
Union	2(1.47%)	1(0.7%)	1(3.70%)
President GDA	5(3.7%)	5(4.59%)	0.0
President SMSA	4(3%)	4(3.67%)	0.0

4. Results

4.1. Attitudes and perceptions towards collective SSE organizations

The first intentions of some farmers interviewed who expressed their fear of collective structures explain their rejection of any participation or membership in a collective entity (see Table 3), by citing the socialist experience of the 1960s (N=20). It also appears that the idea of "cooperative", of "taadoudia" is synonymous with failure and occupation of property for certain categories of farmers who have known the collectivist experience. This policy is a source of mistrust and fear among the farmers interviewed, who see in the collective organizations the reflection of an authoritarian state due to the violence of the former dictatorial regime and the traumas of the collectivist era of the 1960s, which transformed the cooperatives into units of control of the population in recent decades. This experience has marked the memory of the rural community by leaving a psychological shock, so that today some farmers express their refusal to join a collective

entity by referring to the bad experience of their parents who were forced to join cooperatives imposed by the authorities under the responsibility of Ahmed Ben Salah and whose effects were disastrous, *"I do not want to live what my father experienced in the sixties of abuse. I do not want my land to be despoiled again by the authorities. The cooperatives are the cause of our impoverishment and eviction from our land."* (Old farmer). According to the testimony of an old farmer who lived through this experience, *"At the time, the authorities confiscated our land and forced us to join the cooperatives. Thus, the worker became the equal of the landowner, and thanks to Bin Saleh, we became khmmassa"* (Old farmer).

Our result reveals some poorly documented factors, particularly with regard to the individualistic and opportunistic behavior of farmers that prevents the development of collective action, where the farmer prioritizes his or her own interests over those of the communities. This behavior is deeply rooted among farmers who practice intensive agriculture expressed their reluctance to join collective production structures where it is impossible to act collectively to manage a common good (n=76, see table. 3). These attitudes are echoed to some extent in farmers' decisions, whether psychologically, such as farmers' risk aversion regarding loss of productivity or profitability *"I do not share my land and crops with other people"* (an intensive old farmer).

Other farmers expressed their lack of confidence in collective structures, justifying it by the inability of the state in the last decade to respond to their demands due to "*a loss of state authority, a deterioration of public administration and an increase in corruption. There is a kind of incompetence and weakness in the management of major problems. Some problems have increased after the [2011] revolution*" (Old farmer, tertiary eduction) which leads to exacerbate the structural problems from which the sector suffers and deepen the sense of opportunism and individualism of farmers and create a kind of hostility between the government and rural communities.

Only 20. 69% (n=18) of them express the need to create agricultural collectives, with 12 individual organic farmers expressing a willingness to engage in collective grouping and a minority of intensive farmers (7%, who are mainly young farmer with Tertiary level of education) showing their awareness of the need to create agricultural cooperatives to solve the structural and organizational problems from which most farmers suffer : "*The creation of the agricultural grouping within the framework of a process of production in common became a necessity to solve the problems from which the farmers suffer the engagement or the adhesion of the farmers in agricultural cooperatives "really allows us to facilitate the process of production and the distribution of our harvest and also to reduce the costs of production*"(id=74). In the same vein, it appears today that "*the creation of agricultural cooperatives is indispensable for certain productions or stages of the value chain: in certain agricultural productions such as milk or vegetables to ensure the collection, storage and marketing of products under conditions favorable*" (young farmer, tertiary education and also extensionist).

Table 3. Farmers' attitudes and perceptions toward collective SSE organizations

Variables modalities	Total N prop(100%)	Collective N prop(100%)	Individual N prop(100%)
Farmer	109	22(20.8%)	87(79.2%)
Production system?			
Intensification	76(69.72%)	1(4.54%)	75(86.21%)
Organic	33(30.27%)	21(95.45%)	12(13.79%)
Cropping system?			
Diversity	52(47.70%)	1(4.5%)	51(58.62%)
specialize	36(33.03%)	0.0	36(41.36%)
Terroir	22(20%)	22(100%)	0.0
Size of farm			
Big	2(1.87%)	0.0	2(2.35%)
Medium	8(7.48%)	0.0	8(9.41%)
Small	97(90.56%)	22(100%)	75(88,20%)
Social capital			
Mistrust	16(14.7%)	0.0	16(18.2%)
Solidarity	55(50.5%)	1(0.9%)	54(61.4%)
Trust	14(12.8%)	0.0	14(15.9%)
Solidarity and trust	24(22%)	20(90.90%)	4(4.5%)

4.2. Social and solidarity initiatives to enhance the value of products at local level

According to the SSE entities (n=14) we interviewed, there is a dynamism of collective initiatives to promote local products and services (see Table 1). Moreover, the majority of respondents are founders, board chairpersons with higher education, and a minority of respondents are members (n=6). Most of the SSE organizations we surveyed are relatively young (n=10, less than 10 years). This dynamism and mobilization of civil society is due to the freedom and political openness that followed the 2011 revolution (see table 1). Indeed, these same entities are generally the result of the result of farmers' initiatives, "self-creation" in which the State only intervenes as an accompanist.

They revealed a harmony between farmers belonging to GDAs and SMSAs, which is reflected in a higher level of interaction and teamwork through a combination of geographical proximity and respect for trust, solidarity, sharing, and neighborhood among farmers (see table3). These social values were seen as necessary assets to facilitate their individual and community actions: "*For us all to succeed, trust and transparency must be a priority. What unites the members of this group is above all trust and respect* (farmer, male, member of "GDA - BIONORD).

We retain from the interlocutors we met two fundamental principles of the SSE: to recreate the social link in the market exchanges, in particular by introducing relations of reciprocity between the individuals, and to act for the local development in a logic of proximity between the rural people, private organizations and public authorities.

In Tunisian rural societies, most of the communities belong to the same tribe, mutual aid and collective work is part of the traditions and social practices of the population *"Collective work and solidarity are the main characteristics of the rural community... In our traditions, it is frowned upon to take money to help a relative or a neighbor, this is what we call "Twiza" which means cooperation: It is an Amazigh cultural heritage in which a group of women or men from the same village get together and cooperate in order to contribute to the realization of a work, or to help a neighbor of our village to prepare the awla without any compensation and without any intervention, the cooperation is the identity of the inhabitants of the village it is our culture "* (woman, member of GDA-ennour).

Other determinants of product quality include geographical indications, which are of interest to many stakeholders. A geographical indication is also a protection for products whose quality is linked to their geographical origin. As such, the specific role of the SSE appears as a defensive approach intended to highlight the limits of a culturally, economically and socially homogeneous locality and which requires a restructuring and an organization. It is in this case, that some gda and SMSA engage in the procedures of certification in order to approve their products for international export. Some "labels" can provide a marketing advantage, including guaranteeing the local Tunisian quality, and ensuring the traceability of exported products, which gives products a strong credibility on the national scene and export. We cite as such the SMSA Djebba fruit specialized in the production and development of the variety of figs Bouhouli", which is the only fruit label certified AOC (Appellation of Controlled Origin) in Tunisia. The interviewees emphasized their commitment to quality certification procedures as one of the strategies for the preservation of the organic farming model, which is characterized by the low use of external inputs and the participation of the entire community in the journey that takes the product from the field to the table *"We are working on the mechanism of product traceability that also allows farmers to access the growing markets of mass distribution, because the latter requires the traceability of the products it offers for sale. The implementation of a traceability system requires the involvement of all actors in a value chain, including processors. The implementation of this requires a great discipline on the part of all actors with a rigorous respect of the standards and a framing and an obligation at the level of all the sectors through the services of council and training*" (President, Gda bionord).
Other respondents indicate that the labeling of their products increases the degree of belonging and attachment to their region of residence. *"This is the reason why the Atlas association has set up a collective brand to delimit the production area and certify the specificity and originality of the products manufactured by the GDA of the women of Elbaraka. Today, the bottles of floral water, essential oil as well as soaps and bags of plants sold all bear the collective mark Khroumirie which refers both to the region of north-west Tunisia and the descendants of the Kroumirs tribes living in*

its mountains. This brand reinforces the identity and the feeling of belonging to our group (woman, member of the GDA-Elbaraka).

The interviewees expressed the role of international organizations (ILO, GIZ etc.) to develop and supervise collective projects for several years. For its part, GIZ and ILO also aim to finance projects related to the potential the four northwestern governorates (Beja, Jendouba, Kef and Siliana) in the framework of the social and solidarity economy, where farmers can group around a project and receive funding and training for optimal management of their project. According to the representatives of the SSE entities that we interviewed, thanks to GIZ, they have been able to benefit from training on the administrative and financial management of the group and other instructive aspects in marketing, training in distillation and preservation of products. They have also benefited from coaching services to project leaders and help them to create their business in the structured sector.

Our results also show that women's agricultural development groups are more active in adding value to local products for rural women because of the presence of a women's cooperative movement through the creation of GDAs encouraged by GIZ and the government to promote professional equality between women and men in the agricultural sector and to encourage women's economic and social empowerment. We cite the project, Promotion of Sustainable Agriculture and Rural Development (PAD II) in partnership with the Ministry of Agriculture, Hydraulic Resources and Fisheries (MAHRF), initiated in 2016 focusing its interventions on sustainable improvement of the income of the rural population, especially youth and women and on the successful implementation of measures to promote the ecological, economic and social sustainability of farms (GIZ, 2019). We cite the example of the female GDA "Ennour" which was launched under the project PAD II promotion of sustainable agriculture and rural development specializing in the distillation of medicinal and aromatic oils and drying plants, of course, we process other food products such as couscous, jam and carob molasses.

According to the women's testimonies we interviewed, adherence to a cooperative structure provides women with new economic opportunities, strengthening their social networks and improving the living conditions of vulnerable women working in the informal economy. By providing them with education and training and empowering them through democratic control, which allows them to formalize their activities. *"We came out of isolation and found a good location. The teamwork is not new between us just today we are well framed with the GDA. A big thank you to the representatives of GIZ and the CRDA of Kef who have trained us well and allowed us to develop our method of work and support us financially and with the necessary equipment "*(GDA-Ennour member). President GDA-Elbaraka expressed the importance of collective action to improve their living conditions: *"The existence of a collective agricultural structure in poor rural communities is a solution to improve the living conditions of this population and to maintain it in its original environment and limit the exodus of young people to urban areas. The existence of an*

agricultural cooperative or another form of collective work represents an opportunity for the small payers of the region».

For the respondents, grouping and organizing in social enterprises allows them to better benefit from returns to scale and to have a better integration in value chains while improving their know-how. As a potential solution to structural problems often related to value chains. A pilot experience has been initiated by international organizations (ILO, GIZ, etc.) and economic associations to develop the social and solidarity economy through the value chain approach. We can mention the the SMSA api-Service initiated in 2019 under the project Promise of the International Labour Office - ILO, received technical and material support from the PAD II for its project to develop a business model with various actors in the sector in the region of Fernana (Jendouba) to accompany and advise beekeepers in the region in four steps:

- Equipment rental (extractors), hive construction workshop with a support and monitoring service that is carried out throughout the year.
- The creation of a wax recycling unit is a project that was launched with the support of GIZ, this project aims to facilitate the collection of wax from beekeepers.
- The certification of products in collaboration with the American Agency for International Development.
- Packaging - Marketing with the establishment of sales outlets.

4.3. Weak political support for SSE organizations and local development

This section takes stock of the relative weakness of public organizations and the structural and institutional constraints that hinder the regional development of the agricultural sector and, in particular, collective structures. This is expressed in particular by the rigidity and complexity of administrative procedures, bureaucracy, as well as corruption, in the administrations due to the weakness of state control after the January 14 revolution and the instability of the socio-political and economic sphere.

Structural and cyclical difficulties paralyze the development of the sector, which lags behind in terms of infrastructure due to "the absence of processing and storage units, poorly organized distribution channels and very high distribution costs. (id=3).

Another factor that hinders the sustainability of SSE organizations is the difficulty of access to financing, which constitutes an obstacle to the expansion of the sector, particularly because of their "inability to provide an individual contribution or even a joint guarantee, and the rigidity of the banking system (President of ASMA Bio-Nord), and the lack of incentives and subsidies to encourage farmers. These difficulties were highlighted by an administrator in the Regional

Commissioner for Agricultural Development of Kef who pointed out that there are several gaps in the legislation concerning cooperatives. The current law does not promote the autonomy and independence of the cooperative model or access to credit.

As a growth sector in the Tunisian market organic farming (OF) we have raised in our questions to reveal the difficulties faced by farmers in the sector, these difficulties were highlighted by the director of uniobio which concerns mainly farmers who practice organic farming individually; these difficulties are mainly related to market access and difficulties related to certification procedures. He stressed that organic producers face multiple difficulties related to the marketing of their products due of the "lack of coordination between the actors of the sector at the local and national level (...) but also constraints related to the certification procedure and especially for market-oriented products are forced to access markets because of "the difficulty of accessing markets requiring organic products and strict specifications imposed and which must be carried out after a strict control to ensure that the product meets their requirements". He also stressed that obtaining certification from the European Specifications Office is expensive for farmers, he noted that "the subsidy to cover the costs of certification was canceled for budgetary reasons, it is now up to the farmer to pay what is a huge cost for him". He said that the solution to all these problems (increased costs of certification, etc..), goes through the grouping of farmers into cooperatives.

4.4. the constraints faced by SSE organizations that threaten their continuity.

In this section, we present the constraints faced by SSE organizations that threaten their long-term viability, according to our interviewees from the administrative sector and, to a lesser extent, farmers.

A farmer interviewed explained that *"doing things collectively is a priori very difficult because of a lack of knowledge and practices on the strategy to follow in the SMSA or GDA"* (medium farmer, secondary education*).* This situation is explained by the low capacity of farmers to identify common problems and to organize themselves to join forces to solve them (administrator, eduction tertiarty).

According to an administrator of the regional development commission of Kef, there are many factors that can threaten the proper functioning of SSE organizations, in particular SMSA and GDA, among these factors we retain notably:

- Weak governance and lack of respect for administrative and accounting provisions and procedures.

- Modest financial resources due to the reluctance of a large part of the farmers to join, in addition to the modest knowledge of commitment and the spread of the phenomenon of non-payment of dues.
- Difficult financial situations due to the accumulated debt. Lack of efficiency of the financing system and major difficulties in obtaining loans and subsidies (lack of guarantees). The weakness of the monitoring and control system, the multiplicity of supervisory authorities, the difficulty of coordination between them, and the dispersion of the role of information and support.
- Difficult working conditions and the absence of most company headquarters where board members can be active or where administrative and financial documents are kept.
- Lack of trust and credibility among board members or in their relationship with the people involved.
- Lack of necessary skills and experience in management structures, which limits opportunities for modernization and the use of modern management and behavioral technologies. Lack of mentoring, information and support programs.
- Lack of financial incentives for boards of directors to be more diligent and effortful (free and directorships).
- Low level of education of most board members.

To ensure continuity of collective action, the SMSA Api-Services president emphasized that some financial benefits should be derived from the transaction costs associated with farmer participation. The table below summarizes the barriers and levers mentioned in the interviews, the factors that prevent the (Table.4).

Table 4. Summary of discourse analysis organized by types of factors affecting opportunities for change

Drivers	**Barriers to change**	**Factors for change**
Behavioral	-Individualism and opportunism - Lack of trust -Skepticism in the viability of collective structures -lack of credibility and transparency -Misappropriation of collective funds -Nepotism	-Group work -Common production - Engage highly qualified professionals in the design process -Focus support and coaching on the start-up of SSE entities, particularly GDAs and SMSA s. - Create an e platform for SSE organizations: GDA, SMSA and professional organizations to collect, maintain and make easily accessible to the public all studies and information related to this field

		-Support extension services, education of farmers
SSE entities /territorial	-Bad experience with the cooperative model of the 1960s: Agricultural cooperatives are the result of an authoritarian dictatorial state that has caused a trauma in the collective memory of rural society. - Local politics - Lack of investment in productive infrastructure (transformation units, etc.) - Land availability - Rural exodus and old population - Lack of value chain organization - Demand for organic products is limited to elite urban population - Insufficient access to agricultural extension and advisory services, -Poor valorization of local agricultural products	- Invest in, develop, and coordinate the agricultural sector in general, and organic supply chains in particular - Favor cooperatives - Widen distribution channels and develop demand for organic products, on export and domestic markets; -Better organization of agricultural sector - Grant a robust certification system - Raising awareness among farmers about the role of a cooperative in agricultural development -Better coordination between territorial public institutions and international development organizations and donors such as GIZ and the International Labour Organization (ILO),ect. - Promote the grouping of initiatives related to socio-economic innovation, local eco-solidarity projects, and organic farming, sustainable, etc.
Institutional	- Failure of State: no political vision for agriculture, no effective control, corruption and bureaucracy - Very difficult or impossible access to bank financing for for SSE entities: Severe restrictions on bank credit, microcredit schemes whose benefits are limited to individuals, declining government support, and volatile and uncertain external financing. -Very limited financial autonomy of SSE entities, especially in the case of GDAs Poor communication between members and the executive - Influence of support organizations on the SMSAs (CRDA and regional governors regional governors since they represent the public authorities)	- Fight corruption -Transform SMSA s into truly competitive economic enterprises - Lower certification costs -Provide an installation premium and specific credit lines -Independence from public authorities

5. Discussion and Conclusion

Despite its potential to address major contemporary challenges - including poverty, unemployment, inequality and injustice, and climate change - the social and solidarity economy (SSE) has the capacity to be a catalyst for change. SSE, as an integrated, people-centered and environmentally sensitive approach, aims to generate values for the local communities and people based on the principles of equity, inclusion, cooperation, solidarity and democracy (Lee, 2020). By the same token, its practices of collective work and informal sharing are part of the ancestral practices of local communities in Tunsia such as the *"Twiza"*. These practices of solidarity, mutual aid and collective work are strongly influenced by the Amazigh culture and the Muslim religion, and have always been deeply rooted in the traditions and practices of local populations in Tunisia. In this framework, we refer to the GDAs and SMSAs that are born in a territorial context marked by various structural problems and local imbalances. Their activities are born from the territory, develop on the territory and rely on its resources. These SSE entities combine paid and non-market activities by bringing together different actors. They thus participate in the correction of local imbalances and promote a more solidary and proximity development, through a participative democracy and with the aim of a local organizational governance. The surveys that we have conducted among the SSE entities in the northwest region of Tunisia show that these structures have appeared in a context of needs but from individual initiatives - spontaneous. We can therefore consider that the SSE sector, in our study area, is still in its nascent phase: the establishment of structures is based on groups of people previously in intercognition, generally from the same village, but very few institutions installed carrying innovations. Very few SSE entities have qualified leaders capable of managing day-to-day affairs. In addition, SSE principles are not always clear to the leaders of existing entities. For example, the distribution of dividends is not always done according to these principles, but rather according to other forms of arrangement (e.g., favoritism) (Elachhab, 2018).

Despite the various initiatives of public authorities and development agencies (GIZ, etc.) aimed at facilitating access to SSE organizations for marginalized people and small farmers, it is apparent that the perception of rural communities towards collective structures is very negative. In developing countries, the relative weakness of collective action in the agri-food sectors can be explained by the weakness of the institutional framework and the rule of law, which limits the capacities of organized producers to enforce the internal rules of their organization as well as those regulating their relationship with the actors in the sectors (Bosc et al., 2016).In Tunisia , this is one of the important factors that prevents the development of collective action, and is prevalent in the results of the survey we conducted: contemporary agricultural collectives are confused with the

agricultural cooperatives of the 1960s, imposed by the authorities under the responsibility of Ahmed Ben Salah, and which today appear to be synonymous with failure, control systems and land grabbing (Belhaj Rhouma and Ahmed, 2019). Previous studies, these GDAs suffer from the lack of decision-making power vested in them and the lack of reorganization of relations between the state and farmers (Romagny et al., 2007). Other studies have highlighted shortcomings in the technical and financial management of irrigated areas (Al Atiri, 2007).Contemporary efforts to develop the SSE come up against the memorial trauma towards the cooperative experience symbolically tainted by authoritarianism(Yousfi, 2019). In addition, the development of the SSE sector in Tunisia is limited by several constraints internal to the sector that weaken the functioning of organizations: unqualified human resources, low professionalization and an aging agricultural workforce. It is also faced with external constraints (institutional, legal and financial - mentioned in our surveys): the fragility of its actors and the lack of knowledge of its principles and values by public authorities largely explain its difficulties in accessing funding(Elachhab, 2018) . In fact, most of the existing initiatives in the Northwest region are the result of individual initiatives inspired by the Moroccan, French or Italian experience and are supported by funds dedicated to SSE organizations (GIZ, ILO, etc.).

It should also be considered that these spontaneous grouping initiatives of farmers can be motivated by moral (the intrinsic ethics of individuals) and social (adapting behavior to one's peer group, desire for status, altruism) considerations(Mzoughi, 2011) for which the quality and structure of the relational network plays a key role in adoption decisions, as does collective identity when it is anchored in a space (community, village, neighborhood). In our surveys is that the degree of connectivity within the rural community is high at the level of relationships between local farmers - transactions are done informally, with low membership in collective structures, notably the agricultural development group (GDA) and the mutual agricultural service society (SMSA) and a continuity of cooperative behavior in the community, determined by the degree of neighborhood, trust and reciprocity (see Table 3). This is due to the extent of the informal sector which constitutes a priori more than 40% of the national economy. Indeed, this sector concerns an extremely large part of the population, thus highlighting solidarity practices that are well rooted in the territory(Elachhab, 2018).

In this perspective, the results of our field survey show that farmers who have individualistic attitudes, focused on their personal interests to the detriment of the community, are the farmers who practice intensive agriculture the most. These individualistic approaches crystallize into behaviors based on psychological criteria-such as aversion to the risk of loss of productivity or profitability(Chèze, David et Martinet, 2020) or demographics-such as gender, age, or education (Wagner et al. 2016; Burton, 2014).

Finally, in conjunction with the effect on technological lock-ins, corruption also plays a role in the weak development of SSE structures and thus reinforces individualistic practices. Despite the official recognition of the social and solidarity economy through the promulgation of Law 2020/30, structural anomalies are present. To date, in Tunisia, there are no plans for territorial poles of economic cooperation, even though these structures constitute an essential pillar for the foundation and promotion of the SSE(Rhouma, 2020). As an example, in France, the territorial poles of economic cooperation constitute groupings on the same territory between companies of the SSE, private companies and public organizations (local authorities, establishments of education, training and research) and all other physical or moral persons who associate to implement a common strategy to serve innovative economic and social projects and bearers of a sustainable local development.

However, in a rural Tunisian context, we showed that intensive farmers seem satisfied with their current production process insofar as the majority of them (79.2%) express individual management of their productions by expressing their reluctance to join collective production structures where it is impossible to act collectively to manage a common good. There is no doubt that the system of intensification has led to many transformations in rural societies, which are becoming increasingly complex and characterized by the individualization of land ownership and labor, destroying the social character of rural communities through the development of new technological trends labor-saving and profitable (eg, GMOs and pesticides), despite their negative effects on the environment and health that generate rural migration (Luna, 2020). One of the elements that we did not take into account in our field study is the transformation that society is undergoing as seen by Madoui (2012) through which he highlighted the movement of individualization due to modernization and urbanization that Tunisian society is undergoing which would inevitably lead to the explosion of mutual aid that affects the family and social bond.

Another factor that can block the sustainability and development of collective organizations is the divergence between collectivist and individualist tendencies recognized in a variety of status hierarchies, including those provided by gender (Walsh and Smith, 2007). Ather works assert that collective action is a challenge in contested situations where diverse stakeholders have different perspectives, interests, and values, leading to "ambiguity and disagreement about problems and solutions" (Patterson, 2017).

In our study, the weakness of public authorities is strongly evoked by the respondents. The state seems to lack support for agriculture and regional development, in terms of subsidies, investment in infrastructure, and extension and training capacity. This has serious implications for future actions in the redesign of new cooperatives. Other studies have highlighted the development

opportunities represented by SSE organizations too often go unnoticed, notably because public policies too often remain focused on the conventional, agricultural or industrial sectors (Elachhab, 2018). There are many factors that can explain the low level of SSE in Tunisia and the reluctance of farmers to join collective structures due to cumbersome procedures and lack of transparency, a strong concentration on specific sectors, small-scale actors, unqualified human resources, governance problems and limited access to funding. Access to financing remains one of the major constraints for the development of SSE structures due to the lack of financial resources and the reluctance of financial institutions to finance collective initiatives that do not have assets and credit guarantees(Mouelhi et al., 2021).

SSE organizations appear to be indispensable for certain productions or stages of the value chain: in certain agricultural productions such as milk or vegetables, to ensure the collection, storage and marketing of products under conditions favorable to producers.

Today, it has become imperative for small farmers to create collective structures, to enable them to create bargaining power in the markets and official recognition by the relevant authorities. A justification often put forward to promote the formation of cooperatives is the fact that small farmers cannot access promising markets on their own(El Harizi et al., 2019). Furthermore, SSE organizations have a fundamental role to play in the productive strengthening of local farmers, sharing and providing services and support to farmers to improve both their access to production inputs and the exploitation of relational and outreach opportunities of small farmers, taking into account the application of more sustainable practices, in order to improve the quality of food production at the territorial level by benefiting from the positive effects of geographical proximity and the degree of territorial anchorage or rooting in the localization processes.

Appendix A. The interview guide and variables

Variable name	Description	Categories
Age	Category of respondent age	Young [<45], adult [45-59], old [>59]
Education	Education level of respondents	none; primary; secondary, tertiary
Gender	Gender of respondent	Male; female
Occupation	Main professional occupation	Full-time farmer, agricultural worker, extensionist, administration, doctor, teacher, union member
Cooperation		Collective , individual
State		Absent, frequent
Agricture system		Organic, intensive
Decision		Collective, individual
neighbourhood relationship		Trust, solidarity , mistrust
Market	Market, Low storage capacity in silos in the area, processing units	Limited,

Open-ended questions asked

1- Cooperation with local actors: what do you think of agricultural cooperatives?
2- Are you a member of a social economy entity? (association, cooperative, GDA, SMSA)? Do you believe in the usefulness of being part of this type of structure? Why do you think it is useful to be part of such structures?
3- what are the reasons that prevent you from integrating into these collective structures?
4- What are the factors that can hinder the establishment of collectives in rural areas?
5- What are the difficulties that your activity encounters?
6- What are the difficulties you have encountered after the creation of your farming organization??
7- What is the role of the State?
8- What is the role of funders?
9- What are the main issues affecting farmers specifically and the region in general and what are the solutions?

6. Reference

Abaza, K., 2020. Territorial resources and local development : the fig sector in the two mountainous localities of Kesra and Djebba (Northen Tunisia) 10, 211–226.

Abebaw, D., Haile, M.G., 2013. The impact of cooperatives on agricultural technology adoption : Empirical evidence from Ethiopia. Food Policy 38, 82–91. https://doi.org/10.1016/j.foodpol.2012.10.003

Al Atiri, R., 2007. Evolution institutionnelle et réglementaire de la gestion de l ' eau en Tunisie . Vers une participation accrue des usagers de l ' eau To cite this version : HAL Id : cirad-00191075 Evolution institutionnelle et réglementaire de la gestion de l ' eau en T.

Altieri, M.A., 2009. Agroecology, Small Farms, and Food Sovereignty. Mon. Rev. 61, 102–113. https://doi.org/10.14452/MR-061-03-2009-07_8

Altman and Low, 1992. Place attachment: A conceptual inquiry. Place Attach. 1–12.

Bele, B., Norderhaug, A., Sickel, H., 2018. Localized agri-food systems and biodiversity. Agric. 8. https://doi.org/10.3390/agriculture8020022

Belhaj Rhouma, A., Ahmed, Z., 2019. Les sociétés mutuelles de services agricoles (SMSA) en Tunisie : cadre juridique et partenariat Public-SMSA.

Ben-Slimane et al, 2020. Institutional Entrepreneurship in a Contested Commons : Insights from Struggles Over the Oasis of Jemna in Tunisia. J. Bus. Ethics 166, 673–690. https://doi.org/10.1007/s10551-020-04601-6

Bosc, P., Lemeilleur, S., Moustier, P., 2016. L ' action collective dans les filières.

Burton, R.J.F., 2014. The influence of farmer demographic characteristics a review. J. Environ. Manage. 135, 19–26.

Canesse, A.-A., 2010. Les Groupements de développement agricole (GDA), entrepreneurs locaux ou relais administratifs ? Quels enjeux participatifs pour les agriculteurs tunisiens ? 243–255.

Canesse, A.-A., 2009. G estion des ressources naturelles et système institutionnel de gouvernance en T unisie 49–64.

Chèze, B., David, M., Martinet, V., 2020. Understanding farmers ' reluctance to reduce pesticide use : A choice experiment. Ecol. Econ. 167, 106349. https://doi.org/10.1016/j.ecolecon.2019.06.004

Chiputwa, B., Spielman, D.J., Qaim, M., 2015. Food Standards , Certification , and Poverty

among Coffee Farmers in Uganda. WORLD Dev. 66, 400–412. https://doi.org/10.1016/j.worlddev.2014.09.006

Colletis, G., Gianfaldoni, P., Richez-battesti, N., 2005. Social and Solidarity Economy. Rev. Int. l'économie Soc. 956–956. https://doi.org/10.1007/978-3-319-95714-2_300241

Demoustier, D., 2010. Économie sociale et solidaire et régulation territoriale Étude sur quatre zones d'emploi en Rhône-Alpes. Geogr. Econ. Soc. 12, 89–109. https://doi.org/10.3166/ges.12.89-109

Dhaher, N., 2010. L'aménagement du territoire tunisien : 50 ans de politiques à l'épreuve de la mondialisation. EchoGéo 13, 0–14.

Durkheim, É., 1967. Division de la division, PUF. ed. Paris[1893]. https://doi.org/10.3406/chime.1999.2498

El-Idrissi, S., 2017. Peut-on parler d'un mouvement de l'économie sociale et solidaire en Tunisie ?, in: Forum International de l ' Économie Sociale et Solidaire - Engagement , Citoyenneté et Développement : Comment Former à l ' Économie Sociale Solidaire ?".

El Harizi .K, S.. and B.M.. ., 2019. Quel avenir pour les coopératives agricoles ? Rome, Italy.

Elachhab, F., 2018. L'ÉCONOMIE SOCIALE ET SOLIDAIRE EN TUNISIE, UN POTENTIEL TROISIÈME SECTEUR ? Assoc. RECMA | 349, 71–86.

Elloumi, M., 2006. Les politiques de développement rural en Tunisie : Acquis et perspectives. Options Méditerranéennes Sér. A / n, 55–65.

Eschweiler, J., Hulgård, L., 2018. The social and solidarity economy sector: A bottom-up alternative. Compet. Solidar. Eur. Union Interdiscip. Perspect. 126–148. https://doi.org/10.4324/9781351001809-7

Étienne Polge, A.T. et M.P., 2016. Dynamiques de proximités dans la construction de réseaux socio-économiques territoriaux en Amazonie brésilienne. Géographie, économie, société » 18, 493–524.

Fischer, E., Qaim, M., Goettingen, G., 2012. Linking Smallholders to Markets : Determinants and Impacts of Farmer Collective Action in Kenya. World Dev. 40, 1255–1268. https://doi.org/10.1016/j.worlddev.2011.11.018

Gammar, A.M., 2019. Dynamiques rurales et conservation forestière dans le Nord de la Tunisie. Rev. géographie Alp. 0–13. https://doi.org/10.4000/rga.6441

Gana, A., 2008. Restructurations agricoles en Tunisie : adaptations et différenciation. Autrepart

46, 81. https://doi.org/10.3917/autr.046.0081

GIZ, 2019. Promotion de l'Agriculture Durable et du Développement Rural (PAD) 2–3.

Habib, A., 1986. Problématique du développement du Nord-Ouest tunisien. Rev. des mondes musulmans la Méditerranée 264–280.

Habib Attia, 1986. Problématique du développement du Nord-Ouest tunisien. Rev. Occident. Musulman Mediterr. 41–42, 264–280. https://doi.org/10.3406/remmm.1986.2123

Haddar, M., Elachhab, F., Rhouma, A.B., 2017. Étude Stratégique sur l ' Économie Sociale et Solidaire en Tunisie - Resumé.

Hardin, G., 1968. The Tragedy of the Commons Garrett Hardin. Science (80-.). 162, 1243–1248.

Haubert, M., 1981. De la tradition communautaire à la modernité coopérative : évolution, greffage ou récupération ? Tiers. Monde. 22, 789–808. https://doi.org/10.3406/tiers.1981.4068

Hinrichs, C.C., 2003. The practice and politics of food system localization. J. Rural Stud. 19, 33–45. https://doi.org/https://doi.org/10.1016/S0743-0167(02)00040-2

Hinrichs, C.C., 2000. Embeddedness and local food systems: Notes on two types of direct agricultural market. J. Rural Stud. 16, 295–303. https://doi.org/10.1016/S0743-0167(99)00063-7

Israel, S.S. and Q., 1991. Sense of place: an empirical measurement. Geoforum 22, 347–358. https://doi.org/10.1016/0016-7185(91)90017-K

Journal Officiel de la République Tunisienne, 2020. Loi n° 2020-30 du 30 juin 2020, relative à l'économie sociale et solidaire 1399–1403.

Kruijssen, F., Keizer, M., Giuliani, A., 2009. Collective action for small-scale producers of agricultural biodiversity products TRIGGER : Food Policy 34, 46–52. https://doi.org/10.1016/j.foodpol.2008.10.008

Lee, S., 2020. Role of social and solidarity economy in localizing the sustainable development goals. Int. J. Sustain. Dev. World Ecol. 27, 65–71. https://doi.org/10.1080/13504509.2019.1670274

Luna, J.K., 2020. ' Pesticides are our children now ': cultural change and the technological treadmill in the Burkina Faso cotton sector. Agric. Human Values 37, 449–462. https://doi.org/10.1007/s10460-019-09999-y

Madoui, M., 2012. Ridha BEN AMOR, Les formes élémentaires du lien social en Tunisie. De l'entraide à la reconnaissance. Insa. / إنسانيات 219–221. https://doi.org/10.4000/insaniyat.13610

Magrini et al, 2017. Transition vers des systèmes agricole et agroalimentaire durables : quelle place et qualification pour les légumineuses à graines ? Rev. Française Socio-Économie 18, 53. https://doi.org/10.3917/rfse.018.0053

Mouelhi, R.B.A., Mehdi, B.B., Ghazali, M., 2021. The Social and Solidarity Economy in Tunisia and its role in formalising the Informal Economy: a qualitative survey.

Moulaert, F., Ailenei, O., 2005. Social Economy , Third Sector and Solidarity Relations : A Conceptual Synthesis from History to Present 42, 2037–2053.

Mtiraoui, A., 2014. Control of corruption, economic growth and human capital: MENA-OECD benchmarking.

Muchnik, S.C. and T., 2008. Systèmes agroalimentaires localisés: État des recherches et perspectives. Cah. Agric. 17, 513–519. https://doi.org/10.1684/agr.2008.0251

Mustapha, A. Ben, Faysse, N., Marlet, S., Jamin, J., 2015. N atures S ciences S ociétés Une action collective analysée par ses acteurs : une association d ' irrigants en Tunisie 23. https://doi.org/10.1051/nss/2015055

Mzoughi, N., 2011. Farmers adoption of integrated crop protection and organic farming: Do moral and social concerns matter? Ecol. Econ. 70, 1536–1545. https://doi.org/10.1016/j.ecolecon.2011.03.016

Pachoud, C., Labeyrie, V., Polge, E., 2019. Collective action in Localized Agrifood Systems : An analysis by the social networks and the proximities . Study of a Serrano cheese producers ' association in the Campos de Cima da Serra / Brazil. J. Rural Stud. 72, 58–74. https://doi.org/10.1016/j.jrurstud.2019.10.003

Patterson, J., 2017. Purposeful collective action in ambiguous and contested situations: Exploring 'enabling capacities' and cross-level interplay. Int. J. Commons 11, 248–274. https://doi.org/10.18352/ijc.696

Pierre-Marie Bosc, Didier Eychenne, Karim Hussein, B., Losch, Mari-Rose Mercoiret, Pierre Rondot, S., Mackintosh-Walker, 2002. The Role of Rural Producer Organizations in the World Bank Rural Development Strategy The World Bank Rural Development Family: Rural Development Strategy, Background Paper. Washington.

Poncet, 1963. La colonisation agricole en Tunisie de J . Poncet 494–495.

Raimbert et Rebaï, 2017. Collectifs et développement durable des territoires ruraux en Amérique latine. EchoGéo 0–25.

Rallet and Torre, 2005. Proximity and Localization. Reg. Stud. 39, 47–59.

https://doi.org/10.1080/0034340052000320842

Rhouma, A.B., 2020. La promotion de l'économie sociale et solidaire en Tunisie Analyse et mise en œuvre de la loi n°2020-30. Tunisie.

Romagny, B., Riaux, J., Romagny, B., Riaux, J., 2007. La gestion communautaire de l ' eau agricole à l ' épreuve des politiques participatives : regards croisés Tunisie / Maroc / Community-based agricultural water management in the light of La gestion communautaire de l ' eau agricole à l ' épreuve des polit. Hydrol. Sci. J. 52, 1179–1196. https://doi.org/10.1623/hysj.52.6.1179

Sabourin, É., 2007. L'entraide rurale, entre échange et réciprocité. Rev. du MAUSS 30, 198–2017.

Salman, L., 2017. What we talk about when we talk about What we talk about when we talk about decentralization ? Insights from post-revolution Tunisia 0–19. https://doi.org/10.4000/anneemaghreb.2975

Simmons, R., Birchall, J., 2008. The role of co-operatives in poverty reduction : Network perspectives 37, 2131–2140. https://doi.org/10.1016/j.socec.2008.04.016

Thorp, R., Stewart, F., Heyer, A., 2005. When and How Far is Group Formation a Route Out of Chronic Poverty ? 33, 907–920. https://doi.org/10.1016/j.worlddev.2004.09.016

Tibollo et al, 2014. Diagnostic de l'économie sociale et solidaire dans les gouvernorats d'interventon du projet IESS!

Torre, A., Vollet, D., 2016. Aux fondements du développement territorial. Partenariats pour le développement Territ. Éditions Quæ, Collect. « Updat. Sci. Technol. », 1–27.

Utting, P., 2015. Introduction: The Challenge of Scaling Up Social and Solidarity Economy, Social and Solidarity Economy: . Beyond the Fringe (London, Zed Books). https://doi.org/10.5040/9781350222618.0006

Verhofstadt, E., Maertens, M., 2014. Can agricultural cooperatives reduce poverty ? Heterogeneous impact of cooperative membership on farmers ' welfare in Rwanda.

Wagner, J.L., Ferguson, P.L., Kellermann, T., Smith, G., Brooks, B., 2016. Behavioral health referrals in pediatric epilepsy. Epilepsy Res. 127, 72–77. https://doi.org/10.1016/j.eplepsyres.2016.08.017

Walsh, P.E., Smith, J.L., 2007. Opposing standards within the cultural worldview: Terror management and American women's desire for uniqueness versus inclusiveness. Psychol. Women Q. 31, 103–113. https://doi.org/10.1111/j.1471-6402.2007.00335.x

Yousfi, H., 2019. Reshaping state/local communities relations in Tunisia: The socio-cultural and institutional challenges of the decentralization project. Eur. Manag. J. 37, 625–636. https://doi.org/10.1016/j.emj.2019.05.002

Discussion et conclusion

1. L'intensification agricole : une minoration du bien-être des populations rurales qu'il est difficile de quantifier et localiser.

Les travaux qui se sont intéressés à la dimension territoriale du bien-être dans les zones d'intensification de l'agriculture, montrent qu'il s'agit d'un système productif et économique qui ne réduit pas la pauvreté là où il y a une forte inégalité, comme dans les zones rurales excentrées des pays en développement, et qui, au contraire, est susceptible de conduire à exacerber la pauvreté ou à marginaliser les groupes défavorisés (Negin et al., 2009). Toutefois, ces travaux sont soit normatifs, soit contraints par l'absence de données aux échelles d'expression des phénomènes (locales). Des enquêtes empiriques sont disponibles et utiles, mais sont, de fait, difficilement généralisables. Or, l'expression du phénomène est spatialement hétérogène. Il reste donc, à mon sens, à apporter des connaissances d'ordre méthodologiques permettant de mesurer et localiser une relation multifactorielle (entre le bien-être et l'agriculture intensive) qui ne bénéficie pas d'enregistrements systématisés. A cette fin, j'ai proposé une méthodologie reposant sur un modèle structurel de type PLS (Partial Least Square) qui permet d'estimer une relation causale complexe et non mesurée, en l'occurrence l'effet de l'intensification agricole sur le niveau de bien-être de la population rurale, à une échelle localisée (infra-nationale). A ma connaissance, il s'agit d'un des premiers outils de modélisation du bien-être territorial à l'échelle infra communale, adapté aux pays en voie de développement.

De manière également intéressante, mes résultats ont mis en lumière les répercussions négatives de l'intensification agricole sur le bien-être territorial. En particulier dans la région du nord-ouest de la Tunisie, où le développement rapide des productions à forte intensité technologique (irrigation, mécanisation, intrants chimiques et OGM), individuellement rentables et économes en main-d'œuvre, a entraîné une augmentation de l'exode rural dans la vallée de Majerda et les plaines de elkef (Mzali, 1997). Il est important de rappeler que parmi les raisons qui expliquent les mouvements migratoires depuis les zones rurales et les zones d'activités agricoles, on trouve principalement le niveau de bien-être insatisfaisant, déjà constaté dans d'autres contextes ruraux et marginaux (Casini et al., 2019) ; niveau insatisfaisant inhérent à plusieurs composantes fondamentales du bien-être, pas nécessairement monétaires, tels que les services de santé et d'éducation, les transports publics ou les services privés de détail. À titre d'exemple, des études menées en Italie révèlent que la moindre disponibilité des services de santé et d'éducation est pénalisante pour les zones rurales (Boncinelli et al., 2015). En termes dynamiques, la boucle de causalité entre faible niveau de bien-être et retard de développement tend à renforcer le phénomène d'abandon progressif du territoire. En outre, deux éléments renforcent l'effet dépressif sur le bien

être :
- D'une part, l'intensification agricole a reposé, pour ce qui concerne la Tunisie, sur l'introduction de nouvelles variétés de semences à haut rendement qui s'avèrent mal adaptées au climat -déjà souligné par Laajimi (2007)-, ainsi que l'illustre l'effet négatif de l'indicateur bioclimatique au sein du modèle. L'effet dépressif sur le bien-être territorial de la sensibilité accrue à l'aléa climatique, remettent donc en cause, à mon sens, la durabilité du système intensif dans les zones rurales excentrées des pays en développement, considérant la tendance actuelle du changement climatique.
- D'autre part, l'impossibilité du pays à offrir une alternative en termes d'emplois à la main d'œuvre libérée dans les zones rurales qui a, évidemment un lien fort avec le chômage et la migration mais peut également être mise en perspective (Chebil. A et al., 2011; Grami and Ben Rejeb, 2015).

Pour être complet, il est à noter que si j'ai choisi une approche du bien être centrée sur les déterminants de Sen, d'autres perspectives peuvent être utilement complémentaires dont l'application d'une approche dans des contextes territoriaux permettant d'étudier les différences potentielles dans les composantes de base du bien-être rural , ainsi que le rôle qu'elles jouent dans sa formation et les raisons du phénomène d'abandon des zones rurales et des activités zones et des activités agricoles, en se focalisant sur les indicateurs traditionnels de développement tels que la terre, le bétail et le revenu agricole, qui sont des priorités pour le bien-être des populations rurales, ainsi que des pratiques traditionnelles qui sont fortement liées à la sécurité alimentaire de la famille(Dawson et al., 2016), avec un accent sur d'autres attributs collectifs et contextuels tels que le sentiment d'appartenance, la sécurité, le soutien de la communauté et les changements environnementaux avec des impacts liés à la sécurité alimentaire et de l'eau et l'accès aux services collectifs (écoles, hôpitaux, transports publics, etc.)(Casini et al., 2021, 2019; Elliott et al., 2017) afin d'identifier finement les éléments qui influencent la qualité de vie d'une communauté et qui pourrait contribuer également à mieux définir les politiques de développement territoriale.

2. Un verrouillage technologique limite la capacité des acteurs à mettre en œuvre une transition vers des pratiques plus durables

Mon travail contribue également à une littérature traitant de la persistance de l'utilisation des pesticides malgré la disponibilité d'alternatives au modèle productiviste, et permet de discuter la nature du verrouillage qui affecte l'agriculture dans un contexte de pays en développement. En considérant les études sur les mécanismes de verrouillage en économie (Cowan and Gunby, 1996), plus particulièrement celles axées sur le verrouillage technologique, il est évident que les conditions d'émergence d'une technologie sont déterminantes, notamment parce qu'elles initient des dynamiques à effets cumulatifs : au fil des années, l'innovation s'appuie sur un nombre croissant de

producteurs et des contextes socio-économiques structurés (le système bancaire, le mode de distribution, la connaissance incorporée, etc.), ce qui peut rendre la déconnexion technologique couteuse. Dans ce cadre, en reprenant la définition d'Arthur (1989), l'étude empirique que j'ai conduite dans la région nord-ouest de la Tunisie confirme que nous sommes bien dans une situation de verrouillage technologique qui explique, pour une grande part, l'utilisation de produits phytosanitaires et de semences hybrides par la majorité des agriculteurs alors que des solutions alternatives existent, comme l'agriculture biologique ou le recours aux variétés traditionnelles. Parmi les raisons invoquées par les agriculteurs, l'incertitude sur les rendements explique principalement le refus du changement, par souci de faible valorisation économique des produits obérant la rentabilité économique des exploitations (montré par ailleurs par Pissonnier et al., 2016). Or, les impacts des changements peuvent prendre plusieurs années avant de se manifester au sein des systèmes agricoles (Tourdonnet et al., 2018) et ce type de phénomène n'est pas suffisamment renseigné auprès des agriculteurs pour pouvoir induire un changement de stratégie productive. J'ai également montré que les caractéristiques personnelles des agriculteurs et leurs objectifs économiques déterminent fortement leurs choix productifs : les agriculteurs qui ne cherchent pas prioritairement à maximiser leurs revenus sont prêts à prendre plus de risques quant aux choix de pratiques (également mis en évidence par Dupré et al., 2017), par exemple pour se mettre en conformité avec leur sensibilité environnementale, avec leur aversion au risque (climatique) ou avec leurs objectif de mode de vie (Brodt et al., 2004). Au-delà de l'apparente banalité du résultat, il me semble intéressant de le mettre en regard de la politique agricole tunisienne reposant sur les investisseurs internationaux ou les gros producteurs nationaux, qui n'ont pas obligatoirement les attachements territoriaux de la majorité des agriculteurs traditionnels et se focalisent généralement sur la seule maximisation des revenus.

Plus précisément, cette étude met en évidence les facteurs qui favorisent (versus empêchent) l'adoption de pratiques alternatives et les effets de verrouillage induisant une dépendance des agriculteurs aux intrants synthétiques. Ces facteurs sont de types internes lorsqu'ils dépendent directement de l'agriculteur et de son exploitation, ainsi que du degré de ses préoccupations environnementales ; ils sont externes lorsqu'ils sont inhérents aux marchés locaux, à la législation publique, à l'accès aux services de vulgarisation, à l'organisation de l'approvisionnement en intrants et à l'environnement social (Dupré et al., 2017). Dans le cas tunisien, ce sont principalement les contraintes de prix (bas), de calibre standardisé et de qualité esthétique du produit qui rendent nécessaire la lutte contre les maladies fongiques et les parasites. Le recours aux substances chimiques est donc considéré par les agriculteurs comme une quasi assurance de rendements et de commercialisation. A mon sens, dans une telle situation, seule une évolution de la demande peut influencer sur la transition des agriculteurs vers des pratiques plus durables, en réévaluant les exigences en matière de qualité visuelle, de qualité environnementale et de prix (Hunt, 2007; Iles

et Marsh, 2012). D'autres éléments entrent également en jeu, comme les normes techniques : par exemple, les taux de protéines élevés imposés par les industriels pour le blé tendre obligent les agriculteurs à utiliser de fortes doses d'engrais (Fares et al, 2012). Il faut cependant noter qu'en Tunisie, comme dans d'autres pays en développement, l'insuffisance de connaissances sur les effets environnementaux et sanitaires de l'utilisation excessive de pesticides, associée à un faible niveau d'éducation, renforcé par l'environnement socioculturel (l'effet de voisinage, conseil agricole, les expériences personnelles, etc.), rendent plus difficile le changement de comportement des agriculteurs (Khan et al., 2015; Ntow et al., 2006; Stadlinger et al., 2011). J'ai ainsi montré que les personnes interrogées qui expriment une conscience des risques sanitaires et environnementaux associés à l'utilisation des pesticides, sont issues de l'administration, des agents de vulgarisation, des non-agriculteurs (syndicalistes) ou des personnes ayant fait des études supérieures, ainsi que des ouvriers agricoles par effet d'expérience (fréquence des affections). Cette situation contraste fortement avec celle des agriculteurs, qui s'expriment moins sur le sujet, alors qu'ils sont en contact direct avec ces substances. Il s'agit donc d'un système de croyances inhérent au groupe des agriculteurs (Diendéré et al., 2018) qui renforce le verrouillage technologique et dont l'évolution pourrait être un point focal d'une éventuelle action publique souhaitant minorer les effets néfastes des intrants chimiques sur l'environnement et la santé : l'absence d'un véritable plan d'éducation des agriculteurs freine la bonne appropriation des conseils qu'ils reçoivent. En outre, la promotion de l'enseignement agricole pourrait ne pas se limiter aux agriculteurs individuels, mais s'ouvrir plus largement aux organisations d'agriculteurs. Enfin, au-delà du rôle déterminant des conseils et de l'éducation, la décision d'un agriculteur d'utiliser plus ou moins de pesticides est influencée par la disponibilité des produits.

Toutefois, même si l'action publique tend à changer les pratiques, l'effet peut être dilué si elle n'est pas accompagnée d'une meilleure clarification de la réglementation sur les pesticides et d'une application plus stricte de la loi (Diendéré et al., 2018). Mon étude met, à ce titre, en lumière l'importance primordiale du rôle des institutions informelles sur le verrouillage de la transition vers la durabilité (comme montré dans d'autres situations par Hansen , et al., 2018 ou Ramos-mejía et al., 2018) : la corruption pour l'attribution des prêts, le clientélisme, la contrebande et les marchés parallèles d'intrants. En reprenant Gana (2008), et ayant à l'esprit que le phénomène a été exacerbé après la révolution de 2011, je peux considérer qu'il est issu de la privatisation non suffisamment encadrée de la commercialisation et des chaînes d'approvisionnement des intrants agricoles. De fait, les intrants certifiés et contrôlés existent mais ils sont concurrencés en prix et en disponibilité, par des intrants contrefaits provenant principalement de contrebande avec l'Algérie, qui sont vendus dans des points de vente légaux (avec de fausses indications sur la conformité aux normes nationales et internationales). La faiblesse de l'état a donc généré une incitation économique à l'usage de produits non contrôlés sanitairement et dont les faibles prix représentent corolairement un facteur

de sur-utilisation des pesticides qui freine le développement de pratiques plus durables (Marcoux and Urpelainen, 2011; Van Hoi et al., 2013).

3. Vers le développement d'un nouveau système de production qui associe les interactions entre les acteurs locaux, le territoire et la durabilité.

La transition et l'évolution vers des systèmes de production durables nécessitent la co-construction de nouveaux savoirs, basés à la fois sur des connaissances scientifiques et sur des pratiques et savoir-faire locaux, spécifiques aux contextes bioclimatique. Au-delà des connaissances globales, il s'agit d'appliquer des pratiques défensives qui correspondent à la spécificité de l'environnement local. Dans cette perspective, je me suis référé à deux concepts :

- Celui de "système alimentaire localisé" (SAL) (Bele et al., 2018; Hinrichs, 2003, 2000) qui croise les notions de territoire et de filière agroalimentaire, et intègre un double objectif de responsabilité sociétale (des producteurs comme des consommateurs, soit l'éthique alimentaire) et de développement durable.
- L'économie sociale et solidaire (ESS - associations, coopératives, mutuelles, entreprises sociales, groupements économiques, producteurs/trices, entrepreneurs/euses) qui porte de nombreuses initiatives au niveau local (dans le domaine de l'agriculture biologique, des voies d'innovation alternatives à la "chimie" portées par des agriculteurs et des communautés…) et qui vise généralement à renforcer l'autonomie des communautés locales (Allen, 2010), la création de revenus et la cohésion sociale (Utting, 2017).

Dans ce contexte, la mise en œuvre d'une politique agricole territoriale conforme aux objectifs de l'ESS offre une alternative vers une économie locale, collective, responsable et citoyenne, respectueuse des personnes et des ressources, créatrice de valeur économique et sociale dans les territoires et susceptible de répondre à la fois aux enjeux de création d'emplois et de cohésion sociale (Tibollo et al, 2014). En outre, les pratiques de travail collectif et de mutualisation informelles se retrouve dans des pratiques ancestrales telles que la *Twiza*[20] (évoquées dans mes enquêtes). Ces pratiques de solidarité, d'entraide et du travail collectif sont fortement influencées par la culture amazighe et la religion musulmane, et ont toujours été profondément ancrées dans les traditions et les pratiques des populations locales de la Tunisie. Dans ce cadre, je fais référence aux GDA et aux SMSA qui naissent dans un contexte territorial marqué par divers problèmes structurels et déséquilibres locaux. Leurs activités naissent du territoire, se développent sur le territoire et s'appuient sur ses ressources. Ces entités d'ESS combinent des activités rémunérées et non

[20] La Twiza *« consiste en un travail collectif non rémunéré et peut être considérée comme une véritable illustration d'une approche solidaire ancrée dans la culture maghrébine qu'on retrouve encore dans plusieurs régions de la Tunisie. Jusqu'à aujourd'hui, elle représente le mode de fonctionnement de plusieurs groupements informel, fondé sur le sens de l'éthique, la concertation, la cohésion sociale et l'esprit de solidarité. En effet, les pratiques de la Twiza individuelle et collective semblent une forme de résistance à l'évolution précipitée de nos sociétés dites modernes ».*(Tibollo et al, 2014)

marchandes en rassemblant différents acteurs. Elles participent donc à la correction des déséquilibres locaux et promeuvent un développement plus solidaire et de proximité, à travers une démocratie participative et dans le but d'une gouvernance organisationnelle locale. Les enquêtes que j'ai menée auprès des entités de l'ESS dans la région nord-ouest de la Tunisie, montrent que ces structures sont apparues dans un contexte de besoins mais à partir d'initiatives individuelles - spontanées. Je peux donc considérer que le secteur de l'ESS, dans notre zone d'étude, est encore dans sa phase naissante : la mise en place des structures repose sur des groupes de personnes préalablement en interconnaissance, généralement issues d'un même village, mais très peu d'institutions installées porteuses d'innovations. Très peu d'entités de l'ESS ont des dirigeants qualifiés capables de gérer les affaires courantes. En outre, les principes de l'ESS ne sont pas toujours clairs pour les dirigeants des entités existantes. Par exemple, la distribution des dividendes ne se fait pas toujours selon ces principes, mais plutôt selon d'autres formes d'arrangement (par exemple, le favoritisme) (Elachhab, 2018).

Enfin, l'un des facteurs importants empêchant le développement de l'action collective, et qui est prégnant dans les résultats de l'enquête que j'ai conduite, est la perception très négative des structures collectives par les communautés rurales : les collectifs agricoles contemporains sont confondus avec les coopératives agricoles "taadoudia" des années soixante, imposées par les autorités sous la responsabilité d'Ahmed Ben Salah et qui apparaît aujourd'hui comme un synonyme d'échec, de systèmes de contrôle et d'accaparement foncier. Les efforts contemporains de développent de l'ESS se heurtent au traumatisme mémoriel envers l'expérience coopérative symboliquement entachée autoritarisme (Yousfi, 2019). En outre, le développement du secteur de l'ESS en Tunisie est limité par plusieurs contraintes internes au secteur qui fragilisent le fonctionnement des organisations : des ressources humaines non qualifiées, une faible professionnalisation et un vieillissement de la population active agricole. Il est également confronté à des contraintes externes (institutionnelles, juridiques et financières – évoqué dans nos enquêtes) : la fragilité de ses acteurs et la méconnaissance de ses principes et valeurs par les pouvoirs publics expliquent en grande partie ses difficultés d'accès au financement (Elachhab, 2018). De fait, la plupart des initiatives existantes dans la région du Nord-Ouest sont le fruit d'initiatives individuelles inspirées de l'expérience marocaine, française ou italienne et sont appuyées par des fonds dédiés aux organisations de l'ESS (GIZ, OIT, etc.).

Il est également à considérer que ces initiatives de regroupements spontanés des agriculteurs peuvent être motivées par des considérations morales (l'éthique intrinsèque des individus) et sociales (adapter le comportement à son groupe de pairs, désir de statut, altruisme) (Mzoughi, 2011) pour lesquelles la qualité et de la structure du réseau relationnel joue un rôle clé dans les décisions d'adoption, comme l'identité collective lorsqu'elle est ancrée dans un espace (communauté, village, quartier). Dans cette perspective, les résultats de mon enquête de terrain montrent que les

agriculteurs qui ont des attitudes individualistes, centrées sur leurs intérêts personnels au détriment de la collectivité, sont les agriculteurs qui pratiquent le plus une agriculture intensive. Ces approches individualistes se cristallisent dans des comportements basés sur des critères psychologiques - comme l'aversion au risque de perte de productivité ou de rentabilité (Chèze, David et Martinet, 2020) ou démographiques - comme le sexe, l'âge ou l'éducation (Wagner et al. 2016; Burton, 2014). Enfin, conjointement à l'effet sur les verrouillages technologiques, la corruption joue également un rôle dans le faible développement des structures ESS et renforce donc les pratiques individualistes. Malgré la reconnaissance officielle de l'économie sociale et solidaire par la promulgation de la loi 2020/30, des anomalies structurelles sont présentes. A ce jour, en Tunisie, il n'est pas prévu de pôles territoriaux de coopération économique alors que ces structures constituent un pilier essentiel de fondation et de promotion de l'ESS (Rhouma, 2020). A titre d'exemple, en France, les pôles territoriaux de coopération économique constituent des regroupements sur un même territoire entre des entreprises de l'ESS, des entreprises privées et des organismes publics (collectivités locales, établissements d'enseignement, de formation et de recherche...) et toutes autres personnes physiques ou morales qui s'associent pour mettre en œuvre une stratégie commune au service de projets économiques et sociaux innovants et porteurs d'un développement local durable.

En résumé, mes travaux ont porté sur l'analyse de l'impact des systèmes d'intensification agricole dans les zones de production intensives d'un pays en voie de développement. La première étape de mon travail est consacrée à une analyse statistique visant à caractériser et évaluer l'impact du système d'agriculture intensive sur la qualité de vie de la population rurale à un niveau territorial. Dans une deuxième étape, l'étude est prolongée par une enquête exploratoire sur un échantillon couvrant un large éventail d'acteurs locaux afin d'analyser les facteurs de blocage qui empêchent les agriculteurs d'arrêter l'utilisation d'intrants chimiques et de passer à des pratiques plus durables. Dans une troisième étape, j'ai proposé une voie de transition vers un système de production agricole plus durable reposant sur l'action collective.

Mes résultats présentent une avancée originale à trois niveaux. (i) Une méthodologie reposant sur une méthode qui permet d'associer des structures complexes non recensées, comme le système d'intensification agricole et le bien-être de la population rurale à l'échelle territoriale. En outre, la méthode choisie permet de réaliser des analyses spatiales sans avoir recours à des enquêtes de terrain couteuses en main d'œuvre. (ii) La mise en évidence d'un verrouillage technologique spécifique au contexte des pays en développement (la faiblesse de l'état, la prégnance des marchés parallèles…) qui empêche les petits exploitants agricoles de passer d'un système productiviste à des pratiques alternatives plus durables. (iii) La validation empirique d'une proposition de reconception des systèmes agricoles intensif vers des solutions plus durables.

Ceci étant, j'ai conscience que le système productif agricole est inséré dans un contexte social et économique qui le dépasse et dont la transformation nécessite des changements dans les habitudes alimentaires des consommateurs, dans les exigences des agro-industries et des spécialistes du marketing, ainsi que dans les méthodes de travail des chercheurs et des conseillers agricoles. La réussite de cette transition dépend donc de l'implication et de la coopération de tous les parties prenantes de la société et la montée en généricité de mon cadre d'analyse sera le cadre de recherches ultérieures et complémentaires.

Enfin, les travaux que j'ai conduits ouvrent des perspectives de recherche qui ont trait à la territorialisation des modèles d'analyse du bien-être, adaptée aux situations de pays en voie de développement. En effet, tel que montré par (Casini et al., 2021), la dimension territoriale du bien-être est une dimension fondamentale de la notion qui a, jusqu'à présent, été peu mesurée sur l'étendue d'une région ou d'un pays

Reference

Allen, P., 2010. Realizing justice in local food systems. Cambridge J. Reg. Econ. Soc. 3, 295–308. https://doi.org/10.1093/cjres/rsq015

Arthur, W.B., 1989. Competing Technologies, Increasing Returns, and Lock-In by Historical Events. Econ. J. 99, 116. https://doi.org/10.2307/2234208

Bele, B., Norderhaug, A., Sickel, H., 2018. Localized agri-food systems and biodiversity. Agric. 8. https://doi.org/10.3390/agriculture8020022

Brodt, S., Klonsky, K., Tourte, L., Duncan, R., Hendricks, L., Ohmart, C., Verdegaal, P., 2004. Influence of farm management style on adoption of biologically integrated farming practices in California. Renew. Agric. Food Syst. 19, 237–247. https://doi.org/10.1079/rafs200488

Burton, R.J.F., 2014. The influence of farmer demographic characteristics a review. J. Environ. Manage. 135, 19–26.

Chebil. A, Mtimet.N, Tizaoui.H, 2011. Impact du changement climatique sur la productivité des cultures céréalières dans la région de Béja (Tunisie). African J. Agric. Resour. Econ. 6, 144–154.

Chèze, B., David, M., Martinet, V., 2020. Understanding farmers ' reluctance to reduce pesticide use : A choice experiment. Ecol. Econ. 167, 106349. https://doi.org/10.1016/j.ecolecon.2019.06.004

Cowan, R., Gunby, P., 1996. Sprayed to Death: Path Dependence, Lock-in and Pest Control Strategies. Econ. J. 106, 521–542. https://doi.org/10.2307/2235561

Dupré, M., Michels, T., Le Gal, P.Y., 2017. Diverse dynamics in agroecological transitions on fruit tree farms. Eur. J. Agron. 90, 23–33. https://doi.org/10.1016/j.eja.2017.07.002

Fares M, Magrini MB, T.P., 2012. Transition agroécologique, innovation et effets de verrouillage : le rôle de la structure organisationnelle des filières. Le cas de la filière blé dur française. Cah. Agric. 21, 34–45. https://doi.org/10.1684/agr.2012.0539

Gana, A., 2008. Restructurations agricoles en Tunisie : adaptations et différenciation. Autrepart 46, 81. https://doi.org/10.3917/autr.046.0081

Grami, D., Ben Rejeb, J., 2015. L'impact des changements climatiques sur le rendement de la céréaliculture dans la Région du Nord-Ouest de la Tunisie (Béja). New Medit 14, 36–41.

Hansen U.E., Nygaard I., Romijn H., Wieczorek A., K.L.M. et K.L., 2018. Sustainability transitions in developing countries : Stocktaking , new contributions and a research agenda. Environ. Sci. Policy 84, 198–203. https://doi.org/10.1016/j.envsci.2017.11.009

Hinrichs, C.C., 2003. The practice and politics of food system localization. J. Rural Stud. 19, 33–45. https://doi.org/https://doi.org/10.1016/S0743-0167(02)00040-2

Hinrichs, C.C., 2000. Embeddedness and local food systems: Notes on two types of direct agricultural market. J. Rural Stud. 16, 295–303. https://doi.org/10.1016/S0743-

0167(99)00063-7

Hunt, A.R., 2007. Consumer interactions and influences on farmers' market vendors. Renew. Agric. Food Syst. 22, 54–66. https://doi.org/10.1017/S1742170507001597

Iles, A., Marsh, R., 2012. Nurturing Diversified Farming Systems in Industrialized Countries : How Public Policy Can Contribute. Ecol. Soc. 17.

Laajimi, A., 2007. Les périmètres irrigués en Tunisie: Un enjeu pour le développement de la production agricole. Les notes d'alerte-CHIEAM 30, 1–3.

Marcoux, C., Urpelainen, J., 2011. Special Interests , Regulatory Quality , and the Pesticides Overload. Rev. Policy Res. 28, 585–612. https://doi.org/10.1111/j.1541-1338.2011.00528.x

Mzali, H., 1997. Marché du travail, Migrations Internes et Internationales en Tunsie. Rev. Région Développement 151–183.

Mzoughi, N., 2011. Farmers adoption of integrated crop protection and organic farming: Do moral and social concerns matter? Ecol. Econ. 70, 1536–1545. https://doi.org/10.1016/j.ecolecon.2011.03.016

Negin, J., Remans, R., Karuti, S., Fanzo, J.C., 2009. Integrating a broader notion of food security and gender empowerment into the African Green Revolution. Food Secur. 1, 351–360. https://doi.org/10.1007/s12571-009-0025-z

Pissonnier, S., Lavigne, C., Toubon, J.F., Le Gal, P.Y., 2016. Factors driving growers' selection and implementation of an apple crop protection strategy at the farm level. Crop Prot. 88, 109–117. https://doi.org/10.1016/j.cropro.2016.06.007

Ramos-mejía, M., Franco-garcia, M., Jauregui-becker, J.M., 2018. Sustainability transitions in the developing world : Challenges of socio- technical transformations unfolding in contexts of poverty. Environ. Sci. Policy 84, 217–223. https://doi.org/10.1016/j.envsci.2017.03.010

Tibollo et al, 2014. "Diagnostic de l'économie Sociale et Solidaire Dans Les Gouvernorats d'interventon Du Projet IESS!"https://www.cresspaca.org/images/files/Etude1_ProjetIESS.pdf.

Tourdonnet, S. De, Barbier, J.M., Courty, S., Martel, P., Lucas, V., 2018. How can collective organization and the search for autonomy lead to an agroecological transition ? The example of farm machinery cooperatives in France. Eur. IFSA Symp. 1–8.

Utting, P., 2017. Public Policies for Social and Solidarity Economy: Assessing Progress in Seven Countries.

Van Hoi, P., Mol, A., Oosterveer, P., 2013. State governance of pesticide use and trade in Vietnam. NJAS - Wageningen J. Life Sci. 67, 19–26. https://doi.org/10.1016/j.njas.2013.09.001

Wagner, J.L., Ferguson, P.L., Kellermann, T., Smith, G., Brooks, B., 2016. Behavioral health referrals in pediatric epilepsy. Epilepsy Res. 127, 72–77. https://doi.org/10.1016/j.eplepsyres.2016.08.017

Yousfi, H., 2019. Reshaping state/local communities relations in Tunisia: The socio-cultural and

institutional challenges of the decentralization project. Eur. Manag. J. 37, 625–636. https://doi.org/10.1016/j.emj.2019.05.002