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THE AGRICULTURE'S ROLE FOR SUSTAINABLE AND INCLUSIVE DEVELOPMENT

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Sustainable development is characterized by interconnected social, economic, and ecological aspects and it is at the core value of the worldwide economy. A participatory and accountable framework is a prerequisite for inclusive and sustainable development; so power is redistributed, reducing uncertainty, inequality and promoting shared prosperity. Despite its crucial importance and relevance, barriers remain in making progress towards its implementation, in particular for the agricultural sector. The purpose of this paper is to investigate the role of agriculture for sustainable and inclusive development, highlighting environmental, economic and social dimensions. Then, we aim at providing policy-makers more accessible results on trade-offs of alternative measures for greening the agri-food system. The research is based on method of analysis based on an extensive review of research evidence related in particular to Climate Smart Agriculture (CSA). Focusing on CSA role, a set of priority actions for greening systems are drawn up. Results of analysis provide an insight on a new System Dynamics model able to represent the complex causal relations and non-linear feedback loops among key dimensions and actors of sustainable development. Furthermore investments/measures coordination in agriculture and higher farmers' knowledge are crucial driver in reaching this ambition.
Keywords: agri-ecosystems, climate smart agriculture, food system, inclusive development, sustainability, resilience, system dynamics model.
JEL Codes: Q01, Q15, Q56.

1. Introduction

In an increasingly globalized world, agriculture faces new and different challenges during its transformations. Agriculture in development has traditionally been seen to be a provider of goods to the industrial sector although agriculture's role in generating output and providing employment has recently declined relatively. Generally speaking, agriculture has a primary role in socio-economic-environmental systems. Land used for agricultural production (cropland, managed grassland, permanent crops) is about 37.8% of the global land surface (World development …, 2012). Then agriculture has a key role on essential ecosystem and on services and public goods preservation so representing a crucial problem of interest for researchers and policy makers; a plethora di works highlights the agriculture's role for sustainable and inclusive development. Agriculture is both a source of several greenhouse gases (1/3 global GHG emissions – UNFCCC, 2009) and a "sink" for absorbing carbon dioxide but is a comparatively modest negative source than other sectors such as transportation and electricity generation (de Carvalho, 2006; Copeland, 2011); then agricultural lands contribute to 14%, deforestation to 17% (UNFCCC, 2008). On the other side, conservation agriculture can assure higher crop productivity, food security, improved livelihoods and land environmental protection (Nkala, 2011). Indeed, conservation tillage practices for climate change abatement or mitigation is receiving increased attention (Copeland, 2011; Lahmar, 2010; Antonazzo, 2012). Agriculture, Forestry, and Land Use (AFOLU) have a central environmental, economic and social role and dimension for meeting Millennium Development Goals. AFOLU is:

- responsible for meeting a food demand expected to increase by 70% by 2050 (OECD/FAO, 2009);
- livelihood support for 40% of global population and 70% of rural poor in Least Developed Countries (LDC) (IAASTD, 2009);
- on average 28% of Gross Domestic Product (GDP) in LDCs; 10% in middle income countries;
- GDP growth originating in agriculture two times more effective in reducing poverty than GDP growth outside agriculture (World Bank, 2008);
- more than 80% of reduction in poverty worldwide due to development in rural areas, rather than migration to cities;
- for every 10% of increase in farm yields, 7% reduction in poverty.

A huge debate stands out about agriculture's role in promoting pro-poor economic growth and in reduction vulnerability of rural areas: some researchers and policymakers have high expectations of agriculture's potential to alleviate poverty and reduce malnutrition, regardless of a lack of substantive evidence (Headey, 2012; Diao, 2007); other scholars highlight agriculture's 'mythos' role in poverty reduction and for improved food security in developing countries such as Africa (Holmen, 2006; Kydd, 2004). This insight is not accepted by other researchers (Diao, 2007) that demonstrate agricultural growth is still important for most low-income African countries if there is a wide participation of smallholder farmers. Agriculture can produce benefits as urban agriculture too, including increased food access, job creation, educational opportunities, and green space (Reynolds, 2014). Furthermore, within an crisis economic period, scholars (Karelakis, 2013) have demonstrate agriculture's role can be called to play an enhanced role, particularly the livestock sector that comprises a key growth element for the economy; there are few other candidates with the same potential for supporting pro-poor growth (Kydd, 2004). The aim of this research is to analyze and understand the role of agriculture nowadays, by means an extensive review of research evidence related in particular to Climate Smart Agriculture; then, a new modeling methodology that networks key dimensions and actors of sustainable development is introduced. Since we cannot rely on the current modelling approaches and tools, the benefits of the research are to provide insights on possible strategic models for policy-makers aiming at choosing substitute measures for economic-social sustainability of development.

2. Agriculture and climate change

The concept of sustainability takes in account four crucial issues: (1) food security; (2) employment and income generation; (3) environmental and natural resource conservation; (4) people's participation and empowerment (van Mansvelt, 1993). Moreover, the global challenges of climate change, food security, and poverty mitigation are the main issues strongly connected with agriculture that impact on ecosystems, economy and people and require the improvement of the adaptive capacity and mitigation potential of agricultural landscapes (Harvey, 2013). Complex linkages between climate change and agriculture stands out owing to systemic characteristics and chain effects across linked sectors and geographic areas. The effects of changes induced by climate change are faster than socio-techno-economic adaptive capacities; soil erosion, desertification, sea-level rise make agriculture vulnerable to climate change. Disruptive extreme events worsen access to limited resources and induce land and food degradation, increasing volatility and costs for commodities (food, feed, and fuel). All this leads to poverty (especially on small-scale farms), which increases the risk of political instability, conflicts and human consequences so determining uncertainty (opposite feedback loops) and unbalanced distributional effects. Fig. shows the impact of climate change on agriculture highlighting the direct/indirect, tangible/intangible effects and the long term consequences. In this context, climate-smart agriculture (CSA) could contribute tackling climate change and assure food security for a growing global population while increasing sustainable productivity, enhancing resilience, adapting to a changing climate and reducing carbon emissions and biophysical, socio-economic resilience (FAO, 2010; World Bank, 2011; CGIAR, 2014; Singh, 2012).

Fig. Impact of climate change on agriculture

Direct	Indirect	Tangible	Intangible
Physical damage on crops, animals	Loss of potential production and capacities, increased costs of production	Measured in monetary terms	Difficult to measure in monetary terms (fear of future disruption, stress)

Long term consequences

- Loss of perennial crops and forests
- Drought can stimulate reactions often leading to long-term land degradation
- Floods can make land unsuitable for production for years (loss of top soil, nutrients soil etc.)

In this way, CSA could support the creation of short, high value chains and agri-food clusters developing local and regional market in the areas where this approach is applied. Moving towards an agriculture that utilizes climate benefits more smartly is one of the crucial solutions for the sustainable challenges (Xiong, 2014) and lies at the crossroads of climate-change mitigation and adaptation efforts (Harvey, 2013). Some of the key challenges for the implementation are (i) the multilevel governance costs, (ii) the availability of adequate financial resources in to be deployed, in particular in vulnerable areas, and (iii) a good understanding of ecosystems. Mitigation with respect to climate change means implementing policies to reduce greenhouse gas emissions and enhance sinks (Aleksandrova, 2014) reducing adverse effects on human health and the environment (Gallo, 2014). Thus mitigation is principally driven by international agreements (e. g., the Kyoto Protocol) and ensuing national public policies (Harvey, 2013). Instead, adaptation is the ability of a system to adjust to climate change, to moderate potential damages, to take advantage of opportunities, or to cope with the consequences (IPCC 2007). Even if they are different in general, mitigation and adaptation are inter-linked in agriculture, and the integration of adaptation and mitigation goals requires longer term planning horizons (Biesbroek, 2009). Scholars (Aleksandrova, 2014) highlight the relationship between climate pressures, social and ecological systems and the role of adaptation/mitigation and institutions concluding that a single adaptation/mitigation measure could address instead ofone vulnerability component (e. g. practices preserving ecosystem functions could provide social benefits such as income diversification). The agricultural sector is identified as one of the areas where the opportunities for synergies between mitigation and adaptation are potentially high (Sherr, 2012; FAO, 2012; World Bank, 2013). Still, in most cases adaptation and mitigation benefits will only be possible if action is taken across an entire landscape (Sherr, 2012).

3. Results of analysis

The CSA approach could support national food security and inclusive development in high, emerging and low income countries by (i) promoting sustainable agricultural intensification to allow access to food to a growing world population and (ii) assuring resource resilience by introducing agricultural mitigation and adaptation measures to curb greenhouse gas (GHG) emissions linked to agriculture. Despite the positive results in the countries where the CSA was adopted (e. g., Ethiopia, CGIAR, 2014), such approach is still waiting for translation into tailored tools at the country level to support effective implementation. In fact, there is only limited evidence available from country case studies on CSA application and its role for sustainability despite clear international policy support to research in this field. As a matter of fact, a codified multi-sectoral approach would be crucial to implement a ‘triple win’ strategy for the promotion of sustainable development policies where the agricultural sector is a tool for delivering climate adaptation, mitigation, and food security. FAO (2012) identifies 4 key steps for the CAS to be followed:

- integrated, context-specific assessment of drivers of unsustainability/GHG emissions and potential interventions with a focus on: (i) synergies (e.g. diversified production and income sources); (ii) trade-offs (e. g. biodiversity vs. food production); (iii) main barriers to their implementation (e.g. weak information or legal systems);
- strengthening institutions and infrastructure for sustainable practices for farming, forestry, fishing promoting efficient and short food chains; governance systems to manage common resources; strengthen land tenure; improve ecosystem services;
- establishing strategic framework to coordinate key stakeholders (ministries, local governments, farmers, international agencies) in order to implement market measures (credit and market access); blended financing sources (climate funds; public and private sources) to encourage CSA practices, to reduce and respond to disaster risk (e.g. insurance; social protection);
- capacity building for information systems and R&D (varieties and breeds suitable for vulnerable populations), advisory services (risk assessment), info technologies, Monitoring and Evaluation.

Given the complexity, multidimensionality, non-linearity, and uncertainty which characterize agri-ecosystems and the interdependencies between actors and sectors which characterize the CSA approach, in order to asses its impact on sustainability we cannot rely on the current modelling approaches and tools (e.g., neoclassical based general equilibrium models). The complex general equilibrium/ neoclassical based models developed in the last decades provide a set of useful policy tools for near-equilibrium economies and have, importantly, been extended to include externalities such as environmental pollution. However, they are not able, by construction, to model the dynamics of a complex system characterized by non-linearity, multiple opposite feedbacks, time delays, non-linear, non-rationale, short time thinking and free riders agents. Most important, their findings are not easy to communicate to the broad non-academic audience of stakeholders. In fact, they return policymakers one-dimensional strategies aimed at boosting economic growth, instead of adopting a systemic approach that is able to account for multidimensionality of risk which characterize countries' integrated socio-economic and environmental system (Zadek, 2014). Thus, they are not able to understand the effects of the introduction of alternative CSA policy measures on the whole socio-economic system where agriculture represents a dimension, with the risk to misunderstand and/or underestimate the drivers of success or unintended effects, and the overestimation of the policy answer. In order to address such limitations, an international research group (Monasterolo, 2014) is developing a new System Dynamics model able to represent the complex causal relations and non-linear feedback loops among key dimensions and actors of sustainable development to provide policy makers accessible results and policy recommendations for sustainable food security, tacking stock of the experience of SD applied to global development (from the Club of Rome's World 3 to the Millennium Institute's Threshold 21). System Dynamic models which have been readapted from their initial application to engineering and business model theory (Sterman, 2000; Mollona, 2008) are simulation models which mimic the system behaviour that they try to reproduce in its functional relationships. The SD works at the macro, aggregate level. It is built on a discrete difference equations and it is organized in stocks (variables) and flows (derivatives) and the feedback loops (which can be reinforcing or balancing) which shape the causal relations between them. The goal of the model is to provide policy-makers more accessible results on trade-offs of alternative measures for greening the food system while assuring food security.

4. Conclusion

1. Developing policies and strategies to tackle climate change have been at the centre of the attention within the green growth strategy (Copeland, 2011), and lately focused on the potential role of CSA. In considering the farmers' adaptation heterogeneous behavior, it is important to analyze the factors influencing this variability (Toillier, 2009) in order to introduce targeted sustainability measures, in line with existing understanding of the role of agriculture for climate mitigation and adaptation.

2. Policy-makers are requested to focus more on agriculture (given a growing world population with a more constrained agricultural land), and be awake of the diversity of institutional, trade, technological and governance challenges which characterize poverty-reduction strategies (Kydd, 2004), and their relation with green growth. The coordination of funding institutions and investments in agriculture can add value to sustainable development path only if the process of measures selection gives voice to local beneficiaries (Grabowski, 1999). The challenge consists in developing a new institutional framework involving the public and private sectors. Farmers should be at the heart of this strategy but they are often not aware of the multidimensional benefits of CSA (Aleksandrova, 2014).

3. Despite agriculture seems rather a static sector, it is characterized by risk and uncertainty which derive from the specific sector / country and from commodity performance (climate/input/education-culture related yields); from societal trends (population growth, consumption patters, trade), farmers' behavior (incentives, risk aversion – related to age, education, localization, commodity), policy influence and changes, technology appeal and specific learning curves. In order to contribute tackling climate change, the key sources of uncertainty which characterize the sector have to be understood in their systemic relation, accounting for opposite feedback loops and unintended effects. A main obstacle to the analysis of the impact of the introduction of CSA for sustainability is represented by the availability and fluidity of data which may cause misunderstanding of model scenarios results and double counting of mitigation potential in the trade off by sectors (in particular between agriculture, energy and transport sectors).

4. Smart changes in land use may strengthen the capacity of farmers, policy-makers and institutions to respond to climate challenges thanks to a shift towards more fair and participatory distribution of decision power among all the actors and

towards best conditions that reflect sustainable and inclusive values of development. In order to support the policy-making process providing more accessible and transparent data, a new SD model reproducing functional relationships and key dimensions is being developed because able to overcome limitations represented by strong assumptions and structure of currently used equilibrium-based econometric models.

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ŽEMĖS ŪKIO VAIDMUO TVARIAME IR INTEGRACINIAME VYSTYMESI

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Tvarus vystymasis, apibūdinimas tarpusavyje besijungiančiais socialiniais, ekonominiais ir ekologiniais aspektais, – tai viena pagrindinių vertybių pasaulinėje ekonomikoje. Nepaisant darnaus vystymo aktualumo, kliūčių jį įgyvendinant, ypač žemės ūkio sektoriuje, vis dar pasitaiko. Šio darbo tikslas – išskirti žemės ūkio vaidmenį tvariame integraciniame vystymesi, pabrėžiant aplinkosauginius, ekonominius ir socialius aspektus. Tokiu būdu žemės ūkio politikos formuotojams siekiama pateikti priimtinesnes alternatyvias priemones tobulinant ekologiškos maisto sistemos vystymą. Tyrimas grindžiamas analizės metodu, remiantis žemės ūkio veiklos prisitaikymo prie klimato kaitos rezultatų apžvalga, pagal kurią sudaryta prioritetinių veiksnių grupė ekologinių sistemų rengimui. Tyrimo rezultatas – pateiktas naujos sistemos dinaminis modelis, atvaizduojantis sudėtingus priežastinius ryšius ir netiesinius grįžtamojo ryšio ciklus tarp pagrindinių tvaraus vystymosi veiksnių. Be to, nustatyta, kad investicijų ir kitų priemonių koordinavimas žemės ūkyje bei gilesnės ūkininkų žinios yra labai svarbūs veiksniai siekiant tvaraus vystymosi žemės ūkio sektoriuje.

Raktiniai žodžiai: žemės ūkio ekosistemos, klimato kaita, maisto sistema, integracinis vystymasis, tvarumas, dinaminis modelis.
JEL kodai: Q01, Q15, Q56.