Rural transformation, innovation and sustainable agro-food systems

The global challenge of feeding the growing population, while preserving the natural resource base in the context of climate change, implies the need for profound transformation of agro-food systems. This paper considers the changes in progress in rural areas, their multifaceted relationships with the cities, as well as their implications for system-level innovation in driving sustainable rural transformation

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The global challenge of satisfying the growing world food demand and reducing poverty, while preserving the natural resource base of food production and facing the climate change, is of unprecedented dimensions and nature. World agriculture and food systems are in fact called to play the protagonist role in achieving the Sustainable Development Goals (SDG), primarily the SDG 2 "*End hunger, achieve food security and improved nutrition, and promote sustainable agriculture*", and the objectives of the Paris Agreement[1]. A profound transformation is in other words required to reposition the global food and agriculture systems from being an important driver (and a victim at the same time) of environmental degradation and climate change to becoming a key contributor to the transition to sustainability, increasing at the same time the total food production and improving the rural livelihoods [1].
This paper offers a contribution to the analysis of the changes in progress in rural areas, their multifaceted relationships with the cities, as well as the challenges and opportunities offered by these changes to small and medium agricultural producers. The pivotal role of innovation in rural transformation is discussed, including not only the technology drivers, but also organizational and social change. Finally, the development of analytical frameworks and indicators for agriculture and food systems, key for orienting the innovation processes in the desired direction, multidimensional benchmarking and programme monitoring, is examined.

Rural Transformation

Rural transformation occurs within a broader context of economy-wide structural transformation, which is both caused by and affects agricultural sector and is interlinked with recent phenomena of rapid urbanisation, dietary changes, food value chain transformation and intensification in farm technology [1].
Nowadays rural areas vary enormously across different parts of the world, and even within single countries according to the different types of economic activities performed, different levels of productivity and value added, and different social and environmental conditions. Urbanisation is much more advanced in developed countries, while the rural population is still growing in developing countries. Even though in some places economic development and recent information revolution have impacted positively the rural transformation process in bringing prosperity and bridging the rural-urban gap, in others, especially in the global South, the inequalities between rural and urban spaces are widening, leading to negative feedbacks on the transformation process, which is impacted also by climate change and/or processes of environmental degradation. Rural transformation that resulted in reinforcing the capacity of agro-food systems to valorise specific territorial resources and social relations of proximity have shaped a *new paradigm on rural development,* outlined in a seminal OECD report[2], which is driving also a transition in rural

	Old Paradigm	New Paradigm	Rural policy – Implementing the new paradigm
Objectives	Equalization	Competitiveness	Well-being considering multiple dimensions of: (i) economy; (ii) society; and (iii) the environment.
Policy focus	Support to a single dominant resource sector	Support for multiple sectors based on their competitiveness	Low-density economies differentiated by type of rural area.
Tools	Subsidies for firms	Investments in qualified firms and communities	Integrated rural development approach – spectrum of support to public sector, firms and third sector.
Key actors and stakeholders	Farmers' organizations and national governments	All levels of government and all relevant departments plus local stakeholders	Involvement of: (i) public sector – multilevel governance; (ii) private sector – for-profit firms and social enterprises; and (iii) third sector – Non-governmental and civil society organizations
Policy approach	Uniformly applied top-down policy	Bottom-up policy, local strategies.	Integrated approach with multiple policy domains.
Definition of rural	Not urban	Rural as a variety of distinct types of areas	Multiple rural territory types according to policy scope, scale and territorial differences

Tab. 1 Rural policy 3.0[2]

policy approaches toward achieving the SDGs (Table 1).

The new policy orientation adopts a territorial approach shifting from subsidy-based support to agriculture toward investment-driven development of rural territories. The root principles of such an approach lie in recognising that (1) rural areas vary enormously across the world, but are all over inextricably linked to cities, regions and national contexts; (2) governance is a key factor in success or failure of rural development projects; (3) environmental sustainability is a pre-condition to inclusive rural transformation; and (4) in different places agro-food systems are embedded to a different degree in territorial features and intimately linked with other activities such as tourism, nature conservation, industry, health care, education. Policy targets include reconfiguration of the linkages between rural and urban spaces, strengthening small-scale farmers' organisational capacities, diversifying rural economy, promoting community mobilisation to facilitate rural people's access to information, supporting collective action so that rural people take ownership of their own development.

A central focus of such approaches is on sustainable agriculture and food systems. Fig. 1 displays main drivers for food system transformation, which directly impact the rural transformation processes, through re-configuration of four relationship axes between: 1) agriculture and the environment, 2) actors of the food value chain that connect production and consumption 3) urban and rural areas 4) food supply and food consumption, i.e. the food environment. Food systems can be reconfigured by redesigning production, distribution and trade systems and promoting responsible food consumption patterns so as to assure desired outcomes along all four axes. In order to achieve these results, it is necessary to create an enabling environment, which comprises cultural and behavioural aspects, tacit and explicit norms and standards for knowledge creation, use and diffusion, private and public policies, institutions and governance mechanisms.

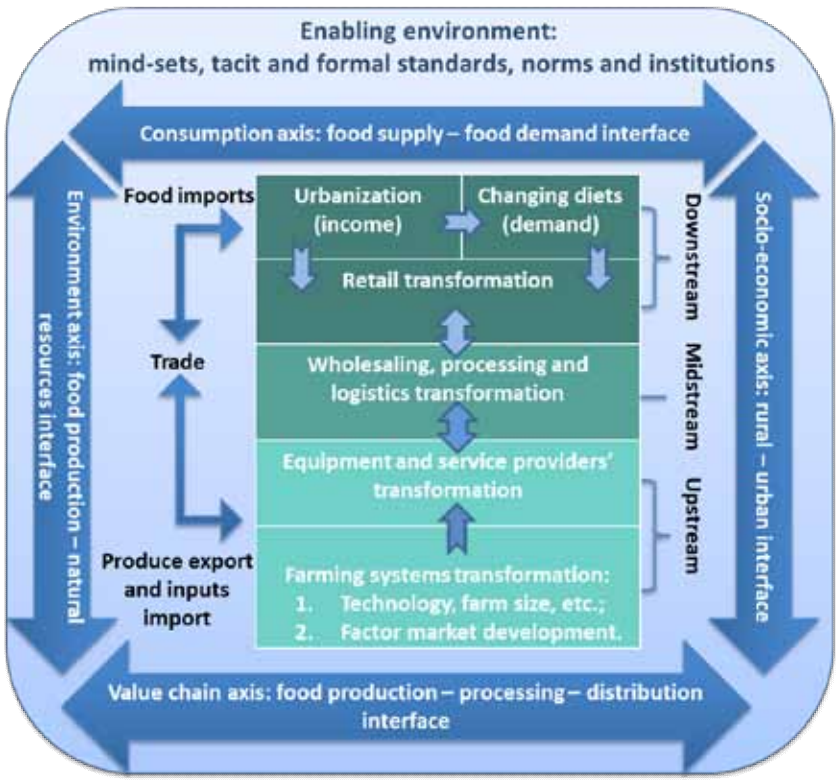

Fig. 1 Main drivers for food system transformation across axes of change with environmental relevance from the perspective of site-based sustainable diets (based on [1])

The role of innovation

In order to drive inclusive and sustainable rural transformation it is necessary to create favorable conditions for innovation, facilitating the generation of new knowledge and effectively translating new and existing knowledge into appropriate use [1].

At present, the prevailing approach in food and agricultural research and innovation is reductionist, characterized by fragmentation of academic disciplines, tendency to overspecialization and focus on only single phases or issues along the food chain at a time. However, sustainable rural transformation cannot be described or planned using exclusively linear functions, while neglecting multiple interdependencies and interrelations among food chain actors, supply and consumption, urban and rural areas as well as agriculture and the environment (see Fig. 1). The complex and dynamic nature of food and agricultural systems and the multifaceted rural-urban interrelationships require the adoption of a more systemic thinking. The systemic ap-

proach (i) integrates different disciplines and perspectives; (ii) does not single out the system's components but studies the complex interplay among them; (iii) consolidates local, traditional and formal scientific knowledge; and (iv) considers production systems together with their determinants, from ecosystems and natural resources to food chains and market drivers [2]. The impressive advances of information and communication technologies (ITCs) and artificial intelligence allow for the gathering, systematization, analysis, and sharing of large amounts of data and therefore can offer substantive contributions to govern complexity. However, system thinking goes beyond data management and requires a mindset change, conceiving innovation at level of the entire food system that affects also the enabling environment (Fig. 1) and its capacities in driving sustainable rural transformation processes. In particular, this implies 1) new investment models in research and innovation, 2) new networking models for innovation adoption, and 3) new analytic tools and indicator systems in facilitating collaborative design and evaluation of innovation at food system level in order to orient the innovation process towards sustainability.

Investments in research and innovation

Regardless of the widely recognized importance of innovation for rural transformation, during the last decades of the XX century public expenditure in agriculture research and development suffered at global level from a severe decline. This global tendency was present also in Italy, where public expenditure in agricultural research diminished by an average annual rate of 1.2% in the '90s [3]. This trend seems to be now inverted, as global public spending increased by an average of 3.1% during the first decade of XXI century, but this increase can be largely attributed to a handful of emerging economies. Investments in agricultural research and innovation need time before giving returns. Insufficient, instable, and unpredictable investments can therefore bar innovation process.

The decline of public agricultural research spending is accompanied by a rapid growth of private investments, which increased from 5.1 billion $ in 1990 to 15.6 billion $ in 2014. While in the '90s private investments were concentrated in research for farm machinery, agrochemicals and fertilizers, and animal health, nutrition and genetics, at present private investments in research for crop seeds and biotechnology became predominant. Investments for research in the food industry come virtually only from the private sector. Privately funded research is focused on commodities, where large markets for agricultural inputs can potentially compensate high, long-term research investments. Private sector research depends to a large extent on using knowledge, methods and technologies developed in the public sector. Private sector cannot therefore replace public agricultural research, which is called to cover not only the upstream science, but also the less commercially attractive innovation fields, including agricultural sustainability. Public and private agricultural research sectors are in this perspective becoming highly interdependent, and in order to be able to drive the transformation process into the desired directions, it is necessary to achieve their complementarity. Furthermore, many public policies affecting food (agricultural, environmental, food and consumption, trade, territorial cohesion, etc.) need to be integrated, as fragmentation of public funding is one of the most important hurdles to system-level innovation [4].

Networking models for research and innovation

Bridging the growing divide between the knowledge generated by public sector research programs and its acceptance and adoption by end-users, requires enhanced collaboration between research-providers and the general public. Inappropriateness of new technology, for instance because it addresses problems that are not perceived by users, has been indicated as a more common cause of non-adoption than inappropriateness of transfer mechanisms. Collaboration between researchers and users should therefore start from co-design of research projects and its objectives and culminate in farmers' direct involvement in validation and economic assessment of new technologies. The complexity of rural transformation requires a rethinking of the way knowledge is transformed into economic, social and environmental value, passing from linear technology transfer models to the Agricultural Innovation System (AIS) perspective. Innovation of agricultural and food systems is, in other words, the outcome of networks of actors that bring existing or new products, processes, and forms of organization into social and economic use. AIS actors can be positioned in three main groups: research and education; business and enterprises, including farmers and their associations; and bridging institutions, including extension services, other

brokering agencies, and contractual arrangements. Supporting policies and institutions (formal and informal), which inform the interaction between these actors, shape the forth component or 'enabling environment', on which the three former components are embedded. According to this perspective, innovation is more the outcome of the network by which organizations or individuals engage with each other than the result of quality and excellence of the single components of the system. Conventional actors (research and extension) in agricultural development play an important role in agricultural innovation, but their services are to be reconsidered in relation to the roles of the other actors that interact within dynamic networks. The enabling environment plays a prominent role in unleashing the potential of innovation. In that respect the capacity of AIS actors to engage in strategic and political decision-making processes assumes a paramount importance. According to the AIS perspective, innovation takes place at different scales, from micro-scale (i.e. the individual farm or farmer group) to meso-scale, when an entire sector or value chain is implicated, to macro-scale when the economy of an entire territory is affected. If it is true that changes at macro or meso levels have implications across the entire system, affecting also the micro level, it is also true that system's behaviours may change as a result of behaviour modifications at individual level.

Tools for co-designing and evaluating innovation in agricultural and food systems

The implementation of inclusive models for innovation management can employ tools, which support communication between stakeholders and allow for systematic management of the existing and newly created knowledge within the respective networks of actors. In this regard, appropriate analytical frameworks and indicators, which allow for co-designing system-level innovation and assess whether they drive rural transformation processes in the desired direction, become fundamental.

While an appropriate theoretical framework to adequately address the innovation needs in the context of sustainable rural transformation is only at its initial stage of development (f.i. [5] and [6]), in practice there are many innovation initiatives which claim to be sustainable by making reference to different types of indicator systems, voluntary certification schemes or other market-oriented instruments. Such information-based tools, make reference to their built-in conceptualizations and theoretical frameworks built around particular values and normative propositions of what is sustainable food (Fig. 2). At present, the most popular tools of this kind, are those based on Life Cycle Thinking (LCT), structured around Life Cycle Assessment (LCA) methodology by extending it in various ways as to adjust the design and assessment to food and agriculture systems or extending it to meso or macro scale (covering economic activities within administrative territorial units). LCT-based frameworks and tools allow for systematic representation, analysis and assessment of food chains, but they are able to support *systemic* analysis only for specific types of food systems, which are consistent with the underlying assumptions and value-propositions upon which LCT-thinking is consistently constructed. Furthermore, the LCA-based indicators are useful tools when related to efficiency or demand-restraint perspectives (Fig. 2), both of which focus on innovation at level of single system components at supply or consumption sides, while their usefulness in considering system-level innovation is questionable.

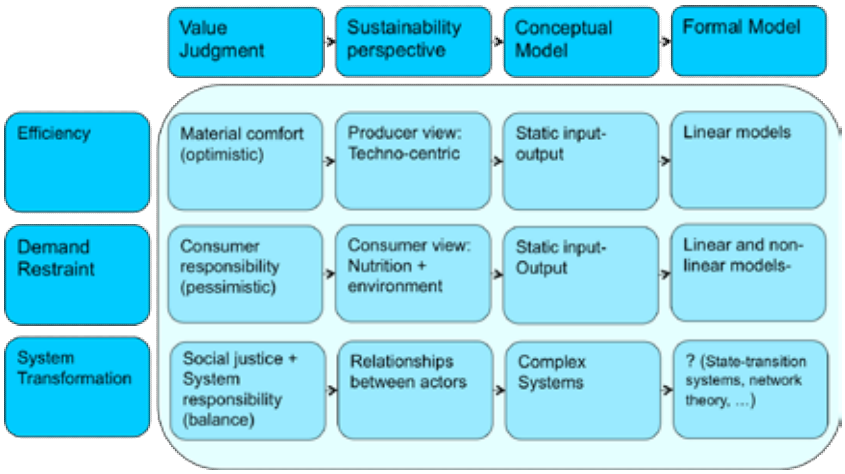

Fig. 2 Linking values with formally defined indicators [7]

Conclusions

The new policy paradigm for rural development recognizes that ter-

ritorial differences could result in different trajectories for sustainable development, which at level of tools could not necessarily lead to identical conceptualizations of sustainability principles for all rural territories across the world, or even within the boundaries of single countries.
In order to deliver information tools which are useful in the collaborative design and assessment of innovation capable of triggering sustainable rural transformation processes, it is of fundamental importance developing sound theoretical frameworks and conceptualizations which allow for (a) shifting the focus of analysis from value-chain/sector-based approaches to integrated landscape approaches targeting the whole economy of a territory, and (b) collective reflection on values that determine what is considered a sustainable food and agriculture system for a specific territorial context and its relations with other territories within the world economy.

[1] http://unfccc.int/paris_agreement/items/9485.php
[2] Adapted from OECD (2016), "The New Rural Paradigm: Policies and Governance", OECD, Paris, http://www.oecd.org/cfe/regional-policy/thenewruralparadigmpoliciesandgovernance.htm

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