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Enhancing innovation in livestock value chains through networks: Lessons from fodder innovation case studies in developing countries

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Fodder scarcity is a perennial problem for many smallholder farmers in developing countries. This paper discusses how fodder technologies and knowledge have been introduced and integrated in diverse livestock production systems in Ethiopia, Syria and Vietnam. A synthesis of lessons learnt shows that fodder innovation is triggered and diffused by actors interacting and learning in networks, and on farms. Fodder innovation, being only one element of livestock value chains, is sustainably enhanced when linked to other innovations and market-oriented activities that optimize productivity gains. Yet innovating smallholder farmers face systemic constraints to access markets, and need to organize in groups to exploit opportunities. The paper concludes that rather than treating innovation systems and value chain approaches to agricultural development as separate tools, the integration of their complementary features enhances smallholders' innovation and market success.

Keywords: fodder; networks; value chain; Ethiopia; Syria; Vietnam.

1. Introduction

In developing countries livestock can be an important pathway out of poverty (Food and Agriculture Organization (FAO), 2009; McDermott et al. 2010a; Rich et al. 2011). Over 1 billion people depend on livestock which provide power and manure for crop production, contribute to food and nutritional security, and are a form of savings for many poor people. Livestock also make major contributions to the agricultural gross domestic product (GDP), export earnings and employment. According to the

'livestock revolution' thesis (Delgado et al. 1999; McDermott et al. 2010a) the sector is driven primarily by rising incomes and urbanization in developing countries like China and India where demand for products such as meat and milk has been soaring. However, livestock are also responsible for adverse impacts on land, water, biodiversity and climate change (Steinfeld et al. 2006; FAO 2009). Despite the conflicting paradigms, many, including McDermott et al. (2010a) argue that, given appropriate policies to address social and environmental effects, livestock provide opportunities for millions dependent on them.

There are, however, challenges to enhancing market success for livestock-dependent people, including fodder¹ scarcity and weak farm-to-market links (McDermott et al. 2010b; International Fund for Agricultural Development (IFAD) 2006). The micro-evidence we generated from Ethiopia, Syria and Vietnam shows that fodder scarcity is severe. For example, in Syria during the dry season (December to February) many farmers face 50–60% fodder shortfalls (Larbi et al. 2010). Fodder shortages reduce productivity and production and, as we noted in Ethiopia, may also damage community relations by provoking conflict over grazing lands. We found complex causes of scarcity including: limited and erratic rainfall, shrinking grazing lands due to competition for land for crops, and changing land use patterns favouring urbanization and settlement.

Over the past four decades R&D programmes have looked into the fodder scarcity challenge, with some success in developing and promoting food and feed crops such as: cowpea, improved grasses, legumes and fodder trees (Lenné and Wood 2004; Kristjanson et al. 2005; Franzel and Wambugu 2007; Horne et al. 2005). Despite these efforts many researchers found ‘limited’ evidence of adoption of fodder technologies (IFAD 2006; de Haan et al. 2006; Hall et al. 2007). Among other factors, this was attributed to farmers’ limited knowledge of technologies and the low level of technical support provided to them, low government priority given to fodder compared to staple crop technologies and limited availability of fodder seeds (IFAD 2006). For Hall et al. (2007) fodder scarcity has less to do with shortage of information or technology *per se* but rather with ‘capacity scarcity’ to innovate. Addressing scarcity entails the development of an ‘innovation capacity’ which consists of:

...the context specific range of skills, actors, practices, routines, institutions and policies needed to put knowledge into productive use.... (Hall 2005: 625)

Innovation capacity development comes under the rubric of an innovation system approach which stipulates innovation as an outcome of interactive learning in networks (World Bank 2007; Rajalahti et al. 2008).

This paper is based on case studies drawn from the Fodder Adoption Project (FAP)² and Duncan et al. (2011) which were implemented in Ethiopia, Syria and Vietnam in the period 2007–10.³ The FAP was motivated by the innovation systems approach, and aimed to achieve a better understanding of the factors and processes influencing fodder innovation (the successful introduction and integration of fodder technologies and related knowledge in livestock production systems).⁴ A small team consisting of a research scientist and support staff coordinated networks in each country to initiate and diffuse fodder innovation at nine learning sites (villages and districts): four in Ethiopia, three in Syria and two in Vietnam. This paper synthesizes the lessons learnt. It pays particular

regard to the underexplored development of innovation architectures in different local and national contexts, seeking to explain that, as in networks, learning on farms is critical for innovation; and sustained improvement to fodder availability occurs when broader livestock value chain issues are addressed.

Section 2 discusses the innovation system and value chain approaches as tools for understanding, organizing and implementing agricultural development initiatives. It also outlines the methodology of this study. Setting the context, Section 3 describes and characterizes the national and local innovation environments. Section 4 discusses the innovation processes and outcomes thereof. Focusing on a meat value chain, it also discusses the factors that enhance fodder innovation in a sustained manner. Section 5 draws lessons and provides the conclusions.

2. Contemporary approaches to agricultural development and study methodology

2.1 Innovation system and value chain approaches to agricultural development

Along with Spielman et al. (2009), the World Bank (2007) and others we understand (agricultural) innovation as a successful introduction and exploitation of knowledge and technologies for social and economic benefits. The use of such knowledge and technologies brings about positive changes in how people make or do things, and ultimately improves their livelihoods. The linear research–development–extension approach has been much criticized for being hierarchical, top-down and supply-driven, and for its limited impacts on the generation and diffusion of relevant knowledge and technologies. The thinking behind the approach has been that scientific research is the driver of innovation, but that it often disregards different sources of knowledge and demand (see Lundvall et al. 2002; World Bank 2007; Rajalahti et al. 2008). The more recent paradigm for knowledge generation and use is the innovation system approach (Lundvall et al. 2002; Clark et al. 2003; World Bank 2007; Rajalahti et al. 2008; Spielman et al. 2009), described as a network of private and public sector organizations whose interactions produce, diffuse and utilize economically useful knowledge. For innovation systems thinkers, innovation of different kinds (technical, institutional etc.) follows a non-linear process and uses multiple sources of knowledge. Networks coordinate and facilitate inter-organizational interactions and knowledge and information flows: they allow the exploitation of complementary capabilities and open up opportunities for exploiting synergies within networks (Pyka and Koppers 2002; Howells and Edler 2011).

The ‘system’ capacity depends on the ‘density and quality of relationships’ between the innovation producing and using agents, and the support institutions (Altenburg et al. 2008). The more diverse the actors the better the

opportunity to combine complementary capabilities. Interaction and learning also depend on actors' 'proximity'—including the physical distance, the institutional environment that shapes trust-based relationships, and actors' capacity to absorb new ideas. The stronger the proximity the better the flow of (particularly tacit) knowledge that cannot be coded and 'transferred' (Boschma 2005; Clifton et al. 2010). However 'more links' and 'denser network ties' could also produce 'lock-in failure' where inward looking tendencies block diverse and open relationships and stifle innovation (Boschma 2005; Clifton et al. 2010; Howells and Edler 2011). Facilitation by 'intermediary' organizations also enhances networking and interaction as such organizations, acting as brokers, help find advice and funds supporting innovation outcomes (Klerkx and Leeuwis 2008). In the cases discussed here the institutional environments provided a limited number and diversity of actors, and barely any network facilitators, making the demand for innovation capacity development more challenging.

The innovation systems approach implicitly assumes that learning in networks unproblematically extends to individual actors and to farmers and produces innovation. Evidence from the case studies reported in this paper shows that, prior to acceptance, farmers learn a great deal on-farm about the performance and suitability of fodder technologies to farming systems, and the sustainability of input and product markets. This is not surprising as many including Johnson (1992) noted, of all types of learning (like imprinting or searching) the most economically worthwhile and useful in increasing the stock of knowledge is 'learning by producing' or 'learning by doing', which we interpret to mean learning on farms. Further relevant innovation capacities reside in networks and partnerships, organizations and in individuals (Ayele and Wield 2005). This paper therefore links network and farm-level learning arenas (with institutional support) as being central to innovation.

The literature on value chains and innovation systems shows many common and complementary features (Anandajayasekera and Gebremedhin 2009). The value chain is understood to include all the actors and activities from production to consumption, and the dynamic relationships between actors involved in a chain (Rich et al. 2011; McDermott et al. 2010b). Key to both approaches is the mapping and characterization of actors and their interactions. As discussed above, an innovation systems approach focuses on knowledge generation and use, often at a particular stage of a value chain, while the value chain approach is more about value creation and market opportunities and linkages across a chain. With few exceptions (Anandajayasekera and Gebremedhin 2009; McDermott et al. 2010b) an integrated innovation system and value chain approach to developing, implementing and evaluating agricultural development initiatives has received limited attention among researchers and practitioners,

arguably resulting in sub-optimal outcomes. To clarify, fodder is important but it is only a single input in livestock production, hence sustainable return to improved fodder depends on the efficiency of a whole value chain. We argue that an integrated approach provides several advantages. First, it provides a better framework to address market failures such as high transaction costs, insufficient market information and the exercise of market power that are inherent in the smallholder livestock system (Rich et al. 2011). Second, it allows for the optimization of gains from innovations in interrelated inputs and services. In relation to the latter, McDermott et al. (2010b: 156) cite 300% gains to smallholders due to the combined use of breed and feed improvements (which otherwise would not have been achieved).

2.2 Study methodology

The case studies reported in this paper are described and analyzed against the backdrop of the above conceptual literature and an integrated innovation systems and value chain approach. The innovation systems framework emphasizes, among other things, the totality of actors and factors required to bring about innovation and growth (World Bank 2007). Following this framework, the study identifies and characterizes the main actors in the study sites such as: knowledge and technology providers and users, and their roles, interaction between actors and their habits and practices that influence joint learning and innovation. It also evaluates the enabling environment for fodder innovation and livestock development. It describes and analyzes FAP's fodder innovation processes, and the capacities developed and technological options introduced and adopted. Using the value chain tool (Kaplinsky and Morris 2001; McDermott et al. 2010b) the study identifies and assesses site-specific livestock production value chain activities and actors and their roles, production quality standards, and opportunities for improving the chain. The tool is employed to evaluate the integration of fodder innovation into smallholder livestock production, and the linking of the latter with markets. The paper uses empirical data collected from six of the nine learning sites over the period 2009–10 from multiple sources including: extensive semi-structured interviews held with FAP country team members, and with partners and participating farmers, and also FAP internal reports (three learning sites, one from each country, were not covered in the analysis as insufficient data emerged at the time of fieldwork). It also draws on close observation of actors' interactions and learning.

3. Background to fodder innovation case studies

3.1 FAP origin and approach

The idea for the FAP originated from debates in 2001–2 among multidisciplinary researchers on ways of addressing

fodder scarcity (Lenné et al. 2003; de Haan et al. 2006). At about the same time, the International Livestock Research Institute (ILRI) and partners began developing project ideas for implementation in countries where a large number of people depend on livestock. This led to the design and implementation of the 'fodder innovation project' in two phases in the period 2002–9 in India and Nigeria.⁵ FAP followed in 2007. As an approach, FAP country teams focused on three levels of interaction and learning, innovation and diffusion: farm, district and region/national levels. First, farmer and farm-level learning was considered to be central, as the improvement of livestock production generally happens at farm level, with farmers learning by themselves and from each other, by testing and integrating new ideas within existing practices. Second, where a network of actors is weak or non-existent, strengthened actor networks at district level were thought to enhance the innovation processes and outcomes. Finally, engaging higher level (regional or above) policy-makers in dialogues over fodder and livestock matters was also thought to improve the enabling environment for innovation, such as improved policy on fodder seed production and distribution.

3.2 Innovation environments in different national contexts

Table 1 provides selected country indicator data for Ethiopia, Syria and Vietnam. In Syria livestock (predominantly sheep) contribute 34% to the agricultural GDP (Shomo et al. 2010). Some 85% of the country receives less than 350 mm rain per year. The humid areas, accounting for 15% of the country, receive more than 350 mm rain per year

(Shomo et al. 2010) (see also Fig. 1). Across Syria grazing provides the most important source of fodder for ruminants but the supply of fodder is insufficient and seasonal (Shomo et al. 2010). In contrast to Syria, Ethiopia is largely high-table land, highlands above 1,500 m comprise 43% of the country, while the rest of the country consists of lowlands where pastoral and agro-pastoral systems dominate. The maximum mean annual rainfall reaches 2,000 mm in the southwestern parts of the country, while the lowest mean annual rainfall is below 250 mm in the northeastern and southeastern lowlands.⁶ Agriculture is the mainstay of Ethiopia. It accounts for 43% of the country's GDP and employs 85% of the labour force. Its livestock population consists of over 50 million cattle and over 45 million sheep and goats. Livestock also provide power and manure for crop production.

Vietnam's agriculture and forestry sectors are the main sources of livelihood for the rural poor who accounted for 74% of an estimated 86 million people in 2008. The country has two fairly equal dry and wet seasons, and in the central highlands (including the FAP learning site area, Ea Kar district in Daklak province) the altitude is in the range 300–2000 m above sea level; the rainfall is in the range 1500–2000 mm per year. While keeping pigs is important nationally, many Vietnamese farmers also keep cattle (Khanh et al. 2009). The FAP Vietnam team estimates that there is a 40% fodder shortage during February and March; and a 20% shortage during November and December.

The structure and authority of different levels of governments in the three countries vary, with implications for the emerging innovation architectures. For example, unlike in Syria or Vietnam, Ethiopia has autonomous

Table 1. Basic indicators of FAP countries

Indicator	Ethiopia	Syria	Vietnam
Total land area, km ² *	1,104,300	185,180	329,310
• Arable land (% of land area) (2007)*	13.0	26.5	21.3
Human population (total in millions) (2008)**	81	21	86
• Rural population (%) (2005)*	84.0	49.4	73.6
GDP (in US\$ million) (2008)**	26,487	55,204	90,705
Value added as % GDP (2008)			
• Agriculture	43	20	20
• Industry	13	35	42
• Services	44	45	38
Gross national income per capita (in US\$) (2008)**	280	2090	890
GDP average annual growth rate (2000–8)**	8.2	4.4	7.7
Road density (road km per 100 km ²) (2000–6)*	3.6	51.6	71.7
Livestock population (total in millions) (2009)***			
• Cattle	50.88	1.08	6.10
• Goats	21.96	1.51	1.48
• Sheep	25.98	12.38	–
• Pigs			27.63

Sources: *World Bank (2009); **World Bank (2010); ***FAOSTAT (2008–9) (see <<http://faostat.fao.org/>> accessed 9 March 2011)

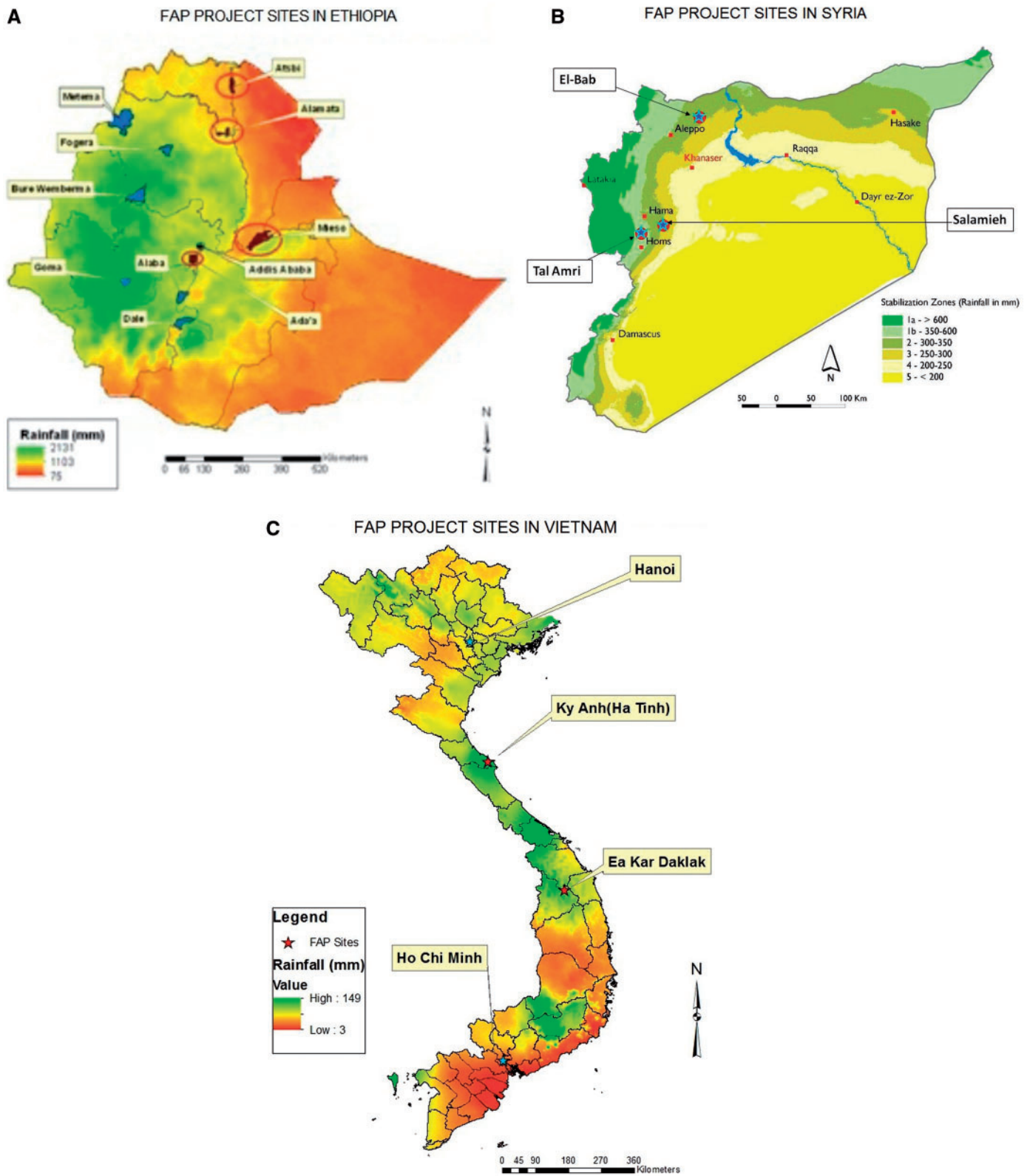


Figure 1. Maps of Ethiopia, Syria and Vietnam showing the FAP Learning Sites.

regional states that have the power to determine their social, economic and cultural affairs. Likewise, non-governmental organizations (NGOs) have more

visibility, particularly in the implementation of development projects, in Ethiopia than in Syria and Vietnam. While livestock development is largely a private activity,

governments in all three countries play a role in providing animal health and extension services. In all three countries the role of the private sector in generating and diffusing agricultural technologies is limited. Fuelled by growing urbanization and incomes, all three countries have been enjoying a growing domestic and foreign market for livestock products. In Vietnam and Syria livestock development has been supported by a relatively developed infrastructure like roads (see Table 1). The above national environment (agricultural, ecological and institutional factors) guided the FAP teams to select partners and learning sites.

3.3 Partner and learning site selections

In selecting learning sites, FAP in Ethiopia focused on market opportunities for livestock products; and agro-ecological and socio-economic challenges to improve food security. First, the team identified a key collaborating partner running the Improving Productivity and Market Success (IPMS), a project located within the ILRI operating in ten pilot learning *woredas* (districts) across Ethiopia. It selected four IPMS learning sites (two highland *woredas*, Ada'a and Atsbi Wobera, and two from the lowlands, Alamata and Mieso) (see Note 6 and Fig. 1). The Alamata and Atsbi Wobera *woredas* are in the Tigray Regional State, in northern Ethiopia, where livestock productivity is severely affected by fodder shortages caused by frequent droughts. Mieso and Ada'a are located in the Oromia Regional State. In Mieso livestock are major contributors to livelihood. The area is semi-arid, and is frequently affected by water shortages and drought. Ada'a is close to the capital Addis Ababa and has a fairly developed industry and infrastructure. It has access to relatively large market opportunities for its produce, notably the cereal crop *teff*. It has a growing smallholder dairy production system with strong milk marketing and farmers' service cooperatives, but limited and erratic rainfall and expanding urbanization have been reducing traditional sources of fodder such as open grazing lands. The *woredas* thus provided the 'setting' for the emerging innovation networks. Within each *woreda* learning sites were narrowed down to one or more *kebeles* (neighborhood associations of farmers) where 50 or more willing participant farmers (who own livestock and land, and who tend to be model farmers and opinion leaders) were experimenting with new fodder options. At national level a fodder platform was set up consisting of stakeholders from the states of Oromia and Tigray, federal government units, NGO and donor organizations to deliberate on relevant policy matters and ways of up scaling successful practices.

The FAP team in Syria started with a consultation process at the national level for identifying potential partners. The Ministry of Agriculture and Agrarian Reform (MAAR) became its core partner. With MAAR support a national project inception workshop was held to

engage a wider set of stakeholders in FAP implementation. The inception workshop also constituted a steering committee led by the head of the MAAR Extension Directorate. Provincial and site selection criteria were: high livestock population density (notably sheep), rain-fed and mixed crop–livestock systems that allow the application of different fodder technologies of tree crops and food-feed crops; and experiences of relevant departments in livestock production and extension. As in Ethiopia, the choice of farmers' focused on their willingness to participate, and their ownership of livestock and land. The innovation architecture thus consisted of:

- A national steering committee in order to provide leadership and a mechanism for scaling up and replicating the lessons learnt at other sites.
- Three innovation networks: El-Bab (Aleppo province); Salameih (Hama province) and Tel Amri (Homs province) (see Fig. 1). Their purpose was to engage farmers; develop and implement options; and monitor and evaluate outcomes.
- On-farm experimentation and learning. At all levels, consideration was given to ensure the participation of women and of policy-makers.

Unlike in Syria and Ethiopia, the Ea Kar site in Vietnam (see Fig. 1) was a continuation of previous research for development projects: 'Forages for Smallholders Project' (2000–2), and Livelihood and Livestock Systems Project (2003–5). The key players in both projects were the International Centre for Tropical Agriculture (CIAT), Tay Nguyen University (TNU) and the National Institute of Animal Husbandry (NIAH). In partnership with the district extension and agriculture and rural development workers, the projects developed forage technologies with smallholder farmers in Daklak province, and succeeded in introducing and evaluating a variety of fodder options such as napier grass (Khanh et al. 2009). Building on experience from these projects, in 2007 FAP inherited the existing network of actors, and focused on strengthening the value chain actors including extension, research, traders and government. The country team also established a new site, Ky Anh in Ha Tinh province. By way of an approach, the FAP team started with key volunteer farmers who had land and animals, and were able to organize hired or household labour to work on their farm. A fodder group, composed of at least ten farmers, was set up around each key farmer in order to identify and introduce fodder options and jointly evaluate performance.

The foregoing description of learning sites and partners' selection, and the innovation architectures that emerged showed no regularity, and varied from what might be described as 'top-down' to 'bottom-up' approaches. It showed the different ways of organizing innovation networks in different socio-economic, institutional and agro-ecological contexts. Selected sites also showed varied conditions: in Syria they started anew, in Ethiopia

they piggy-backed onto an ongoing project, and Ea Kar in Vietnam was built on previous projects that had run for over five years. Appreciating these differences, our next aim was to understand whether or not networking enhanced learning and innovation (the following analysis and discussion does not include the Atsbi Woberta (Ethiopia), Tal Amri (Syria) and Ky Anh (Vietnam) learning sites as insufficient data had emerged at the time when the fieldwork was carried out).

4. Results: Developing innovation capacity and fodder options

4.1 Developing innovation capacity

As the innovation systems approach would suggest, FAP teams and partners diagnosed relevant policies, institutions and infrastructure. They also diagnosed actors and their roles, and attitudes and practices. A participatory assessment of farmers' needs, the causes and extent of fodder scarcity were also conducted. Using FAP facilitation, a set of actors were engaged to 'respond to the fodder challenge'. Table 2 shows that, in addition to the farmers, seven or more actors were involved in networks in Ethiopia but there were fewer, less diverse actors in Syria and Vietnam. Despite encouraging policies, there was an element of mistrust on the part of some government officials in all three countries of organizations operating for 'private gain'. As they often 'come and go' the continuous participation of non-local NGOs in networks was also seen as uncertain. Government departments for agriculture and rural development feature in all networks, providing infrastructure for disseminating knowledge and information, and supporting learning on farms. They are, however, insufficiently resourced and have a 'limited culture of collaboration'. Any engagements in collaborations were guided by official directives and plans, hence were slow to respond to other actors' needs. National and international research organizations were also drawn into the networks as knowledge and technology providers or capacity developers but some were wary of becoming bogged down in 'development work' that might adversely impact on their capacity to produce 'public goods' (publications) and maintain their reputation in research. While the vision to improve the livelihoods of smallholder farmers united the different actors, collaboration was also hampered by a lack of network facilitators. The FAP teams undertook the facilitation role and embarked on various types of innovation capacity development.

4.1.1 Strengthening weak inter-actor ties. Before networking began there were either 'no' or 'weak' actor interactions because of a limited culture of collaboration, trust or lack of facilitators. However, networking allowed regular meetings (on average four times a year in networks)

where actors discussed fodder scarcity, policy and market issues as well as their potential contributions. Less formal and more frequent one-to-one and small group meetings were also reported across the sites. Actors made cross-site and within site visits, and participated in 'fodder field days' etc. which facilitated information and knowledge exchanges. These efforts paid off and by 2009–10 actor interactions had significantly improved from largely 'no' or 'weak' to 'strong' and 'moderately strong' interactions (see Table 2).

4.1.2 Filling organizational gaps. Where the local institutional landscape did not provide actors with the necessary capabilities, actors were nonetheless brought into networks from further afield (e.g. Eden Field in Ada'a, and Adami Tulu and Melkassa research centres in Mieso).

4.1.3 Strengthening the supply system for fodder seeds. Where capacity to produce fodder seeds was weak or non-existent, farmers and development agents were trained. A series of training sessions, varying in length from one to three days, was given on fodder seed multiplication, evaluation etc. for 562 participants in Ethiopia (Duncan et al. 2010), for 50 participants in Syria (Larbi et al. 2010); and for 115 participants at the Ea Kar and Ky Anh sites in Vietnam (Anh et al. 2010).

4.1.4 Interacting with policy-makers to improve policies. Besides regular interactions with policy-makers, FAP teams produced training and communication materials such as: guide booklets, videos and posters to inform actors of their activities and to document lessons for replication in other areas of the respective countries. In summary, networking helped relevant knowledge and information flows, strengthening and coordinating complementary capabilities for joint learning and innovation.

4.2 On-farm learning and implementing fodder options

The purpose of the foregoing networking was to foster learning and produce innovation. Table 3 shows that, supported by the respective networks, farmers in all the learning sites selected and implemented novel technological solutions. Prior to acceptance, farmers experimented and learnt about topics such as: the performance and suitability of improved fodder options for farming conditions, the need for (re)allocation of resources like land and water, and sustainability of the seed supply. Fodder innovation was thus found through interactive learning in networks and on farms. The new technologies fitted farmers' food–feed requirements (e.g. by combining food and feed crops in areas of food scarcity: maize–lablab, cowpea), or rain-fed versus irrigation options, seasonal availability, performance or ease of inter-cropping requirements etc. The number of adopting farmers and area planted grew

Table 2. Summary of actors networks, actors roles and interactions by sites

Actor name and type, scope of operation and degree of interaction	Core activities
Ada'a (Ethiopia)	
Ada'a Dairy Coop (private)*	Milk collection, processing and marketing
Cooperative Promotion Office (govt: regional)**	Information dissemination
Crop Grow (private)**	Production and marketing of feed and food crops
Debre Zeit Agricultural Research Centre (govt: federal)*	Research, evaluation and training
Eden Field Agri Seeds Enterprise (private)*	Producer and supplier of forage/fodder seeds
Ethiopian Meat and Dairy Technology Institute (govt: federal)*	Training, source of improved breeds
FAP-ILRI (international research)*	Network facilitation, providing access to planting materials, joint learning, research
IPMS (ILRI–Government of Ethiopia–international research)*	Research for development (R4D), facilitate access to information and knowledge
Land O'Lakes (NGO)**	Training, technology transfer
Office of Agriculture and Rural Development (govt: <i>woreda</i>)*	Seed multiplication and distribution, extension and training
Farmers*	Testing and joint evaluation of fodder technologies
Alamata (Ethiopia)	
Abergelle Livestock International Trading Plc (private)*	Cattle fattening, supply of farm inputs, training
Ethiopian Sheep and Goats Project (NGO)*	Research and extension
FAP-ILRI (international research)*	Network facilitation, providing access to planting materials, and joint learning, research
IPMS (ILRI–Government of Ethiopia)*	R4D, facilitate access to information and knowledge
Office of Agriculture and Rural Development (govt: <i>woreda</i>)*	Training and technical support, seed multiplication
Alamata Agricultural Research Institute (govt: <i>woreda</i>)*	Research, acting as technical backstop
World Vision Ethiopia (NGO)*	Provision of bull service and fodder seeds
Farmers*	Testing and joint evaluation of fodder technologies
Mieso (Ethiopia)	
Adami Tulu Agricultural Research Centre (govt: regional)**	Research, supply of forage seeds, training
FAP-ILRI (international research)*	Network facilitation, provide access to planting materials, joint learning, research
Food Security Office (govt: regional state)**	Support seed multiplication (including paying for labourers)
IPMS (ILRI–Government of Ethiopia)*	R4D, facilitate access to information and knowledge
Melakassa Agricultural Research Centre (govt: federal)**	Research, supply fodder seeds, act as technical backstop
Office of Pastoral and Rural Development (govt: regional state)*	Fodder seeds multiplication and distributions, extension, training, coordination, monitoring and evaluation
Woreda Administration Council (govt.)*	Follow up and guidance, link to higher offices
Farmers*	Testing and joint evaluation of fodder technologies
Salameih (Syria)	
Aga Khan Foundation (international NGO)*	Rural development, extension, technology transfer
FAP-ICARDA (International Centre for Agricultural Research in the Dry Areas) (international research)*	R4D, facilitation of joint learning, providing access to planting materials, training
Office for Agricultural Research (govt: provisional)*	Research and evaluation
Office for Extension and Animal Resources Administration (govt: provisional)*	Extension
Farmers*	Testing, joint evaluation of technologies and practices
El Bab (Syria)	
FAP-ICARDA (international research)*	R4D, facilitation of joint learning, providing access to planting materials, training
Office for Agricultural Research (govt: provisional)*	Research and evaluation
Office for Extension and Animal Resources Administration (govt: provisional)**	Extension
Farmers*	Testing, joint evaluation of technologies and practices
Ea Kar (Vietnam)	
FAP-CIAT (international research)*	With TNU coordinated FAP Vietnam activities, provide technical support
TNU (national university)*	Research, capacity development, technical support, facilitate stakeholder interaction
NIAH (govt: national)**	Link to national policy-making
District Extension (govt: district)*	Facilitation and evaluation of on-farm testing and dissemination of technologies and information
District Agriculture and Rural Development (govt: district)*	Dissemination of technologies, liaison with policy-makers
Farmers and farmers' fodder groups*	Testing, joint evaluation of technologies and practices, participate in meat value chain
Small and large cattle traders (various contributions)	Buy cattle, provide market information etc.

*An 'active' actor participates in more than 50% of all meetings, and provides input such as technological knowledge on fodder innovation and livestock development to a network.

**A 'moderately active' actor is a member of a network but not a regular and active participant.

Table 3. Fodder options implemented by learning sites

Learning site	Key technological interventions	Number of farmers participating			Area planted (ha)		
		2008	2009	2010	2008	2009	2010
Ada'a (Ethiopia)	Oats-vetch, maize-lablab, napier, alfalfa, pigeon pea, sesbania and fodder beets	44	84	204	11	21	51
Mieso (Ethiopia)	Cow pea, lablab, pigeon pea, napier and alfalfa	40	80	160	10	20	40
Alamata (Ethiopia)	Cow pea, lablab, alfalfa, napier, pigeon pea, sesbania, Rhodes, buffel grass and panicum	20	20	35	5	5	9
Salameih (Syria)	Barley, common vetch, narbon vetch and grass pea for grain, straw or hay production; integrating forages into olive tree systems to improve feed and soil productivity; vetch grain-based mixed rations for dairy production and lamb fattening	67	187	188	28	109	384
El-Bab (Syria)	Various combinations of barley, common vetch, narbon vetch and grass pea (as in Salameih above)	5	67	107	15	92	191
Ea Kar (Vietnam)	Varies types of green fodder mainly napier, pennisetum hybrid/VA06 and guinea grass	N/A	N/A	> 3100	N/A	N/A	N/A

fast, particularly in Ada'a, Salameih and Ea Kar, where the interaction between the actors was much more consistent and on-farm technical support was provided by FAP. Following experimentation with a range of options, farmers adopted fewer but more suitable and high performing fodder options (typically oats-vetch in Ada'a, and cow pea in Mieso and Alamata).

Fodder availability improved for innovating farmers. Some farmers were storing enough fodder to sustain their animals through the shortage season. Farmers also consistently stated that improved availability of fodder increased productivity and production: the quantity and quality of milk increased, and small and large ruminants were fattened in a shorter time. In Ethiopia animals are sources of draught power hence improved fodder also had a positive impact on crop production. Farmers also noted that the increase in production was consumed on farms, improving the quality of the food and the nutritional status of households and/or sold on the market, improving their income. However, it was clear to the stakeholders that the sustainability of fodder availability and the benefits derived depend on factors such as: the dynamics of networking and joint learning, availability of complementary innovations that optimize returns, and access to market opportunities and linkages.

Several key developments promised sustainability to the emerging networking and joint learning culture. For example, coached by FAP teams, extension workers, who gained network facilitation skills, showed an interest in incorporating the innovation systems approach in their

routines and facilitating the networks as FAP exits. To this end, the Ea Kar experience in farmer organization and fodder management was used at the new Ky Anh site with considerable progress being made in fodder adoption in a shorter period (Anh et al. 2010). Moreover, improved fodder technologies were increasingly reaching non-participating farmers around the sites as, for example, a Syrian farmer was noted to have been copied by seven farms in his neighborhood. Interviewees were confident that the political support for fodder innovation would continue. For example, a senior Syrian government official showed interest in 'building on [FAP's] successful experiences in upcoming projects'. The Eden Field Agri Seed Enterprise has been expanding across Ethiopia, becoming a viable supplier of fodder seeds. That said, uncertainties remain, due to high turnover of staff in the Ethiopian public sector, it was uncertain whether or not 'key individuals capable of network facilitation will remain in their positions'.

In Mieso and Alamata in particular farmers operate in weak livestock value chains which, according to the partners could undermine the sustainability of fodder availability:

... some farmers may have been growing fodder but progress so far has not been life changing to them nor can be guaranteed to sustain.

These farmers were 'feeding improved fodder to low milk or meat producing animals' as improved breeds were hardly available. Consequently, the productivity gain was

significant but limited (farmers reported increase in milk production from around 1.5–2 litre per cow per day). The ‘surplus milk’ from these sites did not reach the market due to a lack of milk collection points and access to a market. However, farmers sell animals to local consumers and traders but at a ‘low price’ as they lack information on market prices or they face high transaction costs or they have limited marketing skills for selling animals in far-off large cities.

In response to these and similar challenges, FAP teams identified the respective livestock value chains for potential interventions but progress was mainly seen in the more established Ea Kar site (see below). In Syria, taking advantage of the growing market opportunity, many FAP participating farmers were fattening and selling sheep in the existing local market. A formal coordination of ‘value chain actors’ involving actors such as traders, transporters and slaughterhouses was not pursued due to limited project time and inadequate expertise in value chain organization. Faced with similar limitations, in Ethiopia chain linkages developments showed modest progress only in the market opportune Ada’a site. The Ada’a Dairy Cooperative has been experiencing falling milk supplies largely due to shortages of fodder. The Cooperative’s interest in the fodder network was thus derived from the prospect of increasing milk supply from farmers participating in FAP. Many farmers claimed that improved availability of fodder boosted milk production and sale, some farmers earning as much as birr 1,000 (around US\$60) per month. However, as many of the farmers keep local breeds, yield

was lower. The FAP network responded to this issue by catalyzing the procurement of small numbers of cross-bred cows by farmers with the support of the District Department for Agriculture and Rural Development in the period 2009–10. The Ea Kar case is discussed in Section 4.3 as an example of the approach taken to address the challenges and develop a thriving meat sector.

4.3 Integrating fodder innovation in meat value chain: experience from Ea Kar, Vietnam

According to Stür and Khanh (2010) Ea Kar’s conventional value chain was characterized as farmers growing and selling all types and sizes of animals at local markets without being able to meet the growing demand for the quantity and quality of meat. But through FAP participating farmers, two production lines emerged: farmers with less potential to keep animals for fattening (labelled F1 in Fig. 2) started a ‘cow-calf’ production system to raise cross-bred calves for sale. The second system was beef production where farmers (F2 in Fig. 2) fatten and sell animals. The FAP Vietnam team worked by steps to strengthen the meat value chain (Stür and Khanh 2010): first, fodder was planted to stimulate farmers’ interest in increasing productivity. Realizing that they were sometimes paid twice as much for their fatter cattle on the local market (compared to conventionally raised animals), farmers adopted a ‘buy thin – sell fat’ strategy. Second, new markets were identified and developed for fat cattle in provincial urban centres such as Buon Ma Thuot. This led to producing and marketing meat to city markets and

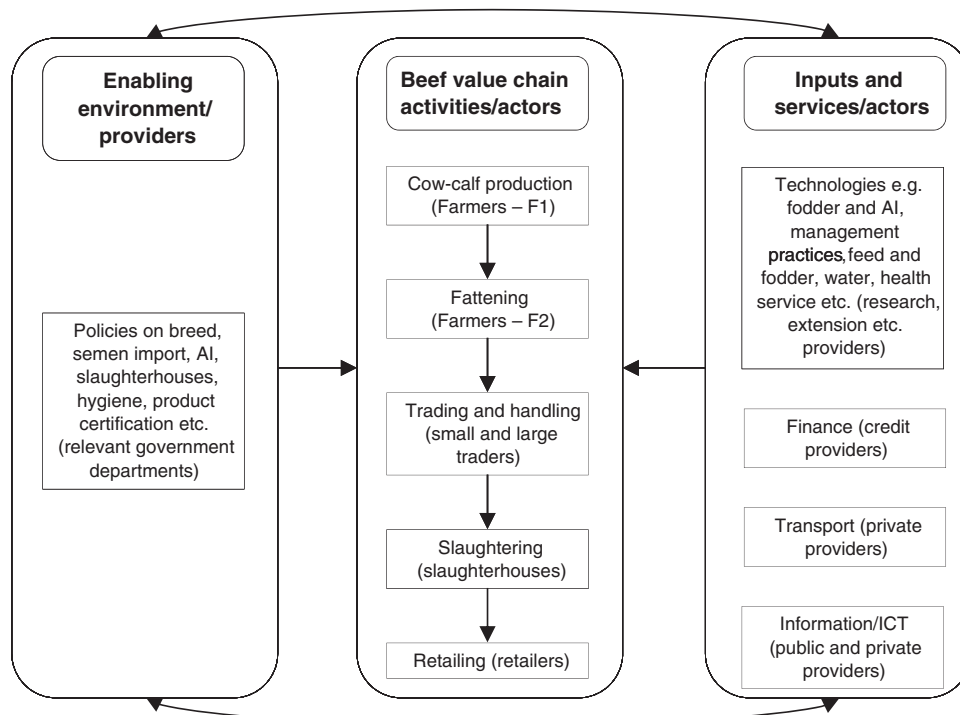


Figure 2. Simplified meat value chain – Ea Kar, Vietnam.

restaurants. Third, chain actors negotiated and introduced standards to ensure that fattened animals would be less than three years old and more than 300 kg at slaughter weight, and generally healthy. To meet the standards, farmers improved their animals' feed and fodder intake, shelter and health services. They kept information on each animal's weight, breed type and health conditions. These measures helped farmers receive better and relatively stable prices. Handlers were able to make direct and regular contacts with farmers and were able to purchase animals directly from the farm, and they in turn sold the animals to large traders and slaughterhouses. The government supported them in areas like breed improvement and regulation of meat slaughterhouses (Fig. 2 is a simplified diagram, arrows showing the dense value chain actors relationships and interactions are kept to the minimum).

By the end of 2010 the Ea Kar meat value chain was growing (Stür and Khanh 2010):

- A total of 44 farmers' clubs was established in the district with a focus on cattle production, and 3,100 households (30% of cattle producers in the district) planted forage crops.
- 532 households were fattening cattle for urban markets, and 800 households produced cross-bred calves.
- There were three farmers' clubs which had contracts with city traders, and cattle and beef were sold to local, provincial and several other city markets across the country.

FAP's approach started impacting on the livelihoods of many participating farmers in Ea Kar. One of the fodder groups in the district is in Ea Kmut commune, located in the neighborhood of Ea Kar town. The fodder group had 13 household members in 2009, and each household was fattening, on average, 32 animals per year (8 animals per 3-month cycle). After covering their costs, farmers on average made net US\$69 per month or US\$828 per year (according to the farmers, income from sale of fattened animals made up about 70% of their total income). The income was spent on farmers' basic needs and children's education, and the head of the farmers' group noted a 'bright future for beef production' in his commune. Farmers in Ea Pal commune were also able to benefit from the applied approach. However, they faced challenges such as: poor access roads and insufficient water to grow forage crops all year round. Ea Pal commune farmers noted that it was difficult to sell the animals on time for lack of easy access to markets, and small traders were colluding with large traders to cut prices. Like farmers in the Ea Kmut commune, they noted that raising capital to buy and fatten animals was also a major problem:

... yes we earn more money now from fattening than two years ago... but our capacity is still limited to raise capital as high as 10 million Vietnamese dong [about \$520] to buy an animal. We don't get bank credit because of tight collateral conditions. (head of farmer fodder group)

At the time of data collection FAP partners were looking into these challenges but despite the challenges, the FAP Vietnam team and partners stressed that the approach helped produce rewarding and sustainable outcomes: that the technological options and institutional arrangements introduced fit local context and meet local needs, and were supported by the local and national governments. As summed up by Stür and Khanh (2010) in 2010 the Ea Kar learning site was changing from 'traditional' cattle management to a 'refined' cattle production system, where farmers moved from feeding animals on naturally available resources to planted forage, from free grazing to confined animal keeping, from extensive production to defined production like fattening, and from production not linked to markets to market orientation.

5. Discussion and conclusions

More, and increasingly diverse, actors would provide the ideal complementary capabilities for innovation but the real world of the case studies presented networks with a limited number and heterogeneity of actors, and the networks had to be triggered and facilitated through an external research for development project. Actors outside the 'current systems' were drawn in and different types of capacity were developed. Sustained interactive learning in networks, and on farms, brought about fodder innovation at all sites. The integration of improved fodder in production processes also resulted in promising productivity gains, with improvements in farmers' food, nutrition, and income.

The study reported in this paper shows that fodder technological innovation is sustainably enhanced when linked with other innovations and market-oriented activities that optimize productivity. Testimony to this was the Ea Kar learning site, where a thriving meat value chain emerged. The key features of the success are worth stating here. First, once fodder innovation was found, dynamics were built into networking for continuous learning and innovation. To make fodder innovation more rewarding, it was integrated into interrelated innovations (notably breed and animal management) and value chain activities. Benchmarks were developed for keeping and fattening animals so that the quality was consistent, and this helped farmers earn better value for their produce. Second, a new organizational innovation (a farmers' group) was created to learn and innovate, and to support farmers' engagement in markets. Small and isolated farmers often suffer, hence farmers' groups became key instruments to improve marketing efficiency and profitability by reducing transaction costs. However, the need for, and organization of, such groups cannot be legislated for. It depends on the value chains that innovating farmers are in (meat, dairy or the species they keep), farm sizes, availability of infrastructure etc. In summary, the Ea Kar site demonstrated that fodder innovation triggered

technological, and social and economic changes where the actors' behaviour changed from an isolated to a more collaborative and interactive learning and innovation, where interrelated innovations were incorporated into production processes, and smallholder farming was changing from extensive and subsistence-based farming towards an intensive and market-oriented business.

Some of the factors that influenced innovation outcomes relate to time and contexts: notably whether learning sites were started anew or built on previous projects. Sites with more favourable conditions (such as those where the facilitators or partner organizations have worked before, and where there are good prospects for market development) produced more successful results than those with less favourable conditions. In Ea Kar it took more than five years for farmers to learn about the potential benefits and risk of fodder technologies, and effectively engage in markets. This suggests that, as underlined in studies involving science and technology partnerships (Chataway et al. 2006), time and patience, and the necessary support are required to take success from simply producing inputs to the level of meeting long-term objectives like improving livelihoods. Another key lesson was that farmers select and deselect fodder options appropriate to them based on technical, socio-economic and agro-ecological criteria. Fodder options attuned to farmers' local contexts led to successful adoption. Hence it is critical to understand farmers' needs and constraints, and support them to have a range of technological options to deal with the challenges they face. As FAP concludes, the innovation capacity developed in the networks and on farms is likely to support farmers to select and adopt fodder and related livestock technologies. However, transferring lessons beyond learning sites and countries entails making the necessary adjustments to fit into farmers' circumstances, and local and national contexts.

The present study highlights the importance of policy for innovation in value chains. For example, meat production was expensive for some farmers in Vietnam and might require credit. The supply of improved breeds of cows and milk collection points were inadequate in Ethiopia. Where such constraints prevail, governments need to support innovations and livestock-based businesses by facilitating the provision of credit, improved breeds etc. Second, due to market manipulation by some cattle traders, some farmers were selling animals for less than the market price. Thus, governments and other stakeholders need to step in and prevent such destructive behaviour. Third, networking is best facilitated by local and dedicated 'intermediary' organizations (Klerkx et al. 2010) but this seems a long way off in the sites studied—hence public investment is required to support local NGOs and public organizations to develop facilitation capacity. Finally, the weak and often missing actor in local networks was the private sector. Thus, governments should nurture that sector so

that it plays its due roles, particularly in disseminating agricultural knowledge and technologies.

In conclusion, the study shows that fodder innovation can be successfully triggered and integrated in livestock production by actors interacting and learning in networks, and on farms. However, fodder is one among many inputs in livestock production. The success of fodder innovation, and for that matter innovation in other livestock technologies, depends on other inputs, institutions and markets. The key lesson is that fodder can be an entry point but real improvement occurs when broader value chain issues are addressed in a holistic manner.

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Notes

1. 'Fodder' refers to plants grown for feeding animals. It includes 'food-feed' crops, grown for human consumption but whose residues and by-products are fed to livestock, e.g. grass, legumes and tree species (see Hall et al. 2007).
2. See <<http://fodder-adoption-project.wikispaces.com/>> accessed 9 March 2011.
3. The International Livestock Research Institute (ILRI) acted as the implementing agency, on behalf of the System-wide Livestock Programme of the Consultative Group for International Agricultural Research. It was run by a consortium of centres: ILRI, the International Centre for Tropical Agriculture (CIAT) and the International Centre for Agricultural Research in the Dry Areas (ICARDA). FAP in Syria was run into 2011.
4. Besides fodder technological innovation, at some sites FAP also promoted organizational innovations such as the formation of farmers' groups and the coordination of value chain actors and activities.
5. See <<http://www.fodderinnovation.org/>> accessed 14 July 2011.
6. See <<http://www.ipms-ethiopia.org>> accessed 14 July 2011.

References

- Altenburg, T., Schmitz, H. and Stamm, A. (2008) 'Breakthrough? China's and India's transition from production to innovation', *World Development*, 36: 325–44.
- Anandajayasekeram, P. and Gebremedhin, B. (2009) 'Integrating innovation systems perspective and value chain analysis in agricultural research for development: implications and challenges', Improving Productivity and Market Success (IPMS) of Ethiopian Farmers, Project Working Paper 16. ILRI: Nairobi, Kenya.
- Anh, N. N., Thi Mui, N., Thi Thin, V., Dinh Hieu, H. *et al.* (2010) 'Options for effective delivery systems including innovative communication strategies and on farm interventions to improve fodder supply', paper presented at FAP End of Project Workshop, held at Luang Prabang, Laos, 15–9 November 2010 <<http://fodder-adoption-project.wikispaces.com/>> accessed 14 July 2011.
- Ayele, S. and Wield, D. (2005) 'Science and technology capacity building and partnership in African agriculture: Perspectives from Mali and Egypt', *Journal of International Development*, 17: 631–46.
- Boschma, R. A. (2005) 'Proximity and innovation: A critical assessment', *Regional Studies*, 39: 61–74.
- Chataway, J., Smith, J. and Wield, D. (2006) 'Science and technology partnerships and poverty alleviation in Africa', *International Journal of Technology Management and Sustainable Development*, 5: 103–23.
- Clark, N., Hall, A., Sulaiman, R. and Naik, G. (2003) 'Research as capacity building: The case of an NGO facilitated post-harvest innovation system for the Himalayan Hills', *World Development*, 31: 1845–63.
- Clifton, N., Keast, R., Pickernell, D. and Senior, M. (2010) 'Network structure, knowledge governance, and firm performance: Evidence from innovation networks and SMEs in the UK', *Growth and Change*, 41: 337–73.
- de Haan, N. C., Romney, D., Bezkorowajnyj, P. and Olufajo, O. (2006) 'Feeding livestock through partnerships', *Knowledge Management for Development Journal*, 2: 123–35.
- Delgado, C., Rosegrant, M., Steinfeld, H., Ehui, S. and Courbois, C. (1999) 'The coming livestock revolution', *Choices: Magazine of Food, Farm & Resources*, 14/4.
- Duncan, A., Ergano, K., Adie, A. and Tedla, A. (2010) 'Enhancing livelihoods of poor livestock keepers through increasing use of fodder: Ethiopia Report on Outputs 1 and 3', paper presented at FAP End of Project Workshop, held Luang Prabang, Laos, 15–9 November 2010 <<http://fodder-adoption-project.wikispaces.com/>> accessed 14 July 2011.
- Duncan, A., Stur, W., Larbi, A. and Tiemann, T. (2011) 'Enhancing livelihoods of poor livestock keepers through increased use of fodder: Programme completion report', Nairobi, Kenya: ILRI <<http://cgspace.cgiar.org/handle/10568/12497>> accessed 31 January 2012.
- FAO (Food and Agriculture Organization). (2009) *The State of Food and Agriculture 2009: Livestock in the Balance*. Rome: FAO.
- Franzel, S. and Wambugu, C. (2007) 'The uptake of fodder shrubs among smallholders in East Africa: Key elements that facilitate widespread adoption'. In: Hare, M. D. and Wongpichet, K. (eds) *Forages: A Pathway to Prosperity for Smallholder Farmers. Proceedings of an International Symposium*, pp. 203–22. Thailand: Ubon Ratchathani University.
- Hall, A. (2005) 'Capacity development for agricultural biotechnology in developing countries: An innovation systems view of what it is and how to develop it', *Journal of International Development*, 17: 611–30.
- Hall, A., Sulaiman, R. and Bezkorowajnyj, P. (2007) 'Reframing technical change: Livestock fodder scarcity revisited as innovation capacity scarcity', <http://www.fodderinnovation.org/publications/FIPConceptual_Framework.pdf> accessed 14 July 2011.
- Horne, P. M., Stur, W. W., Phengsavanh, P., Gabunada, F., Jr. and Roothaert, R. (2005) 'New forages for smallholder livestock systems in Southeast Asia: Recent developments, impacts and opportunities'. In: Reynolds, S. G. and Frame, J. (eds) *Grasslands: Developments, Opportunities, Perspectives*, pp. 357–82. Rome: FAO.
- Howells, J. and Edler, J. (2011) 'Structural innovations: Towards a unified perspective?', *Science and Public Policy*, 38: 157–67.
- IFAD (International Fund for Agricultural Development). (2006) Technical Agreement Grant: Enhancing livelihoods of poor livestock keepers through increasing use of fodder. <<http://fodder-adoption-project.wikispaces.com/>> accessed 14 July 2011.
- Johnson, B. (1992) 'Institutional Learning'. In: Lundvall, B.-Å. (ed.) *National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning*, pp. 23–44. London and New York: Pinter.
- Kaplinsky, R. and Morris, M. (2001) *A Handbook for Value Chain Research*. Brighton: Institute for Development Studies, <<http://oro.open.ac.uk.libezproxy.open.ac.uk/5861/>> accessed 5 May 2011.
- Khanh, T., Stür, W., Van Ha, N. and Duncan, A. (2009) 'Developing innovation capacity through effective research and development partnerships', paper presented at Innovation Asia Pacific Symposium, held Kathmandu, 4–7 May 2009 <<http://www.innovation-asia-pacific.net/home2/>> accessed 9 March 2011.
- Klerkx, L. and Leeuwis, C. (2008) 'Matching demand and supply in the agricultural knowledge infrastructure: experiences with innovation intermediaries', *Food Policy*, 33: 260–76.
- Klerkx, L., Aarts, N. and Leeuwis, C. (2010) 'Adaptive management in agricultural innovation systems: The interactions between innovation networks and their environment', *Agricultural Systems*, 103: 390–400.
- Kristjansson, P., Okike, I., Tarawali, S., Sigh, B. B. and Manyong, V. M. (2005) 'Farmers' perceptions of benefits and factors affecting the adoption of improved dual-purpose cowpea in the dry savannas of Nigeria', *Agricultural Economics*, 32: 195–210.
- Larbi, A., Sawasan, H. and Mohammed, A. (2010) 'Enhancing livelihoods of poor livestock keepers through increasing use of fodder: Syria Report and Project Output 3', paper presented at FAP End of Project Workshop, held Luang Prabang, Laos, 15–9 November 2010 <<http://fodder-adoption-project.wikispaces.com/>> accessed 14 July 2011.
- Lenné, J. M. and Wood, D. (2004) 'Is there a 'logic of fodder legumes' in Africa?', *Food Policy*, 29: 565–85.
- Lenné, J. M., Fernandez-Rivera, S. and Blümmel, M. (2003) 'Approaches to improve the utilization of food-feed crops – synthesis', *Field Crop Research*, 84: 213–22.
- Lundvall, B.-Å., Johnson, B., Andresen, E. S. and Dalum, B. (2002) 'National systems of production, innovation, and competence building', *Research Policy*, 31: 213–31.
- McDermott, J., Rich, K., Gebremedhin, B. and Burro, H. (2010b) 'Value chains and innovation'. In: Swanepoel, F., Stroebel, A. and Moyo, S. (eds) *The Role of Livestock in Developing Communities: Enhanced Multifunctionality*, pp. 151–69, <Mahider-ILRI> accessed 9 March 2011.

- McDermott, J., Staal, S. J., Freeman, H. A., Herrero, M. and Van de Steeg, J. A. (2010a) 'Sustaining intensification of smallholder livestock systems in the tropics', *Livestock Science*, 130: 95–109.
- Pyka, A. and Koppers, G., eds. (2002) *Innovation Networks: Theory and Practice*. Cheltenham: Edward Elgar.
- Rajalahti, R. Janssen, W. and Pehu E., eds. (2008) 'Agricultural innovation systems: From diagnostics towards operational practices', Agriculture and Rural Development Discussion Paper 38. Washington DC: World Bank.
- Rich, K. M., Ross, R. B., Baker, A. D. and Negassa, A. (2011) 'Quantifying value chain analysis in the context of livestock systems in developing countries', *Food Policy*, 36: 214–22.
- Shomo, F., Ahmed, M., Shideed, K., Aw-Hassan, A. and Erkan, O. (2010) 'Sources of technical efficiency of sheep production systems in dry areas in Syria', *Small Ruminant Research*, 91: 160–9.
- Spielman, D., Ekboir, J. and Davis, K. (2009) 'The art and science of innovation systems inquiry: applications to Sub-Saharan African agriculture', *Technology in Society*, 31: 399–405.
- Steinfeld, H., Gerber, P., Wassenaar, T., Castel, V., Rosales, M. and de Haan, C. (2006) *Livestock's Long Shadow: Environmental Issues and Options*. Rome: FAO.
- Stür, W. and Khanh, T. T. (2010) 'Linking fodder to livestock markets in Vietnam– the Ea Kar experience', paper presented at FAP Symposium on Feed in Smallholder Systems, held Luang Prabang, Laos, 18–9 November 2010 <<http://fodder-adoption-project.wikispaces.com/>> accessed 14 July 2011.
- World Bank. (2007) *Enhancing Agricultural Innovation: How to go Beyond the Strengthening of Research Systems*. Washington DC: World Bank.
- . (2009) *World Development Report 2009: Reshaping Economic Geography*. Washington DC: World Bank.
- . (2010) *World Development Report 2008: Development and Climate Change*. Washington DC: World Bank.