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Connecting Agriculture to better Nutrition in South Asia: Innovation as a process of socio-technical change

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About LANSA
Leveraging Agriculture for Nutrition in South Asia (LANSA) is an international research partnership. LANSA is finding out how agriculture and agri-food systems can be better designed to advance nutrition. LANSA is focused on policies, interventions and strategies that can improve the nutritional status of women and children in South Asia. LANSA is funded by UK aid from the UK government. For more information see www.lansasouthasia.org

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Acronyms

ANT	Actor—Network Theory
BRAC	*originally* Bangladesh Rural Advisory Committee, *now* Building Resources Across Communities
Co-PI	Co-principal investigator
DFID	Department for International Development (UK government)
FSN	Farming Systems for Nutrition
FV	fruit(s) and vegetable(s)
HH	household
ICTs	information and communication technologies
LANSA	Leveraging Agriculture for Nutrition in South Asia, a research consortium
MLP	Multi-Level Perspective
OFSP	orange-fleshed sweet potato
PDS	Public Distribution System (India)
PI	principal investigator
SP	sweet potato
STS	Science, Technology and Society Studies or Science and Technology Studies
VAD	Vitamin-A Deficiency

Abstract

This paper explores the role of innovation in strengthening the linkages between agriculture and nutrition in South Asia. This paper eschews the common bias in discourse about 'innovation' towards eye-catching novelty and invention, which emphasises high-tech gadgets and devices, external inputs and industrially and/or commercially produced technologies. Instead, this paper adopts a broad conceptualisation of innovation as a change process, which involves a reconfiguration of technical and social components, and has material, economic and behavioural dimensions. Thus, the paper embraces practical and behavioural changes at farm- and household levels, such as the establishment of home gardens for improved nutrition, as well as more obvious technological novelties such as machines or the genetic engineering of biofortified crops. This inclusive, catholic approach is inspired by insights from the anthropology and sociology of technology, and the specific field of science and technology studies (STS), which view technology first and foremost as an assembly of social and technical components, in which purposeful human agency interacts with the material world in order to accomplish particular goals. From this perspective, the study of innovation entails a focus on changes where information and knowledge, practices and behaviours, and tools and inputs are being introduced, eliminated, modified and/or transformed. The particular cases discussed in this paper are examples selected from the range of interventions studied by partners in the LANSA consortium (Leveraging Agriculture for Nutrition in South Asia). The paper introduces a framework comprising a series of useful questions that may be asked before, during or after an intervention that intends to achieve better nutrition outcomes through technological change in food production or consumption systems. Using this framework of questions, which focus on the practices and practitioners of technology, the paper identifies the different and contrasting ways in which the interventions have been conceived and, in particular, differences in their expectations about who will practise the technologies concerned, how the desired benefits are supposed to be realised, and how readily these expectations may be met.

Keywords: agriculture, nutrition, South Asia, innovation, technological change, practice

1. Introduction

This paper contributes to technical and policy debates about how agriculture and food systems may be transformed in order to better address problems of hunger and malnutrition, with a geographical focus on countries of South Asia. Despite rapid global population growth over the past century, human endeavour has succeeded in producing enough food to feed everybody. Yet the world still faces a 'triple burden' of malnutrition, a term which expresses the paradox that hunger (a basic energy deficiency stemming from insufficient consumption of food) and micronutrient deficiencies ('hidden hunger') co-exist with rising levels of obesity and overweight – despite a general background of abundant food, much of which is wasted across all levels of the global food system (Patel 2007, World Bank 2016, Foley et al. 2011, Stuart 2009). In South Asia, undernutrition remains a widespread problem, in spite of strong economic growth in countries such as India, which continues to struggle with stubbornly high rates of maternal malnutrition and child stunting (Black et al. , 2008; Deaton and Drèze, 2009; Haddad and Zeitlyn 2009; Headey, 2011; Levitt et al., 2011; Subramanyam et al., 2011; Kadiyala et al. 2014).

The paper explores the potential for different kinds of innovation to strengthen the connections between agriculture and nutrition in South Asia. The paper draws insights from research carried out under the Leveraging Agriculture for Nutrition in South Asia (LANSA) consortium, a partnership of six research organisations located in Bangladesh, India, Pakistan, the UK and USA.[1] The interventions and case studies examined by LANSA researchers have approached the challenge of strengthening agriculture—nutrition linkages in a range of different ways. All of them may be considered innovations in some sense or degree, in so far as they involve a change or reconfiguration of knowledge, practices, organisation or material inputs in order to achieve a different (and hopefully better) outcome. This paper reviews a selection of these interventions, alongside some reference examples not studied directly within LANSA, so as to understand their general approaches, key principles, and the basic features of their design and implementation. The aim is to create cross-cutting insights into the various ways in which alternative kinds of innovation may help to strengthen the nutrition-sensitivity of agriculture and food systems. The purpose of this analysis is not to evaluate the impacts or success rates of the innovations in question, but to consider them from first principles as alternative models or propositions for improving the linkages between agriculture, food and nutrition.

The paper is organised as follows. The next section lays out a conceptual framework that defines innovation broadly as a process of technological change, which involves the reconfiguration of social, technical and material components. In this conceptual framework, it is suggested that a technological intervention is best thought of as a *proposition*, which represents an opportunity or invitation to people and organisations, as actors or agents, to engage in a process of learning and coordinated technical change, in order to produce new kinds of outputs (or to continue producing existing outputs in a new way, or in a changed context). Based on this conceptual framework, in the section that follows I then present an analytical framework comprised of a series of focused questions, which enable the researcher or analyst to understand the particular kinds of social-material-technical reconfigurations that are entailed by the proposition (intervention) in question. Using this analytical framework, I present a short discussion of cases and examples selected from the portfolio of interventions studied by researchers under the LANSA programme, as well as a handful of other interventions from the literature, identifying the reconfiguration of social, material and technical relations involved in each of them. The cases are discussed in relation to the level or stage of the value chain where an intervention is made: at the level of individual crop and livestock production systems on farm; at the level of the farming system as a whole; interventions in the value chain upstream of the farm; and interventions that target the value chain downstream of the farm. There are some overlaps between these cases. The last two sections of the paper offer a discussion and conclusions, which highlight practical and policy lessons and identify directions for further research.

2. A conceptual framework

This paper adopts a perspective on technology and innovation that places the purposeful activity (or agency) of human beings at the centre of attention. This may be contrasted with an everyday understanding of technology in common speech, where the term is usually understood rather

[1] LANSA is a programme of research and capacity building supported by a grant from the UK's Department for International Development (DFID). For more information see http://lansasouthasia.org/

simplistically as referring to discrete and self-sufficient technical units. These units are generally portrayed as embodied in the concrete form of machines, devices and 'gadgets', and very often conflated with modern 'high technologies', epitomised by the latest information and communication technologies (ICTs, conceived in the concrete form of smartphones or tablet computers), artificial intelligence, drones and robots (such as self-driving cars), nanotechnology and biotechnology. There are several problems with this everyday usage, which portrays technology as something concrete and almost autonomous. This framing neglects human agency or practice, which is enabled and constrained by the material world, including nonhuman living organisms and technical objects of many kinds – not only high-tech electronic devices, nanomaterials and transgenic seeds but also familiar artefacts such as knives, paperweights and flags. These technical objects and nonhuman organisms are only made into tools, instruments and machines when they are taken up, manipulated, assembled and configured by human beings working individually or in groups and networks. In other words, technology comes into existence through purposeful activity and through the interactions among humans, plants, animals, materials and a surrounding agro-ecosystem.

This approach to technology recognises that effective nutrition is an accomplishment of action by multiple people, groups and organisations, operating within a particular institutional and agro-ecological setting. The approach is inspired by insights and concepts drawn from anthropological and sociological studies of science and technology. One such tradition is *technography*, which draws an ethnographic and sociological tradition associated with Emile Durkheim and especially Marcel Mauss. A technographic approach places tasks, or the activity of 'making', at the centre of attention. This guides the researcher to focus on the bodily skills, material interactions, contingent knowledge, situatedness of practice (in time and space) and socio-cultural coordination of tasks, which constitute technical practice or technology. Technological change – known otherwise as innovation – is understood as the reconfiguration and reorganisation of tasks and task groups in response to new ideas, inputs and goals (Richards 2000) (Jansen and Vellema 2011). The technographic approach is also helpful in the present case because it has been elaborated particularly in relation to farming and agriculture, with a recognition that producing, distributing and consuming nutritious foods is an outcome of diverse and coordinated activities throughout a production chain (Jansen and Vellema 2011).

Another inspiration is the body of concepts and theories developed within science, technology and society studies (STS), including actor—network theory (ANT). This body of work is helpful in various ways. To begin with, it is useful for thinking about how objects, technical artefacts and nonhuman organisms help to create and stabilise relationships between human beings across time and space. ANT refers to animate and inanimate nonhumans within the actor—network collectively as 'actants', a term coined to recognise the limited kinds of agency that may be expressed by nonhumans through a network of relationships with humans. This conceptual language provides a grammar for understanding how a relationship is established between a technical object's designers and its users, or the ways in which materiality may be employed by one set of actors to influence or discipline the behaviour of other human beings (Callon 1987, Latour 1991, 1992). Particularly useful in this regard are the twin concepts of *inscription*, which refers to the ways a specific mode of use may be built in (i.e. inscribed, creating a script) into the design of technical objects and systems (Akrich 1992); and *affordance*, which refers to the scope or range of different uses or techniques to which a technical object or assembly may lend itself (Pfaffenberger 1992, Hutchby 2001). These concepts draw attention to the ways in which individual agency is enabled and constrained in interaction with other people, technical objects, material resources, information and institutions. These interactions help to define the space for individuals to act in pursuit of their goals, and therefore the space where external interventions might assist or encourage the achievement of better outcomes, such as improved nutrition.

The key insight of this literature is to recognise that technology is not an autonomous force that determines outcomes independently, but a human capacity enabled and constrained by the materiality of technical objects, the agency of nonhuman organisms, social relations, cultural frames, and the surrounding environment. Applied to the challenge of improving nutrition by changing farming and food systems, these perspectives remind us that innovation is a distributed process, involving action in diverse sites and at various scales. Improving nutritional outcomes may not be as simple as introducing a new seed variety into a farming system, but could require changes in cultivation techniques and schedules, harvesting practices and storage methods, food preparation practices and consumer behaviours, and other areas.

From this perspective, achieving socio-technical change (for better nutrition or other purposes) is a matter of assembling and 'aligning' a heterogeneous network of actors, tools and resources needed to construct a new way of operating. The inventor or designer of a new technical process or device has a key role to play as an initiator or instigator of change, but if positive change is to be accomplished then many others will need to be engaged and enrolled. So-called 'users' are not just passive implementers of a technical model determined in advance by the inventor, but agents (actors and communicators) in a socio-material change process. The outcome emerges from interactions among inventors, designers, manufacturers, regulators, pilot testers, the media, consumers, retailers, and many others, whose interactions are situated in and mediated by socio-cultural frameworks and material relationships in a specific time and place. The more extensive the actor-network involved in a technological transformation, the more challenging the task facing the people or organisations trying to drive change towards a preferred outcome (such as improved nutrition) (Bijker, Hughes, and Pinch 1987, Bijker and Law 1992, Latour 2005, MacKenzie and Wajcman 1999).

From an independent but overlapping tradition of the academic literature on technological change comes the concept of the 'innovation system'. This approach recognises that multiple actors with complementary capacities and resources operate on different levels and within different dimensions to achieve change. It shares with the approaches mentioned above a recognition that technology comprises not only tools and machines ('hardware'), but also knowledge, information and skills ('software') and social organisation and coordination ('orgware' or 'socware') (Lundvall 2007). The innovation systems concept was first applied to agricultural research and development in the 1990s and is now rather mainstream, but how agricultural innovation may lead to better nutrition is a relatively novel research question (Hall et al. 2001, Loevinsohn and Mehmood 2014). One impact of this type of thinking is that agricultural research for development increasingly includes interventions that engage with entire value chains rather than only farmers (this is the case in the LANSA programme; (Henson and Humphrey 2015)).

Finally, this paper also draws from the insights of a recent strand of the innovation systems literature, which proposes a 'multi-level perspective' (MLP) on the dynamics of socio-technical transitions (Geels 2002, Geels and Schot 2007). The MLP distinguishes conceptually between socio-technical *niches*, *regimes* and *landscapes*. According to this perspective, an innovative technology may first emerge and be incubated or fostered within a niche. If it goes on to have wider impacts at a larger scale, this will likely occur by transforming established ways of operating within a given industry or sector (a regime), perhaps by creating an entirely new type of industry while rendering existing technologies and institutions obsolete. Ultimately, an innovation may go on to have a revolutionary impact, transforming the overarching socio-technical landscape, with profound and far-reaching implications for the organisation and functioning of macro-economic and political systems and institutions. For the case of nutrition in South Asia, this would imply a root-and-branch transformation of national and regional agricultural and food systems to deliver more and better food to people who are currently malnourished.

Arguably, however, the intrinsic value of niches is too often overlooked, when policy makers and business owners search for solutions that will 'scale up'. A niche may have enduring importance for particular groups or in certain contexts. But the key insight of the MLP, which it has in common with ANT and innovation systems perspectives, is that the complexity (scope and scale) of change increases with each level of transformation: the number of relevant actors expands, the size of the network increases, the range of different situations and related interests that are implicated in the change increases, and the opportunities, challenges and risks entailed also grow. This is the nature of the challenge involved in 'scaling up' promising innovations. Improving the linkages between agricultural activities and nutrition within one household might involve a very limited number of actors and relatively brief interventions from outside. By contrast, an intervention to transform the nutritional quality of a variety of a staple crop, such as rice, requires a much larger network of actors – such as molecular biologists, plant breeders, biotechnology regulators, and so on – a longer timescale, and larger investments both 'upstream' and 'downstream' of the farm and the household (e.g. in research, policy frameworks, regulatory change, consumer engagement, and so on).

The conceptual language discussed in this section draws attention within processes of technological change towards the agency of individuals and groups operating within networks of socio-cultural and material-economic relationships. From this general perspective, a technological change initiative may be conceived as a *proposition* (or set of linked propositions) made to a particular community or network of actors. Those actors then have the opportunity to respond to the proposition (intervention) in various ways – potentially including ignoring the proposed change and attempting to carry on as before. The next section lays out an analytical framework, based on the conceptual insights introduced in this section, which may be used to investigate the nature of different interventions in agriculture and food systems that are aimed at improving nutrition. The framework comprises a series of questions, which aim to discover systematically who are the people and groups expected by the intervention to change their practices and behaviours, and reorganise their task groups, in order to practise new styles of agricultural production that are expected to lead to better nutritional outcomes.

3. An analytical framework

The analytical method used in this paper involves a series of questions based on the theoretical insights and conceptual categories outlined in the previous section. The questions posed are likely to be relevant in all cases to some degree, while particular cases might give rise to more detailed and specific follow-up questions, as appropriate. The questions aim to discover key features of the interventions under consideration, with the aim of evaluating the scope, scale and complexity of the changes envisaged in practices, institutions or organisations. This information will make it possible to evaluate the feasibility of the intervention in question and consider whether those expected to align themselves with the technological change are likely to have sufficient incentives to do so. The questions proceed in a sequence of steps, each one shedding additional light on the nature of the technological change proposed and how it is conceived to work. This creates the platform needed to assess the intervention, consider its feasibility and appreciate the steps needed to ensure it is effective in reaching its goals.

3.1 What is the basic concept of the intervention? Does the intervention reflect an implicit impact pathway or theory of change?

The first question seeks a concise statement of the basic approach involved in the intervention concerned. It asks, what is the essence of the technological change in question, and is the innovation based on, or does it imply, a *theory of change* or an *impact pathway*? In this paper I use these terms loosely, as their precise meanings are not central to this discussion. I use them here to stand for the arguments that appear to underlie a given intervention, expressing the means by which it is expected to 'work', in order to deliver improvements in nutrition. The theory of change or impact pathway might be stated explicitly or it may be entailed by the assumptions and design features that can be seen to inform the intervention. This question is a preliminary step towards understanding the basic approach and general features of the intervention. It focuses specifically on the proposed changes to techniques, practices and operations that comprise the technological proposition in question.

This is an important first step, but the remaining questions are vital because the visible changes to technical practices do not completely define the scope and scale of the technological change, which almost inevitably will entail wider changes in the social organisation and coordination of tasks, as well as changes to connected parts of the system upstream (such as research, extension and input supply) and downstream (such as distribution, retail and consumption). The remaining questions dig deeper into these connections, aiming to discover more information about how the proposed technology is conceived to work. The questions aim to identify the material, informational, organisational and institutional factors on which the successful realisation of the envisaged technological change depends.

3.2 What forms of practice or behaviour are envisaged if this intervention / innovation is taken up?

The next step is to ask about the changes proposed in technical practices, specifically, what practices or behaviours are to be introduced, eliminated or changed? This question enquires into the nature of tasks: what is done and how it is done, using what tools; how the process consumes resources and transforms materials; and what outputs are supposed to be produced. It also addresses the organisation and configuration of technical practices – the timing, sequencing and location of tasks, their spatial configuration and social organisation. The purpose of these questions is to understand on an abstract level the purposes and functions of tasks and how the intervention proposes to reconfigure them and to what purpose.

3.3 Who is expected to practise or employ the technology?

The next step is to identify the human agents who are envisaged as the main practitioners (and implicitly beneficiaries) of the technology concerned. In other words, the question aims to discover the people and groups who are conceived as the principal targets of the intervention, whose changed practices and behaviours would provide the most obvious signals of innovation and technological change, if the intervention succeeds. In the conventional language of technology transfer, these people might be identified as the principal 'users' or 'adopters' of new technology. Using the more sophisticated concepts reviewed in the previous section, they may be recognised as agents in their own right, possessing some capacity (be it high or low) to respond to the proposition in front of them. These actors are also seen to be connected to a wider actor—network comprised of various people, organisations, institutions and resources. Importantly, though they might be prominent actors within the socio-technical system, their ability to take up or sustain the new practices envisaged in the proposed technological change will depend to some degree on resources and information provided by other actors, or made available within the agro-ecological and socio-economic context where they live and work.

In concrete terms, this question asks whether the key components of the proposed technology will be implemented principally by individuals and/or households on their own behalf, by wider communities cooperating together, by specialists with particular skills, or by organisations exercising responsibilities on behalf of groups or institutions. This question begins to shed light on who the actors and stakeholders are in a technological system, what interests are engaged, and how agency and power are distributed within a network of different actors. The remaining questions dig yet deeper into this enquiry.

3.4 What material inputs, equipment or tools may be needed in order to take full advantage of the technology?

After having discovered something about the nature of tasks and the communities involved in performing them, this question addresses whether the proposed technology depends on additional supplies of resources from within or beyond the local area, such as seeds, mineral fertilisers, machines, chemical food additives, or irrigation water. If so, are these resources readily available and accessible to the people, groups and organisations identified with the previous question? This question brings the analysis closer to an evaluative stage, in which it should be possible to judge the economic, logistical and technical practicality of the proposition in question.

3.5 What information, knowledge or skills are required to make the most of the new technology?

Novel technical practices will probably also depend on 'know-how', in other words, a bundle of information, knowledge and skills that may be embodied in individuals, task groups or institutions. Key questions include, what kinds and quantities of information and knowledge are required, and what degree of skill is needed to successfully practise the proposed technology? Does the successful implementation depend on very abstruse and technical know-how or is the knowledge required fairly accessible to the proposed practitioners? How will farmers or food preparers be supported to acquire knowledge and skills they may need to benefit from the technology, or avoid possible risks or negative impacts? Above, I noted that some functions might need to be performed by specialists or organisations on behalf of individuals and communities. We can think of these specialist tasks as types of know-how and skilful practice that are embodied within individual professionals, or institutionalised within organisations such as agricultural research and extension services, banks or ministries of health. The more a technology depends on these kinds of specialised skill, the more heavily the success of the intervention depends on an extended network of people and organisations. This leads directly to the following question.

3.6 How extensive is the actor—network implicated in the change?

This question addresses the complexity of the technological change envisaged by the intervention, by examining the size and breadth of the network of people, organisations and resources involved in it. Are the necessary know-how and resources concentrated in particular people and places, or are they distributed through a wider network of actors? All kinds of resources may be encompassed by this enquiry, including skills, information, raw materials, energy, funding, legal instruments, policy frameworks, land, labour, machinery, and so on. In some cases, most of what is needed may be available locally or within a small and tightly integrated network; in others the network may be much larger and looser, with weaker ties of loyalty and solidarity. Essentially, this question aims to assess the feasibility of the proposed technological change, by identifying the full range of actors and actants which need to be assembled in order for the innovation to be successfully realised and sustained over time. It addresses questions of scale (the size or extent of the actor—network to be created) and scope (the number and complexity and of the changes in practice and coordination, compared to existing systems and practices).

3.7 How does the intervention create cultural changes and redistribute power?

This final question is evaluative. It asks who are the winners and losers of the proposed changes in production, distribution and consumption. This represents the ultimate purpose of the analysis as a whole, a qualitative assessment of the intervention's likelihood of achieving positive change – both in the phenomena targeted by the intervention (such as malnutrition) and in other dimensions. The deployment of new technology commonly implies a reconfiguration of cultural institutions and economic relations, as well as a redistribution of power, income, employment or other assets. Who may be affected, positively or negatively, by such changes? The answers to these questions have a practical benefit, allowing the designers and implementers of the intervention to consider the strengths and weaknesses of their approach and how it might be improved. How might potential losses be mitigated or how might losers be compensated? Or can policy ensure that the benefits are more evenly distributed? The redistribution of power and resources is liable to affect perceptions of the desirability of the change among the different parties concerned and influence their motivation to take up the opportunity or resist the change. In particular, it is important to consider how heavily the success of the intervention depends on infusions of cash and other support from outside. There is a real risk that new practices and systems may be abandoned as soon as funds, or the resources they secured, are no longer available.

4. Applying the framework to selected interventions

Strengthening the connections between agriculture and food and nutrition security might be done in various ways. Conceptually, addressing the whole of this challenge must encompass the entire chain from production to consumption (including aspects upstream of farms, such as farm input supply, crop breeding research, and financial services). In this section, the analytical framework presented above is applied to a selection of cases, representing different types of interventions that have sought to organise and focus the activities of human beings, animals, natural resources, tools, machines, institutions and relationships to improve nutrition through agriculture and value chains in South Asia. The table in Appendix 2 summarises the insights of this analysis. The cases included in the table were drawn from examples studied by LANSA researchers, as well as some additional cases from the wider literature relating to the agriculture—nutrition nexus.

The first three interventions listed in Appendix 2 targeted changes in individual crop or livestock production systems. The first example concerns measures to encourage the cultivation of vegetables in home gardens or kitchen gardens at farm household level. The second case is similar, but it targets vegetable cultivation by groups of adolescent girls from different households within a community. The third case concerns the stimulation or improvement of small livestock or poultry production systems within rural households.

These three interventions have some common features as well as some important differences. In all three cases, the central concept is that members of rural households should be encouraged to take up, expand or improve the production of highly nutritious foods, whether fresh vegetables, eggs, milk or meat. In all three cases, the underlying theory is that these ventures will improve household nutrition both directly (through consumption) and indirectly (by raising incomes, which may be used to purchase nutritious foods). In a systematic review of agricultural interventions designed to improve the nutritional status of children, some evidence has been found to that these types of approaches have had positive results (Masset et al. 2012). Alongside inputs, training and advice on crop cultivation and livestock husbandry, not to be overlooked are the health and nutrition-related information and guidance that may be needed to encourage dietary diversity and raise awareness of the nutritional value of fresh vegetables and animal products. Good sanitary practices on the farm, safe slaughtering methods and hygienic food handling practices may be especially necessary in relation to animal production, consumption and marketing.

The scale and scope of these types of interventions is relatively small and narrow, in so far as the ongoing production of vegetables, livestock or poultry would remain largely within the control of individual households. While an initial intervention may be needed to initiate change, by providing start-up resources (such as quality vegetable seeds or healthy ducklings), if the intervention is found valuable then the technological change may be sustained over time by the individuals and households engaged in it, who may manage their seeds and livestock to keep them healthy and productive over time. Some external inputs will be required on an ongoing basis, such as seeds, ducklings, vaccines, feed supplements, and veterinary services, but if the target population appreciates the value of these inputs and is able to obtain them from local suppliers in the quality and quantity they require, then a sustained improvement in productivity and nutrition might be achieved. This implies that industries exist which can supply quality vaccines, feeds and feed supplements, or professional veterinary services, at affordable prices.

In the case of the scheme to encourage small-scale cultivation of vegetables by groups of young women constitutes a partial exception to the above remarks, in several respects. It entails the creation of a new social grouping of young women belonging to different households, encouraging them to cooperate. It depends on the provision of a suitable piece of land. Both of these moves are likely to require the blessing and support of parents or guardians, and elders of the community, particularly to overcome traditional objections to independent economic activity and control over resources by young women. In general, engaging women in crop and livestock production at farm level is considered an important step to take advantage of women's traditional roles as carers and food providers to families, including infants, children and the elderly. However, the cooperation and support of male members of the household or community may also be needed, for example where men are considered the ones to construct greenhouses or polytunnels, carry heavy loads, or operate machinery. Women will likely also have limited time and energy to devote to crop cultivation if they are also responsible for other tasks, such as care work, domestic chores and income-generating farm work.

The fourth intervention in Appendix 2 is an example representing projects that encourage farmers to cultivate and consumers to eat more of a specific vegetable type, identified as a 'biofortified' crop because of the density of its nutritional content. In this case, the crop in question is the orange-fleshed sweet potato (OFSP). This crop variety is high in beta-carotene, a dietary compound that is converted by the human metabolism into vitamin A, which is an important micronutrient involved in healthy vision. Vitamin A deficiency (VAD) is a serious medical condition that causes blindness and even death, especially in children. VAD is widely prevalent in South Asia among children and pregnant and lactating mothers (Akhtar et al. 2013). OFSP is not widely grown or consumed in Bangladesh, where advocates are attempting to increase production of seed potatoes, encourage farmers and home gardeners to take up cultivation of the crop, incorporate OFSP into school feeding programmes, and increase demand among consumers (Sirajul Islam et al. 2017).

The challenges and opportunities presented by this intervention are similar in some ways to the home gardening interventions discussed above, but with a narrow focus on the cultivation of a novel crop that is targeted due to its specific nutritional profile. In an important sense the major challenges for the intervention are not agronomic, but require engagements with actors at several different stages or levels of the food system, in order to accommodate an unfamiliar food crop. In simple terms, this means working on both supply and demand aspects of the system simultaneously. A functioning OFSP food system would require a regular supply of healthy seed potatoes, fuelled by demand from growers, which in turn would be fuelled by demand from consumers. To achieve the targeted improvements in vitamin A status, it would not be enough to encourage the uptake of OFSP unless measures were also in place to ensure that the beta-carotene profile of OFSP varieties is sufficiently high to make a difference, and that farmers, processors and consumers understand how to protect the beta-carotene content during post-harvest storage, distribution and cooking. Also, since beta carotene is fat-soluble and the absorption and conversion of the compound in the body can be undermined by gut parasites and bacteria, it may be even more challenging to improve the vitamin A status of people who have low-fat diets or are exposed to unhygienic food preparation and consumption conditions (Haskell 2012). Therefore the impacts of the OFSP intervention depend quite heavily on communication and guidance to raise awareness of VAD and its causes, the health benefits of the beta-carotene found in OFSP, and healthy ways to prepare and serve the vegetable to maximise its beneficial impacts.

The next type of intervention listed in Appendix 2 involves a different kind of biofortification. Modern biotechnologies, including genetic modification, are being used to change the nutritional composition of food crops. In the examples shown, genetic engineering is being used to modify the micronutrient profile of rice, a major staple crop. A high-profile example of this approach is a project to modify rice to express beta-carotene in its grains (as well as its green leaves and stems). The resulting plants produce pale yellow rice grains, so the crop has been named Golden Rice. Other projects have targeted the levels of micronutrients such as iron and zinc in rice (Brooks 2010, 2011, 2013). This type of intervention has something in common with the one just discussed, in that the conceptually simple goal is to use food crops with better nutritional profiles to improve the nutritional status of consumers. However, the comparison is misleading beyond a certain point. The use of genetic engineering means that a much more extensive network of actors must be engaged in the effort. The techniques of genetic engineering are highly specialised and require advanced scientific skills as well expensive scientific equipment. Genetic engineering has also attracted special regulatory testing and oversight, and stimulated considerable public opposition from some consumers, environmental activists and development campaigners. These facts mean that the number and diversity of actors involved in helping or hindering the project is quite large, and so the complexity of delivering the project goals increases.

Above all, the intervention depends on the getting the technology to work effectively in a technical sense. ANT theorists would go so far as to argue that the intervention depends on the 'cooperation' or 'enrolment' of rice which, as a living organism, expresses a limited kind of agency in relation to the human beings who are trying to manipulate and control it. Scientists must accomplish a number of technical steps before the intervention may succeed in improving the nutritional status of people at risk of VAD. First, the genetic transformation needs to work. In the Golden Rice project this step has been achieved, but it took considerable time and effort to move from a successful transformation to a transformation in which the expression of beta-carotene in rice grains was significant enough to have a chance of making a substantial difference to the vitamin A status of people eating the rice (Enserink 2008, Brooks 2013, Dubock 2014, Eisenstein 2014). The next step is to get the transformed rice varieties to perform agronomically in farmers' fields, and this has been another significant hurdle for the Golden Rice project. At first, the project scientists transformed rice varieties that were convenient to work on, because they were familiar and well characterised genetically and phenotypically, rather than the types farmers most commonly grow. The next challenge is to backcross the transformed experimental varieties with the modern rice varieties that are popular with farmers in different rice-growing zones and regions. The new trait needs to be incorporated into commercial rice varieties in ways that do not interfere with the crop's growth and yield. As with any commercial variety, the trait needs to be expressed uniformly within the population and stabilised across successive generations (Bollinedi et al. 2017). Once these steps have been accomplished, there still remains the challenge of convincing farmers to cultivate the new varieties and consumers to eat them (Bongoni and Basu 2016). In these aspects, the challenges facing an intervention such as Golden Rice are similar to those faced by the OFSP project – how to deliver a usable quantity of beta-carotene to a vulnerable population of malnourished consumers at risk of VAD (Haskell 2012). In India, for example, this might mean that the rice has to be incorporated into the Public Distribution System (PDS), which distributes subsidised grains to the poorest households (see below).

The next intervention listed in Appendix 2 is an example of food fortification that occurs in the post-farm value chain. In Pakistan as in other countries, public programmes or mandates have been used to fortify foods such as grains and oils with micronutrient supplements such as Vitamin A and iron. Chemical fortificants are added during milling and processing. This type of intervention need not involve farmers or require any change to existing cultivation systems. There is also no need in principle for changes in food preparation practices or consumption habits by consumers, certainly when foodstuffs are fortified routinely under a government mandate, and otherwise only in so far as consumers might need to be encouraged to select a fortified commercial product in preference to an unfortified one. Apart from that change in marketing or awareness raising, the only part of the value chain that will be affected by food fortification will be largely under the control of the public or private company concerned. The only external inputs required are supplies of chemical fortificants of a specified quality and quantity, which can be obtained commercially, and the equipment needed to combine them with the foodstuff in question. Blending the fortificant into the grain or oil is typically a simple procedure that can be routinised, and the whole process falls under the control of company managers and factory supervisors. Things do become more complex if poorer consumers and populations in rural areas and small towns are to be reached with fortified foods, because many thousands of village-scale mills must be engaged in the fortification business. This multiplies the number of individual actors to be enrolled into the system, therefore it increases the costs of monitoring the quality and safety of fortified products. However, the technical requirements remain quite simple and manageable by small business owners or communities.

Fortified foods are also seen by some private-sector food industry players as commercial opportunities, which they have targeted with branded food products. Examples reviewed by LANSA researchers include Britannia Foods' Tiger biscuits in India and Grameen Danone's *Shakti Doi* yoghurts in Bangladesh. Tiger biscuits are fortified with iron, calcium and vitamins and are sold through commercial channels.[2] *Shakti Doi* yoghurts are rich in protein and calcium and contain added zinc, iron and vitamin A and are sold through small shops and directly to consumers through a door-to-door sales network (Sirajul Islam et al. 2017). In such cases, nutrition-related health claims are incorporated within the branding and advertising of the products, which are marketed to middle class consumers and in small package sizes to poorer customers as well. Grameen Danone, which is a joint venture between a transnational food company and Bangladesh's Grameen group of social enterprises, and which is run on a 'make no loss' basis, also uses a network of community health workers to promote the health benefits of *Shakti Doi* yoghurts. As with the fortification of basic food staples discussed above, these commercial fortified foods can be produced and marketed without necessarily changing the practices of producers of grains, oils or milk. The food supplementation may take place in mills or factories under the control of a company, using fortificants sourced from commercial suppliers. However, the novelty of the resulting products may require special marketing

[2] http://britannia.co.in/products/tiger/tiger-glucose (accessed 15 March 2017).

as well as a change in behaviour on the part of individual consumers, who may choose to purchase and consume fortified food products, including items that may not have featured in their food basket in the past.

The interventions discussed above have, in different ways, targeted individual crop production systems and consumption practices relating to individual foodstuffs. The next couple of interventions listed in the table in Appendix 2 target wider or whole farming systems rather than individual crop or livestock production systems. The first one is a project encouraging farmers to produce and use biochar as a vehicle to recycle valuable nutrients through the farm system. The second is an even more ambitious intervention to transform local farming systems by adjusting and diversifying them in a variety of different ways, with the goal to make the entire agricultural system more sensitive to and facilitative of better nutrition for the rural community as well as consumers in markets served by it. Moreover, in addition to transforming the farming system, the latter intervention also implies substantial changes to agricultural research and extension services, to equip them to be more nutrition-centric in their activities and programmes. I shall address this second aspect in the section below about interventions in upstream value chains.

The nutrient cycling project involves the production of biochar on the farm or in the community, using biomass (wood and crop residues) collected from the farm or the local environment. The biochar is then intended to be combined with urine collected from farm animals or, potentially, from humans. The biochar itself is not rich in plant fertilising chemicals, but its porous structure allows it to absorb a very large volume of liquid urine, which is loaded with nitrogen (N), potassium (K) and micronutrients. The nutrient-charged biochar then has to be dug directly into the root zone of crops as they are being sown or transplanted, because the plant roots need to be in direct contact with the biochar in order to draw out the available nutrients. Applied directly, undiluted animal urine can be toxic to plants, but when made available in this slow-release, packaged form, the valuable nutrients can be safely retrieved by the plants' roots. Biochar is also said to improve soil quality by increasing soil organic matter and water-holding capacity. According to proponents of the biochar system, 1,000 L of urine contains about 10 kg each of N and K, which is enough to supply about 500 m^2 of farmland per year. This volume of urine needs to be combined with about 300 kg of biochar, which is derived from a significantly larger weight of collected biomass.

The biochar nutrient-cycling system entails a significant reconfiguration of farming operations, including some completely novel practices. To make this system work, farmers need to gather a substantial volume of crop residues, woody material and other suitable biomass, and subject it to a controlled burn in a special kiln or properly excavated fire pit. The burn technique requires skilful initiation and supervision over a period of several hours. As soon as the burn is completed the biochar must be doused with urine collected for the purpose. Subsequently the nutrient-charged biochar slurry must be conveyed to the fields or plots where it is to be used, where measured doses need to be applied in furrows or pits where crops are to be sown or planted.

It is evident that these measures impose considerable demands in terms of labour, time, skill and attention. The know-how required to operate the system successfully is rather wide-ranging, including the skills and knowledge relating to biomass selection, preparation and quality control, the digging and ongoing maintenance of pit kilns, the supervision of the controlled (oxygen-limited) burn, the collection and storage of urine, the preparation and handling of the biochar—urine slurry, and the methods of applying the fertiliser to the root zone of different crops. The rewards, in terms of increased yields, improved crop productivity or improvements in soil quality over time, would need to be substantial enough to justify the care and effort invested. The potential direct benefits in terms of household nutrition may depend on how effectively the biochar system returns valuable N and K to the crop root zone, and how well crop plants take up any additional micronutrients that the nutrient-loaded biochar may provide. If the crop productivity and yield improvements are large enough to generate a marketable surplus, then the technology may also help to improve nutrition indirectly, via increased household income.

Although the biochar nutrient cycling method entails substantial hurdles in terms of resources, time, effort and organisation, in principle the material resources needed for ongoing management could be readily available within the farming system or the local environment. This may depend critically on whether penned animals are kept, and how easily their urine can be collected and stored. In some sites, a cultural barrier may discourage the use of human urine for the system, but where this practice is accepted it represents an effective way to directly close a human nutrient loop. To introduce the method to a community, a short-term intervention may be enough to introduce the concept, demonstrate the construction of kilns and urine-collecting pits and train people in their use. Thereafter, provided the method is economical and sufficiently rewarding, and if the techniques of controlled burning are relatively easy to learn, then the method may be self-sustaining without much ongoing support. The benefits of the system are likely to be greatest if it is used to maximise the production of higher value crops, such as nutritious vegetables. The effort required to sustain the system is likely to be spread most economically among a group of people or households cooperating to gather biomass and delegate a few members to make the biochar. For this reason, the biochar method has been promoted to groups of rural households, including women, for use in home gardening.

The next example shown in Appendix 2 is Farming Systems for Nutrition (FSN), an intervention which adopts an integrated approach to agriculture and nutrition. The FSN approach begins by investigating nutritional problems and designing a suite of agricultural strategies to address them. Agricultural research and extension programmes are targeted to address the particular nutrient deficiencies discovered within a community, and these efforts are backed up with interventions to raise community and household awareness of nutritional problems and their dietary solutions, the nutrient content of specific food crops, and the merits of a diversified diet rich in micronutrients. The FSN approach encourages a more biodiverse agriculture and the creation of 'nutrition gardens'. The impacts on nutrition of these changes in the farming system are monitored to evaluate their impact (Das, Bhavani, and Swaminathan 2014, Nagarajan, Bhavani, and Swaminathan 2014).

The FSN intervention is quite broad in scope and scale, since it envisages changes in consumption patterns and dietary habits as well as farming practices and cropping systems. It may entail changes in land use and cropping patterns at both household and community levels. A wide network of people and groups needs to be engaged and the range of practices and systems implicated in the changes is quite extensive. The FSN approach entails changes in the organisation and strategies of agricultural research and extension programmes, making them more sensitive to nutritional problems and outcomes. The intervention may depend on considerable investments of money and professional support from agricultural technicians and community health workers over an extended period before agricultural and nutritional habits and conventions are decisively influenced. However, if the new cultivation practices and consumption choices are taken up and found valuable, they may endure after the intervention ends, relying only on resources that are accessible locally.

The next example in Appendix 2 shares some common features with the FSN approach, specifically the way it seeks to stimulate behavioural and practical changes by women through a new, integrated approach to delivering health and nutrition advice alongside agricultural extension services. A project in India, studied by LANSA researchers, used modern ICT tools to deliver nutritional information and advice to women, especially mothers of infants and young children (Kadiyala et al. 2016). In this project, the connection to agriculture was somewhat incidental, in the sense that the intervention focused primarily on health and nutrition guidance but was delivered alongside an existing agricultural extension intervention and using the same kinds of tools. Agricultural practices were implicated indirectly, for example women were advised about the nutritional implications of working during pregnancy and breastfeeding.

The intervention depends on the provision of material resources including equipment for audio-visual recording and playback, and services including electricity, internet and telecommunications, and the financial resources necessary to sustain the intervention, to scale it up, and to reach successive cohorts of young women and new mothers. A range of specialist knowledge is required, including expertise in health and nutrition, and skills relating to health communications and film-making.

The previous intervention could be considered an institutional innovation in so far as it exploits existing audio-visual technologies to reorganise the modes by which agricultural and nutritional information and advice are delivered to communities. The last intervention listed in Appendix 2 is even more appropriately identified as an institutional one, because the principal innovation involved is a change in policy and redirection of a public subsidy. India's Public Distribution System (PDS) is a long-established government scheme that gives poor households access to subsidised grains through 'fair price shops'. Until recently, the PDS covered rice and wheat, while some states also included items such as sugar and kerosene (Balani, 2013). The National Food Security Act of 2013 provided for millets to be included within the PDS. Millets are coarse grain food crops, traditionally grown in rainfed and semi-arid areas of India, which are more nutritious than rice and wheat. Including millets in the PDS and other publicly supported schemes, such as school midday meal programmes, creates a mechanism to stimulate increased consumption of these nutritious and culturally appropriate grains, with a potential nutritional benefit for poor households (Parasar and Bhavani, 2016).

However, there is a risk that subsidised procurement prices, which are intended to encourage farmers to grow millets for the PDS, may tend to increase general millet prices in consumer markets outside the PDS, a perverse outcome that could undermine the goal of increasing millet consumption (Rajshekhar and Raju, 2017). With this type of intervention, changes in behaviour are required from both farmers and consumers, but these changes are stimulated with relative ease. The direction of the new policy is largely under the control of government ministers through existing bureaucratic structures, and relatively easy to implement in the context of the existing PDS system. The major requirement is to communicate the change in policy to both farmers and consumers, but as awareness increases changes in practices and behaviours may be sustained through price signals. It may also be necessary or helpful to raise awareness of the nutritional benefits of millets, and take steps to promote their cultural status compared to alternative grains. The mere fact of including them within the PDS might contribute to this revaluation of millets as a traditional and popular food.

5. Discussion/Summary

In this paper I have sought to demonstrate the practical usefulness of understanding innovation as a process of technological change with material and practical, cognitive and social, communicative and organisational aspects. To develop this argument I have adopted an eclectic, catholic approach to the theoretical and conceptual bases for this type of understanding, drawing on a selection of anthropological and sociological sources as well as a body of policy- and practice-oriented literature on innovation processes and systems. I have argued in favour of an understanding of technology in which human agency is a key mechanism, which is enabled and constrained by a network of social, organisational and institutional relationships with other people and groups, and even with nonhumans. These perspectives and approaches are practically useful because they draw attention to the fact that technological change cannot be delivered by a single actor, and certainly not by a singular technical package that is merely 'transferred' or 'adopted' by new users. Instead, a change in technical practice is accomplished through the agency of various individuals and groups.

This conceptual language provides a framework for analysing the dynamics of technological change and, especially in the present case, a means of appreciating the scale and scope of change sought by an external intervention, such as a project or policy designed to deliver an improvement in nutrition through strengthened linkages with agriculture. The framework helps the designers and implementers of such an intervention to identify the range of actors who need to be enrolled or mobilised within the proposed change process. It also helps them to identify the stakeholders whose interests are implicated in the change, who might need to be accommodated or incentivised to go along with it. Often, problems that arise in programmes and projects stem from misunderstanding who are the principals chiefly responsible for changing techniques, practices and social coordination, and taking into account their capacities, interests, priorities, values and goals.

In this paper I have considered several kinds of interventions, including interventions to stimulate new or improve existing production systems at household level (e.g. home/kitchen gardens, vegetable cultivation by groups of young women, husbandry of small livestock and poultry, or adoption of nutrient-dense crops such as OFSP); interventions to transform wider farming systems (e.g. nutrient cycling using biochar, or the FSN concept); interventions downstream of farms (such as food fortification and crop biofortification); and innovations in institutional practices and policies (e.g. reforms in service delivery or the inclusion of millets in the PDS).
Some systematic differences can be identified between the interventions reviewed here, including:

- The size of the financial investment required. For example, the project to develop Golden Rice has required sustained investments of millions of dollars, as well as substantial donations in kind, over more than a decade. The size of the payoff is also expected to be very large, if the project is successful. By comparison, promoting kitchen gardening requires a very small investment over a short period of time, although scaling up the intervention to reach many groups and communities might require multiplying that initial investment many times, unless the innovation starts to spread spontaneously or through individual initiatives.

- The size and diversity of the network engaged. Do the technological changes proposed lie largely within the control of individuals or households, or do they require the cooperation and coordination of many others? How widely dispersed is the network spatially and temporally? Are the actors involved relatively homogeneous, or separated by cultural differences, socio-economic distinctions and status hierarchies? Is there sufficient trust and confidence between members of the network whose cooperation is required?
- The scope and complexity of the changes envisaged in practice. Are the changes technically difficult to master? Are the changes concentrated in time and space or do they have knock-on implications for longer time periods and wider groups and spaces? Are the potential benefits large enough to compensate for the effort invested? Can they be realised quickly and tangibly or do they emerge only slowly and imperceptibly?
- The directness or indirectness of the connection between an intervention and its impacts on nutrition (or other goals). Will the projected benefits be realised as a necessary consequence of the proposed changes in practice or only indirectly, e.g. via an increase in incomes?
- The distribution of opportunities, risks, benefits and disadvantages. Are there winners and losers from the intervention? Are the costs and benefits distributed evenly or equitably among women, men, children, young people and the elderly? Do these groups have equal or fair access to the new technological proposition and capacity to take advantage of it? A good example is the case of women, who typically bear special responsibilities for feeding other household members including men, infants, children and elderly people. Often, women lack secure access to land and other productive resources, including money. Interventions to improve nutrition may be most effective if they increase women's agency.
- The feasibility and sustainability of the intervention. What does the technological proposition compete with, in terms of time, money, energy, attention, skill, etc? For example, women often carry a substantial burden of care for other family members as well as engaging in income-generating labour. Practices such as vegetable cultivation in greenhouses require an additional investment in watering and plant care. A technical system such as the biochar nutrient cycling method require practitioners to gather, transport and process biomass and urine, supervise controlled burns, and painstakingly apply biochar slurry to the root zone of crops. These tasks demand time, energy and skill. Is this investment actually feasible alongside other tasks? Can other tasks be abandoned to accommodate the biochar practices? Are the rewards of biochar nutrient cycling substantial and rapid enough to reward the people engaging with the innovation?

6. Conclusions and further implications

The conceptual approach and analytical framework presented in this paper may assist the designers, implementers and evaluators of nutrition-focused agricultural interventions to approach their tasks. One practical lesson is that delivering better nutritional outcomes might require interventions at various levels of a whole value chain encompassing production, distribution and consumption, and even activities upstream of farms such as basic research, crop and livestock breeding, product development, extension services and input supply. The value chain to be addressed by the intervention may be rather short in the case of foods that are produced and consumed directly on the farm, or very long and diffuse in the case of some very novel inputs, such as transgenic crop varieties, or farm products that are sold into distant markets to generate incomes.

Another lesson is the importance of carrying out a careful stakeholder analysis in order to identify all the people and organisations implicated in the intervention, especially those who are being asked to change their practices and behaviours and those who may be affected, positively or adversely, by the intervention. Within such a stakeholder analysis, special attention should be given to gender issues, including the agency of women as decision-makers and practitioners of farming, women's own health, and their roles as carers, income earners and controllers of household resources.

Using the type of analysis recommended in this paper, project designers and implementers should be better equipped to define and understand the opportunity space within which they want to intervene, identify the actors they will need to enrol and the resources they will need to assemble, and plan the sequence of steps they will need to follow in order to realise better nutritional outcomes for particular target communities in specific situations.

Appendix 1: Analytical framework to assess interventions/propositions for technological change

1. What is the basic approach involved in the intervention?
   - What is the essential technical (material, practical) change envisaged by the intervention? Is the change sufficiently clear and coherent conceptually to be summarised in a few sentences?
   - Does the intervention reflect an (implicit) 'impact pathway' or 'theory of change'?
2. What forms of practice or behaviour are envisaged if this intervention/innovation is taken up?
   - What new activities would be introduced? What existing activities would be eliminated or changed?
   - Are the envisaged changes in practice small and simple, or extensive and difficult?
   - Are the changes concentrated in time and space or do they ramify across a wide area and/or an extended timescale (entailing knock-on effects for other activities)?
3. Who is expected to practise or implement this technology?
   - Who are the key individuals, groups or organisations envisaged as the principal practitioners (and beneficiaries) of the proposed new technology?
   - Where are they situated geographically, culturally and economically? What resources do they have at their disposal?
   - How much power or agency do they have to effect change? What is their capacity to handle and manage risk?
4. What material inputs may be required?
   - What kinds and quantities of materials, resources, equipment or tools will be needed in order to take full advantage of the opportunities presented by the technology?
   - Does the new technology require additional supplies of inputs such as land, chemical fertilisers, machinery, irrigation water, and so on? If so, are these resources readily available? Who will procure and/or supply them, and how?
5. What information, knowledge or skills are required?
   - What kind and level of know-how or guidance is needed in order to take full advantage of the opportunities presented by the technology? Are the required skills specialist or general?
   - Who will supply the necessary information, training or advice? How?
6. How large is the actor—network implicated in the change? How is it composed?
   - How extensive is the network of actors and resources likely to be engaged or affected by the proposed technological change?
   - How evenly are power and agency distributed through the network? Which of the nodes (actors, resources) are unique and essential and which are generic and interchangeable?
7. How does the intervention create cultural changes and redistribute power?
   - Who are the likely winners and losers of the intervention? What implications does this distribution have on the motivations and cooperation of different stakeholders and interest groups?
   - How may the benefits be maximised and widely shared, and how might losses be minimised and compensated?
   - How do these considerations affect the likelihood of implementation, and realising the proposed benefits of the proposed technological change?

Appendix 2: Summary examples of interventions/propositions for technological change to strengthen agriculture—nutrition linkages in South Asia

	Example inter-ventions	Essential concept (Implicit impact pathway or theory of change leading to improvements in nutritional outcomes)	Who is expected to practise the technology? (principal or emblematic practitioners)	What behaviours or practices are expected to change?	What material inputs are needed?	What information, skills and knowledge are required?	Extent of the actor—network to be engaged (scale of the change)	Scope of the change (complexity of the transformation)
1	Home / Kitchen gardens	Stimulating/ increasing domestic production of nutrient-dense food crops will lead to increased consumption of nutritious foods at HH level, and increase HH incomes (under women's control). Will also increase accessibility of FV on local markets, increasing consumption among consumers.	Rural (farm) HHs, especially women.	New or expanded cultivation of nutrient-dense crops in home gardens; especially by women. Consumption of domestically produced FV within the HH, especially by children; or sale of FV	Suitable, accessible land under control of the HH (and under women's control). Seeds Water Other inputs e.g. fertiliser, pest control equipment.	For crop cultivation: knowledge and skills of FV cultivation (sowing, care, harvesting). For consumption: knowledge about FV processing, storage, food preparation; nutritional content and health benefits.	Agricultural extension service; community support and health workers.	Modest changes in practice largely under control or within domain of HHs (context-dependent). Cultural barriers around gender roles and empowerment of women within HHs.
2	Collective vegetable gardening by young women	Stimulating small-scale production of vegetables and fruits by young women will lead to empowerment of young women and increase in production and consumption of nutritious FV at HH level, and increase HH	Young rural women cooperating in small groups.	Young women form groups to learn and take up FV production for consumption and sale. Increased consumption of nutritious FV at HH level.	Land for young women to cultivate. Seeds, fertilisers; Material for greenhouses and polytunnels: Farm tools and implements	For crop cultivation: knowledge and skills of FV cultivation (sowing, care, harvesting). For consumption: knowledge about FV processing, storage, food preparation; nutritional content	Small groups of women supported by families and wider communities; trained and advised by agricultural extension officers and technicians.	Substantial new activities involving formation of new groups, allocation of land and resources, learning of new skills. Cultural hurdles around

	Example inter-ventions	Essential concept (Implicit impact pathway or theory of change leading to improvements in nutritional outcomes)	Who is expected to practise the technology? (principal or emblematic practitioners)	What behaviours or practices are expected to change?	What material inputs are needed?	What information, skills and knowledge are required?	Extent of the actor—network to be engaged (scale of the change)	Scope of the change (complexity of the transformation)
		incomes (under women's control). Will also increase accessibility of FV on local markets, increasing consumption among consumers.		Sale of FV to increase HH (women's) incomes.		and health benefits.		gender and youth in relation to independence, control over land, engagement in FV production.
3	Small livestock/ poultry (e.g. ducks, chickens.)	Encouraging rural HHs to undertake or improve small livestock/poultry husbandry will lead to increased HH consumption of nutritious foods (e.g. eggs, meat, milk) and/or increased HH incomes from sale of livestock/poultry products. Will also increase accessibility of healthy animal/poultry products on local markets, improving diets of consumers.	Rural HHs, especially women and young people.	Adoption of new or improvement and expansion of existing practice of livestock/poultry husbandry. Increased consumption of livestock/poultry products (eggs, meat, milk).	Healthy and productive chicks/ ducklings/ breeding goats; feeds; vaccines.	Veterinary services (esp. vaccination); advice on poultry breeds, husbandry methods, disease controls measures, etc.	Agricultural extension services; community health workers; NGOs; veterinary services. Sellers and consumers in the market.	Modest to substantial changes of practice within HHs, largely under HH control, but depending on ongoing supply of healthy animals/birds, and delivery of vaccines and veterinary services. Also improvements in public market facilities and practices.
4	Nutrient	HH-level cultivation of	HHs, especially	HHs adopting or	Clean planting	Training and	Seed suppliers;	Could be a

	Example inter-ventions	Essential concept (Implicit impact pathway or theory of change leading to improvements in nutritional outcomes)	Who is expected to practise the technology? (principal or emblematic practitioners)	What behaviours or practices are expected to change?	What material inputs are needed?	What information, skills and knowledge are required?	Extent of the actor—network to be engaged (scale of the change)	Scope of the change (complexity of the transformation)
	dense/ biofortified crops (e.g. OFSP, high-zinc rice)	(new, nutrient-dense varieties of) food crops will lead to increased consumption of nutritious foods by producer HHs and consumers on local markets	women (cultivating and cooking nutrient-dense food crops)	increasing cultivation of nutrient-dense food crops. Producers HHs consuming or selling them.	material of nutrient-dense varieties. Other farm inputs (e.g. fertilisers, fungicides, water).	information about cultivation practices, storage and cooking precautions, nutritional benefits.	agricultural extension services. Community health workers / NGOs. Women responsible for food preparation and family feeding; consumers in the market.	simple change where new varieties (e.g. OFSP) may be substituted for existing/ alternative ones (e.g. traditional SP). Much more complex where the intervention entails adoption of a totally novel food.
5	Food product fortification (e.g. Vitamin-fortified oils and iron-fortified wheat in Pakistan, Bangladesh; Tiger biscuits in	Fortification of basic food products (e.g. flours and oils) or processed food products (e.g. snack foods) will lead to improvements in nutritional outcomes.	Food processing industry (major food companies; small-scale millers, etc.). Regulation by state (compulsory fortification; quality and safety standards).	Manufacturing and marketing of fortified foodstuffs and processed food products; consumers buying and using fortified foods.	Micronutrient additives (fortificant premixes). Equipment to incorporate the fortificant (e.g. premix feeder for flours).	Skills and equipment for qualitative and quantitative monitoring of fortified products. Nutritional advice/ marketing info. / advertising to consumers (e.g. on risks of VAD and Vit A benefits).	Post-farm value chain, including retailers and consumers. May include many thousands of small-scale grain millers as well as big-brand food companies.	Modest technical changes, largely within control of food processors, but requiring capital investment and ongoing input costs. Challenging to involve small-scale, village-level processors and

	Example inter-ventions	Essential concept (Implicit impact pathway or theory of change leading to improvements in nutritional outcomes)	Who is expected to practise the technology? (principal or emblematic practitioners)	What behaviours or practices are expected to change?	What material inputs are needed?	What information, skills and knowledge are required?	Extent of the actor—network to be engaged (scale of the change)	Scope of the change (complexity of the transformation)
	India; Shakti Doi yoghurt in Bangladesh)							reach poorer (price-sensitive) consumers.
6	Biofortified transgenic crops (e.g. Golden Rice)	Altering the genetic characteristics of staple crop varieties will create more nutrient-dense foods and increase consumption of micronutrients (e.g. zinc, pro-vitamin A [β carotene], vitamin D, iron).	Farmers cultivating biofortified transgenic crops; Consumers choosing and consuming them.	Plant breeders and seed companies developing and suppling biofortified crop varieties; Farmers choosing to plant them; Value chains segregating and advertising distinctions of biofortified foods; Consumers choosing biofortified food products. Potentially, adoption of new/ modified/ improved food storage and	Biofortified seeds, including transgenic varieties.	Information and training about novel traits; how to cultivate the crops; how to process/ store them after harvest. How to cook them (modified methods to preserve distinct characteristics?).	Whole value chain (from input supply to consumption), including regulation, marketing: Public AR4D system; private sector agribusinesses; agri-input dealers and distributors; food processors, retailers; regulators; consumers.	On-farm impacts potentially minimal (substitution of new variety); In seed system and post-farm value chains, implications potentially very large (segregation, labelling, monitoring); In HH food preparation and consumption practices: changes potentially significant (e.g. improved storage, changed

	Example inter-ventions	Essential concept (Implicit impact pathway or theory of change leading to improvements in nutritional outcomes)	Who is expected to practise the technology? (principal or emblematic practitioners)	What behaviours or practices are expected to change?	What material inputs are needed?	What information, skills and knowledge are required?	Extent of the actor—network to be engaged (scale of the change)	Scope of the change (complexity of the transformation)
				preparation (cooking) methods and practices.				cooking methods and times).
7	Nutrient cycling using biochar (Biochar Urine Nutrient Cycling for Health, BUNCH).	New methods for processing and combining (a) crop residues and (b) human/ animal waste (urine) will capture nutrients that will (c) be applied as fertiliser to the crop root zone using new crop establishment techniques, which will increase crop productivity and improve nutritional profile of crops grown on poor soils.	Rural HHs including men and women. Sometimes organised into groups of neighbours.	Adoption of new processes to produce biochar, collect urine, combine them, and apply resulting nutrient-charged biochar to plant root zone.	Biomass (crop residues and other vegetation) for burning; kilns for controlled (oxygen-limited) burning to create biochar; urine collected from livestock and/or human beings; vessels for storage and transport of urine and biochar.	Initial training and guidance on entire system, especially (a) constructing kilns, (b) controlled burn, (c) application of biochar to root zone.	Men and women within HHs; farm labourers. External support from trainers and technicians.	Substantial changes in activities, skills and organisation, but largely within HHs or small groups.
8	Farming System for Nutrition (FSN)	Reorganisation of farm production systems at village scale, in order to diversify cropping patterns, increase production and consumption of	(a) Farmers and village communities. (b) Agricultural researchers and extensionists.	In production: Changes in farm- and village-level crop and livestock mix. In consumption: HH and individual	Land. New crops, improved seeds; other farm inputs e.g. fertiliser, pest-control equipment and methods.	Guidance and information on diversified crop and livestock management techniques; nutritional	Farmers, labourers, HH-members. Public sector AR4D and extension system; Agri-input dealers	Context-dependent; potentially extensive, involving significant change in land use,

	Example inter-ventions	Essential concept (Implicit impact pathway or theory of change leading to improvements in nutritional outcomes)	Who is expected to practise the technology? (principal or emblematic practitioners)	What behaviours or practices are expected to change?	What material inputs are needed?	What information, skills and knowledge are required?	Extent of the actor—network to be engaged (scale of the change)	Scope of the change (complexity of the transformation)
		nutritious foods. Making the agricultural research and extension system more nutrition-sensitive.		dietary changes (quality and diversity). In research and extension: promoting nutrition-sensitive forms of production.		information and dietary advice.	and distributors; Community health workers; NGOs.	cropping patterns, seasonal activities, etc.
9	Integrating nutrition advice into agricultural extension platforms	Providing health and nutrition advice through a digital agricultural extension platform will raise awareness of healthy maternal, infant and young child nutrition (MIYCN) practices, leading to beneficial changes in behaviour and improvements in nutritional outcomes.	Women, especially mothers and people caring for infants and young children. Women's self-help groups.	Target population engages with health and nutrition advice delivered via video format, and follows recommended advice.	Video-recording and editing equipment; devices for screening and sharing videos; venues to screen videos and hold discussions and training sessions.	Nutritional information and guidance; health and nutrition knowledge; Health communications expertise; Film-making expertise (storyboarding and script-writing, filming, interviewing, editing, etc.).	Individual women and women organised into self-help groups; Nutrition experts; Community health workers; Communication specialists; film makers.	Context-dependent. Behavioural changes relating to feeding potentially extensive depending on existing situation, e.g. availability of foodstuffs. Changing women's working habits during pregnancy and breastfeeding may entail complex

	Example inter-ventions	Essential concept (Implicit impact pathway or theory of change leading to improvements in nutritional outcomes)	Who is expected to practise the technology? (principal or emblematic practitioners)	What behaviours or practices are expected to change?	What material inputs are needed?	What information, skills and knowledge are required?	Extent of the actor—network to be engaged (scale of the change)	Scope of the change (complexity of the transformation)
								adjustments, difficulties for families dependent on women's labour.
10	Inclusion of millets in the PDS (India)	Including millets within the PDS will stimulate demand, increase supply, improve accessibility of nutritious coarse grain cereals, thus diversifying diets of poor consumers and improving their nutrition.	State governments procure millets for the PDS and include millets among subsidised grains in fair price shops; Farmers respond to price signals and increase millet production; PDS-eligible HHs purchase and consume more millets	Production, distribution and consumption of millets to increase (relative to alternative grains, especially rice and wheat).	Millet seeds (increased supply?).	Notification and awareness-raising activities to inform farmers and consumers. Advice and guidance on nutritional benefits of millets and dietary diversification. Knowledge of millet-based dishes/ recipes for home consumption.	National legislation, state-level policy and implementation; funds for procurement and distribution of grain; farmers and consumers, managers of fair price shops.	Simple, one-time change to legal/ policy framework (e.g. National Food Security Act 2013) may lead fairly easily to extensive reconfiguration of practices across the PDS system. Ongoing challenges in administration, monitoring and policing of PDS.

Key: FV = fruit(s) and vegetable(s); HH = household; OFSP = orange-fleshed sweet potato; SP = sweet potato; PDS = Public Distribution System (India); VAD = vitamin-A deficiency.

Appendix 3: LANSA studies nominally including an innovation focus

Title	Organisations	Country
Household duck rearing as a tool to combat poverty and malnutrition among rural communities in Bangladesh	University of Queensland (Lead: Joerg Henning, PI) Chittagong Veterinary & Animal Sciences BRAC Royal Veterinary College, UK	Bangladesh
Biochar Urine Nutrient Cycling for Health (BUNCH); A feasibility study of organic nutrient cycling to enhance homestead food production for improved nutrition	University of Heidelberg (Lead: Sabine Gabrysch, PI) Ithaka Institute for Carbon Strategies Helen Keller International BRAC University	Bangladesh
Feasibility of an integrated agriculture and nutrition behaviour change intervention to improve maternal and child nutrition in rural Bangladesh	University of Sydney (Lead: Michael Dibley, PI) International Centre for Diarrhoeal Disease Research, Bangladesh (ICDDRB) Agriculture Extension Division, Government of Bangladesh Solidarity, Bangladesh	Bangladesh
Design suitable approach for promoting Nutrition Sensitive Farming System (NSFS) as foundation for Healthy tribal Community in Banswara, India	Vaagdhara (Lead: Deepak Sharma, PI) Action Against Hunger (ACF)	India
Female agricultural labour and nutrition: resolving conflicting time demands	Institute for Financial Management and Research (Lead: Andre Butler & Aparajit Mahajan, Co-PIs) Department of Agricultural & Resource Economics, University of California-Berkeley National Agro Foundation	India
People's perspective and feasibility of Kitchen Gardening under different geographical and environmental contexts	Action Against Hunger (ACF) Pakistan (Lead: Ashok Kumar, PI)	Pakistan
Promoting collective vegetables gardening by adolescent girls for reducing malnutrition in Afghanistan	BRAC Afghanistan (Lead: Anowar Hossain, PI) BRAC International	Afghanistan

Note: further details are available on the LANSA website: http://lansasouthasia.org/tags/responsive-window-2
Key: PI = principal investigator; Co-PI = co-principal investigator.

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