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Business models of SMEs as a mechanism for scaling climate smart technologies: The case of Punjab, India

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ABSTRACT

Many Climate Smart Agricultural (CSA) technologies fail to achieve their full potential impact due to low levels of adoption by smallholder farmers and difficulties in scaling CSA. This paper presents how small and medium-sized enterprises (SMEs) can act as change agents for the uptake of CSA technologies where their business models may be seen as adoption and scaling mechanisms. Drawing upon our fieldwork in Punjab (India) during which over 100 respondents have been interviewed, critical issues and enabling factors for the business model of two types of SMEs, i.e. farmer cooperatives and individual service providers of climate smart technologies have been identified. Enabling factors supporting adoption are driven by scientific and practical evidence of CSA technologies, good partnership between SMEs and research institutes, good customer relationships and effective channels through farmers' field trials. Critical issues consist of distortive government subsidies on energy and the lack of market intelligence affecting the profitability of the business model. Scaling is enhanced through market intelligence and a favouring regulatory landscape. However, difficult socio-economic circumstances and distortive government subsidies limit the role of SMEs business model as mechanism for scaling.

1. Introduction

Agriculture faces the enormous challenge of feeding the world's growing population. Although crop yields have grown impressively in the last few decades, production still requires an increase by another 60–70% by 2050 to meet the expected demand (Neufeldt et al., 2013). Climate change poses additional challenges to agriculture, particularly in developing countries. Since 1980, climate change is estimated to have reduced global yields of maize and wheat by respectively 3.8% and 5.5% (Campbell et al., 2014). Increased climate variability in the coming decades will increase the frequency and severity of floods and droughts, and will increase production risks.

Climate Smart Agriculture (CSA) aims to respond to these challenges. It represents a strategy that could help to increase farmers' resilience to weather extremes (Aryal et al., 2016), adapting to climate change and climate variability, whilst decreasing agriculture's greenhouse gas (GHG) emissions (Steenwerth et al., 2014). Currently several options are available for farmers to sustainably increase productivity, enhance resilience to climatic stresses, and reduce greenhouse gas emissions, which are known as climate-smart agricultural (CSA) technologies and practices. Despite the availability of CSA technologies and practices, many of them are still not achieving their full potential impact due to low levels of adoption by smallholder farmers. Barriers in adopting CSA technologies vary in economic, political, institutional, organisational, behavioural or social character and/or are related to poor markets (Westermann et al., 2015).

Long et al. (2016) were among the first examining the role of small and medium-sized enterprises (SMEs) and their business models in the adoption of CSA technologies. Their study, however, focusses only on the European context (Long et al., 2016). A relatively small body of literature is concerned with adoption of CSA in a developmental context (Senyolo et al., 2018). Strategic partnership with the private sector is recognized as promising to support the adoption of CSA (Westermann et al., 2015), but is not systematically examined.

Climate change adds considerable urgency to the need to

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transform agricultural systems to support food security. CSA technologies contribute to such transformation process, but need large scale adoption to achieve aspired impact. Opportunities for closer collaboration with the private sector for scaling CSA are noted, but mainly concern large companies (Vermeulen and Cotula, 2010). There is a hardly any literature that is concerned with the role of SMEs and their business models in scaling CSA in developing countries.

This paper starts from the premise that SMEs can act as change agents for the adoption and scaling of climate smart technologies. Their business models are seen as mechanisms supporting adoption and scaling. The main question this paper responds to is 'what are critical issues and drivers of SME's business models for the adoption and scaling of CSA technologies in the context of a developing country?' Drawing on our fieldwork in Punjab, India, drivers and critical issues for the business model of two types of SMEs are identified, i.e. farmer cooperatives and individual service providers who are selling and hiring out climate smart technologies to small and medium - size landholders.

2. Conceptual framework

2.1. Adoption from a business model perspective

Extensive research on adoption of technological innovations in sustainable agricultural development show drivers and barriers associated with the innovations (that may not be suitable for risk-exposed smallholders), with the context (policies, infrastructure, trading opportunities), with the agricultural extension system (Leeuwis, 2004; Pamuk et al., 2014), and with farming households (access to credit or attitudes towards risk) (Aker, 2011; Rogers Everett, 1995; Sunding and Zilberman, 2001). A relatively small body of literature is concerned with barriers and enabling factors for adoption of climate smart technologies in a developmental context. In a recent review on adoption of climate smart technologies in European countries, (Long et al., 2016) identify a set of barriers, which they classify as internal (e.g. behaviour) and external barriers (e.g. policies) (Long et al., 2016). Furthermore they distinguish barriers on the supply side (e.g. financial costs), and the demand side of these technologies (e.g. conflict with traditional methods). Recent studies focusing on the adoption of CSA technologies in a development context identify low awareness of climate change, limited understanding of what works in different agro-ecological systems and difficulties in proving added value of CSA technologies' as factors constraining adoption of CSA (Lipper et al., 2014; Westermann et al., 2015).

So far, little attention has been paid to the potential of agribusiness to support adoption of CSA. Agribusinesses are often accused of pursuing short-term gains at the expense of social development and the environment. However, in recent years, the private sector has shown renewed interest to invest in climate smart agriculture. Agribusiness leaders are increasingly realizing that aside from profits, a license to produce is of equal importance for acceptance in society and long term investments (Connolly and Phillips-Connolly, 2012). Not only large companies but also SMEs can act as delivery mechanisms for CSA. Long and colleagues were amongst the first who examined the role of business models in the adoption of CSA technologies (Long et al., 2017). They applied the Business Model Canvas (BMC) to review literature on business models for climate smart agriculture. They examined the business models of ten service providers selling or leasing CSA technologies in different European countries and identified critical issues and enabling factors.

The BMC is a framework extensively used by practitioners, from start-ups to large FT Global companies to describe how a firm creates value, relates to its customers and generates revenue from a set of operations. It combines several elements into a coherent mix that is considered to be essential for a business to be viable (Osterwalder, 2004):

- Value proposition –embedded value in the product/service offered to the customers;
- Customer segment –different type of targeted customers;
- Customer relationships –way the firm engages its customers;
- Channels –ways the customers are reached and supported;
- Key activities – activities required for the business to successfully function;
- Key resources – physical, financial or human resources essential to function successfully;
- Key partners –actors that are critical to the delivery of the value proposition;
- Cost structure and revenue streams –key costs, revenues and market potential.

Building upon the findings of Long and his colleagues (Long et al., 2017) and those of other scholars (Boons and Lüdeke-Freund, 2013), an initial list of critical issues of business models for the adoption of CSA technologies is produced, which is mapped onto a Business Model Canvas (BMC) (Fig. 1). Mapping these factors onto a BMC allows us to create an initial framework, which is used to contrast our own findings from the context of Punjab. In this way, the business model framework is used as a lens to identify critical issues and enabling factors in the adoption of climate smart technologies.

The review highlighted the value proposition as a critical issue hindering the adoption of CSA technologies because it appears difficult to prove the value and demonstrate the impact of these technologies (Long et al., 2017). Similar findings are discussed by (Westermann et al., 2015). Service providers also experience obstacles in accessing customers, which is relevant for the channel building block and relates well to the importance of links to customers stressed by others (Boons and Lüdeke-Freund, 2013). Widening the network would facilitate the diffusion of CSA technologies. Key-resources are identified as barriers in the adoption of CSA technologies as well. (Long et al., 2017) highlight difficulties to access capital and investment hindering the organisation of suitable marketing campaigns or investments into customers' relationship. They also cite the lack of market intelligence as barrier relevant for the key-resource building block. Poor access to wider networks, including those related to lobbying and policy are also

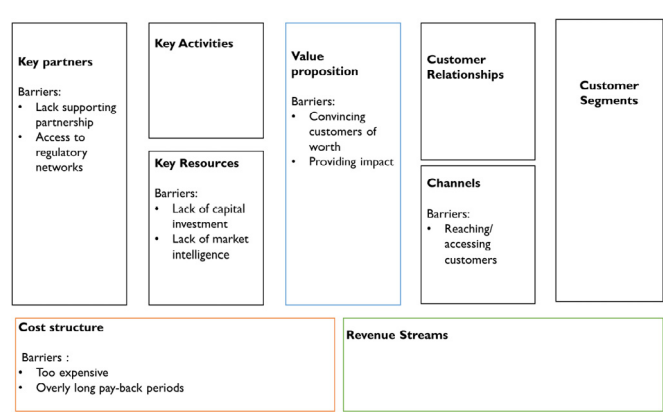

Fig. 1. Critical issues of SME's business models for the adoption of CSA (Boons and Lüdeke-Freund, 2013; Long et al., 2016; Long et al., 2017; Osterwalder, 2004).

identified as barriers, which relate to the key-partners building block. In addition, (Nair and Paulose, 2014) emphasize the need for a supportive regulatory environment for green innovations. The cost structure forms another critical issue for service providers. CSA technologies appear to be expensive and have a non-competitive return on investment (Westermann et al., 2015).

2.2. Scaling from a business model perspective

This paper takes the discussion on SME's business models as mechanism to support adoption of CSA one-step further by also looking at scaling CSA. Some authors use both the terms 'scaling up' and 'scaling out'. Scaling out means that technologies and practices are spread geographically to cover more farmers and communities, and involves expansion within the same stakeholder group or sector (Pachico, 2004). Strategies supporting scaling out are farmer-to-farmer learning, agricultural extension and the use of participatory approaches (Westermann et al., 2015). Scaling up is institutional in nature and involves different stakeholder groups from the level of grassroots organisations to policy makers, research institutes and investors at the national and international level. Developing large-scale investment plans, informing policy instruments, mainstreaming institutional changes and establishing multi-stakeholder learning alliances are examples of scaling up strategies. For simplicity, in this paper the term 'scaling' refers to a number of processes that brings more quality benefits to more people over a wider geographical area, more quickly, more equitably, and more permanently (Franzel et al., 2001). Scaling includes both scaling out and scaling up which occurs in multiple dimensions. As programs scale quantitatively and functionally (more complexity), they typically need to scale politically and organizationally as well involving multiple actors and layers (Hartmann and Linn, 2008).

Due to its complexity, knowledge about the process of scaling remains limited (Wigboldus et al., 2016). First experiences show the context specificity of CSA technologies impedes the generation of science-based evidence for CSA, limiting its potential for scaling out (Aggarwal et al., 2018). Scaling out at the local level is also hindered by the relatively high transaction costs of agricultural extension and participatory research struggling to work over large areas beyond pilot villages (Braun and Hocdé, 2000). The institutional barriers constraining scaling up include a lack of adequate and sufficient finance for farmers and service providers, poor markets and severe gaps in capacities of farmers, extension staff, bankers and service providers on CSA (Westermann et al., 2015).

Building upon the insight on SMEs as delivery mechanisms supporting adoption of CSA technologies, research on the role of SMEs as change agents for scaling CSA:Gill demonstrated the commercial profitability for SMEs hiring out the Land Laser Leveller, a climate smart technology promoted to level irrigated fields in the North of India to farmers (Gill, 2014). He concluded that service providers are to play an important role in supporting the process of scaling out. (Westermann et al., 2015) highlight the expanding role of private service providers, from mere dealership in inputs to increasingly procuring and selling climate smart technologies together with advice and information. To fulfil this more complex role, public sector extension services, along with Non-Governmental Organisations, Community Based Organisations, farmers, and research institutes, are to play unique roles in supporting them. SMEs will conduct business in CSA technologies when they experience the net economic and social profit outweigh the costs. Searching for viable business models for CSA technologies and exploring factors that enable or hinder the scaling of these models may thus be a promising way to support SMEs as change agents in the scaling of CSA.

The above discussion results in the conceptual framework as shown in Fig. 2. It positions adoption as a process of accepting a new CSA technology delivered by service providers and adopted by clients, i.e. farmers. From a business perspective adoption is about entering a market involving experimentation and pilots at the niche level. The framework furthermore places the process of scaling between adopted and scaled CSA technologies. Scaling from a business perspective, however, is about market scaling requiring a supportive institutional and policy environment. For both the adoption and scaling process, SMEs' business models are assumed a moderating factor affecting these processes.

3. Method

3.1. Context

Punjab was chosen as case study area to examine the role of business models of SMEs in scaling climate smart agriculture (CSA). In Punjab the urgency for CSA is high, data on CSA technologies is well available, and where farmer cooperatives and service providers are selling or hiring out CSA technologies to farmers. In Punjab, adaptation to climate change is no longer an option, but a compulsion to minimise the losses due to adverse impacts of climate change. About 51% of the Indo-Gangetic plains, on which Punjab is located, may become unsuitable for one of their most important crops; wheat, due to increased heat-stress by 2050 (Lobell et al., 2012; Ortiz et al., 2008). Similarly, in central Punjab, the rate of decline in the water table increased over time from 0.2 m yr to 1 during 1973–2001 to about 1 m yr-1 during 2000–2006 (Humphreys et al., 2010). To address these challenges, research is supporting farmers with CSA technologies and practices that promote sustainable intensification and adaptation to emerging climatic variability (Aryal et al., 2016), (Kakraliya et al., 2018). Research institutes such as the International Maize and Wheat Improvement Centre (CIMMYT) and the Borlaug Institute for South Asia (BISA) are working closely with farmer cooperatives and service providers in so-called climate smart villages. Participatory field trials have generated knowledge on the agricultural and socio-economic effects of CSA technologies, which is needed to assess the viability of the business model. In Punjab, 1609 farmer cooperatives exist out of which 1308 were viable during 2015–2016. Total membership in cooperatives is 719,460 members. Cooperatives cover 88.18% of a total of 6687 Punjabi villages (Government of India, 2007). BISA's director estimates approximately 13,000 services providers are in the business of selling CSA technologies to farmers.

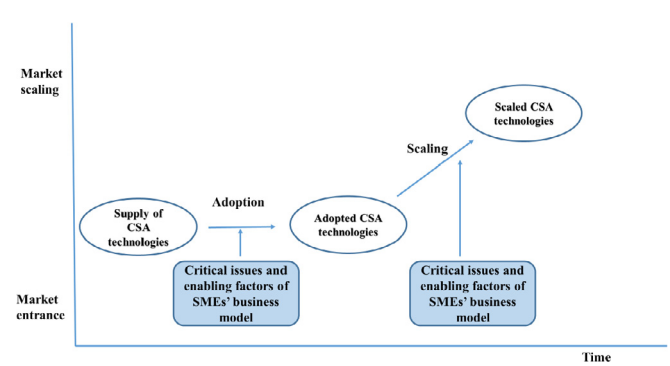

Fig. 2. Conceptual framework to identify critical issues and enable factors in the adoption and scaling of CSA.

3.2. Data collection and analysis

Examining SME's business models in relation to adoption and scaling CSA in a developing context is relatively new topic this paper seeks to improve understanding about. Therefore the paper takes an exploratory research approach and attempts to lay the groundwork leading to future studies. Data for this research was collected through the Climate Change, Agriculture and Food Security (CCAFS) project "Developing, adapting and targeting portfolios of CSA practices for sustainable intensification of smallholder and vulnerable farming systems in South Asia". The research team involving three researchers applied two data collection strategies to collect qualitative and quantitative data. Firstly, analysis of documents with relevance to sustainable business models and CSA technologies, including results of field research trials. Secondly, semi-structured interviews with key informants to gather in-depth data on SMEs' business model in use and its enabling and hindering factors for adopting and scaling CSA technologies.

The team used an iterative process for data collection and analysis following grounded theory methodology (Glaser, 1992). In the beginning the Business Model Canvas was used to gather and analyse data. When other issues of importance to adoption or scaling emerged these were addressed in the next steps. In addition, in the beginning the research focussed more on understanding SMEs' business model and its drivers and barriers to adoption, later on the focus shifted more towards scaling.

Over a period of 3 years, 103 respondents were interviewed, including smallholder farmers (members and non-members of cooperatives), private service providers, manufacturers, policy makers, researchers, NGOs, agro food companies and financial institutes (Table 1). The respondents were identified with the use of the snowball sampling method starting from the researchers' network. Some of the respondents were interviewed once, others multiple times either face-to-face or in group interviews. Most of the interviews were conducted in the local language and simultaneously translated. Each interview lasted between 60 and 120 min. Follow-up telephone/skype interviews were conducted to clarify previous unclear responses. Reports were made of each interview. In total 11 SMEs have been interviewed of which 5 co-operatives and 6 service providers.

Prices and costs (constant cost, variable cost, sales) of CSA technologies are derived from the interviews. Data on effects of CSA technologies on yield, labour requirement, fuel and water use are collected from respondents and crosschecked with research results. Data on effects of layered CSA technologies and practices are based on participatory research trials (Kakraliya et al., 2018). Figures used to assess the market potential of the business model are derived from literature.

The conceptual framework to identify critical issues and enabling factors in the adoption and scaling of CSA (Fig. 2) has been further operationalized in terms of indicators to guide the data collection and analyses (Table 2). Over the course of time, discussions on scaling gave rise to new themes to look into. Indicators including potential new markets, competition, competences, finance, culture, regulatory framework and policies were used to further analyse the interviews.

The indicators in Table 2 as well as the newly emerging ones were used to analyse empirical data. Interview reports were analysed manually using different colours for different indicators. Inconsistencies and gaps were discussed amongst the team members and addressed or cross checked in follow-up interviews or literature. Moreover, preliminary findings were cross checked with respondents and discussed in six (inter) national conferences (Table 3).

4. Results

The results are presented in three sections. Firstly, a description of the business model of SMEs who sell and/or hire out a package of CSA technologies is presented. Secondly, drivers and barriers of this

Table 1
Number and type of respondents interviewed in the period February 2015–November 2017.

Year/period	No. informants interviewed	Type of interview	Type of informant	Village	Coding
February 2015	2	Individual	Farmers	Taraori, Haryana	1
	5	Focus group	Farmers	Anjanthalli, Haryana	2
	6	Individual	Researchers from ICAR institutes, CIMMYT and IFPRI	Ludhiana, Punjab and Delhi	3
September 2015	4	Individual	Researcher of CIMMYT and BISA	Ludhiana, Punjab	4
	8	Focus group	Farmers of cooperative Noorpur-Bet	Noorpur-Bet, Punjab	5
	2	Individual	Farmers	Bagga Khurd, Punjab	6
	2	Individual	Freshfield, agri food company (Private company)	Ladhowal, Punjab	7
May 2016	23	Focus group	Farmers of cooperative Phagla	Phagla, Punjab	8
	5	Focus group	Farmers of cooperative Noorpur-Bet	Noorpur-Bet, Punjab	9
	6	Focus group	Farmers of Khera society	Khera, Punjab	10
	5	Individual	Researcher of CIMMYT and BISA	Ludhiana, Punjab and Delhi	11
June 2017	1	Individual	Deputy Commissioner (Government)	Amritsar, Punjab	12
	4	Individual	Service providers	Punjab Villages: Gari Fazal, Burj Lambram, Bagga Kalan, Bagga Khurd	13
	4	Individual	Manufacturers	Ludhiana, Punjab	14
	2	Focus group	Banks (NABARD, Co-operative Bank)	Karnal, Haryana	15
	2	Focus group	Agriculture Commissioner and Director Agriculture (Government)	Punjab	16
	1	Individual	Global Self Help Group (NGO)	Ludhiana, Punjab	17
November 2017	3	Focus group	Researchers of CIMMYT/BISA	Punjab	18
	1	Individual	Treasurer of cooperative Noorpur- Bet	Punjab	19
	5	Focus group	Ayli Kalan cooperative multi-purpose agriculture society	Punjab	20
	4	Focus group	Cooperative Kokri Kalan	Punjab	21
	1	Individual	Branch manager, District Cooperative Bank, Ayali Kalan (Bank)	Punjab	22
	1	Individual	A.D.O Ayali Kalan, local branch of Department of Agriculture (Government)	Punjab	23
	6	Individual	Service providers	Punjab (villages: Baranhara, Bagga Khurd, Bagga Kalan, Navan Rajapur)	24

Table 2
Framework with indicators guiding data collection and analyses (Long et al., 2016), (Chong, 2014).

	Aspect	Indicators
Critical issues and enabling factors for SME's business model to support adoption and scaling	Value proposition	Needs, problems of smallholder farmers that could be addressed by CSA technologies provided by SME
	Customer segment	Types of farmers buying or selling CSA related services
	Revenue model and streams	Revenue model in use; revenue in INR/year; market potential
	Customer relationships	Ways of engagement with customers
	Channels	Channels used by SME to create awareness, support purchase, to deliver and provide after sales
	Key activities	Activities to sustain the value proposition and customer relationships
	Key resources	Human, financial and biophysical resources needed (and how these assets will be generated)
	Key partners	Direct partners with whom the SME operates the business model and indirect partners who support or facilitate implementation of the business (e.g. financial institutions, research, government)
	Cost structure	Fixed and variable costs, competition

Table 3
Scientific conferences and workshops in which preliminary findings were cross-checked.

Scientific events
International Workshop on Climate Smart Villages conference, Delhi-Ludhiana, 3–6 September 2015
Advanced course on 'Conservation Agriculture, Ludhiana, 1–4 November 2015
Advanced course on 'Conservation Agriculture, Ludhiana, 7–21 November 2016
Workshop Business Models and Innovation platform, Wageningen 4 July 2016
4th International Agronomy Congress, 22–26 November, Delhi, 2016
Advanced course on 'Conservation Agriculture, Ludhiana, 5 November 2017

business model in the support of adoption will be highlighted. Thirdly, drivers and barriers of the model for scaling are provided.

Noorpur-Bet is used as concrete example to describe a business model for a cooperative. The cooperative is a private institute providing a variety of services to all members. The cooperative runs a small petrol station and a shop for villagers. It sells improved certified seeds and different types of fertilizers to farmers, and provides them with relative cheap loans. It rents conventional agricultural machineries including a rotator, harrow, cultivator, disc plough and tractors as well as CSA technologies such as zero-till multi crop planters (3), Land Laser Levellers (3), Happy Seeder (1) and a GreenSeeker for Nutrient-management (1). All interviewed cooperatives (Code 8, 10, 20, 21) provide similar services. However, relatively new or expensive technologies such as the GreenSeeker, Happy Seeder and Combined Harvester are not part of a standard package.

For anonymity reasons the name of a specific service provider is not mentioned. But service providers are relatively large entrepreneurial farmers who aim to generate an income from selling services to farmers. For most of them, renting CSA technologies is an additional source of income. The interviewed service providers (Code 13, 24) own one or more Land Laser Levellers, a Happy Seeder, one or more Combined Harvester(s) and multiple zero-till multi crop planters. In addition, they own conventional machineries such as rotavator, cultivator, harrow etc. and one or more tractors, which they rent out as well.

This paper describes and analyses the business case relevant for both cooperatives and service providers for the following package of CSA technologies:

- Land Laser Leveller (LLL) enables the levelling of fields within certain degree of the desired slope (applied once in every three years)
- Happy Seeder enables direct drilling of wheat into rice stubbles
- Zero-till multi crop planter enables direct drilling of rice and
- Combined Harvester and tractor[1]

4.1. SMEs' business model

Customers: Customers are farmers with a rice - wheat cropping system. For cooperatives, the customers are small (<2–3 acres) and medium-size farmers (3–7 acres). Only few large farmers (>7 acres) are part of their clientele (Aryal et al., 2016). The cooperative Noorpur-Bet has about 400 customers consisting of 200 members and 200 non-members coming from different surrounding villages representing approximately 4000 acres. Service providers do not work through memberships, but sell their services to any farmer willing and able to pay. The number of clients vary from 10 to 40 and include mainly large farmers from neighbouring villages.

Value proposition: The CSA technologies increase yield, save input costs in the form of labour and water, and allow for sowing on time. Farmers' experiences are confirmed by research trials showing that layered use of the CSA technologies, in combination with the recommended fertilizer application, increased yield by 9% and profitability by 25%. It saved 28% of irrigation water use and improved total water productivity by 37% compared to traditional farmer practices. Energy use-efficiency and energy productivity were improved by 58% and 56% respectively compared to farmers' conventional practices. Greenhouse gas intensity was also reduced with 34% compared to conventional farmer practices (Kakraliya et al., 2018). The application of Happy Seeder reduces air pollution as it enables sowing of wheat without the need for rice stubbles burning. The improvement in yield and profitability, and the possibility of sowing at an optimum time increases farmers' resilience to climatic stresses. The overall value propositions for the CSA technologies are the same for cooperatives and service providers. Through interviews, customers of both SMEs have expressed factors they consider to be valuable for cooperatives and others for service providers. Cooperatives may offer additional value in offering extra service such as relatively cheap loans for renting and/or buying CSA technologies. Service providers offer additional value when offering flexibility in service hours as they deliver even during evening hours.

[1] The Combined Harvester and tractor are not climate smart technologies, but essential to implement the CSA package.

Cooperatives and service providers are important for farmers acquiring new knowledge. Through the interviews (Code 1,2,5,6,8,9,10) it became clear farmers are often unaware of alternatives when facing environmental problems or new regulation, such as the ban on stubble burning. This is where cooperatives and service providers, often considered peers, play a role. Farmers are more open to receiving and getting knowledge from people from their own community. Lastly, CSA technologies are expensive, especially for smallholder farmers. Cooperatives and service providers provide access to the latest technologies in a relatively short distance in a trustworthy environment without the need of purchasing the machinery themselves.

Customer relationships and channels: Managers of cooperatives and service providers have a strong personal relationship with their customers and with technology developers such as CIMMYT, BISA and Agricultural University of Punjab. This enables them to share new insights from research trials amongst customers and to develop skills for application. Personal contact on effects continues even after the service has been provided, which is highly appreciated by the customers.

Key resources: These exist of the capital factors encompassing capital (funds, machinery, inputs), nature (water, land), and labour. Both SMEs need funds to purchase new CSA technologies. The cooperative is eligible to receive government subsidies on new technologies. In 2017, Noorpur-Bet received a subsidy of 3 lakhs (~33% of the initial costs) on a package of technologies including a tractor, LLL and a rotavator). Earlier the cooperative had received a subsidy of 50,000 INR for another LLL. In 2017, the government announced that also service providers could apply for subsidy on machineries. However none of the service providers who submitted a request had received any approval.

Both SMEs can take a loan from the bank e.g. the National Bank for Agriculture and Rural Development. 50% of the interviewed service providers (Code 13, 24) mentioned that they had taken a loan from the bank to purchase a CSA technology, which implies additional costs in the form of interest to be returned through revenues. None of the interviewed cooperatives (Code 19, 20, 21) had taken a loan.

Key activities: Cooperatives rent out machines for an hourly (or daily) rate and are able to provide a tractor driver. Service providers undertake the same activities, however they usually apply the technologies on the field themselves. An important activity of cooperatives is organising demonstrations with the help of research institutes and producers of CSA technologies. This is where farmers are introduced to new technologies and learn from their peers. It is a form of marketing and creating a customer relationship.

Key partners: Research and academic institutes play a key role in research and development of CSA technologies. Contacts with CIMMYT, BISA, Punjab Agricultural University, the Department of Agriculture, Krishi Vigyan Kendra (farmer training centres) and the Agricultural Management Training Institute are important sources to acquire reliable knowledge and skills in the use of CSA technologies. New machineries are mainly purchased from manufacturers in Ludhiana and Amritsar. Cooperatives have a strong relationship with the government because of the provision of subsidies on CSA technologies.

Cost and revenues: In assessing a Business Model Canvas, attention is usually primarily geared towards the value proposition and secondly to the revenue model. Furthermore, conducting business in a social or sustainable way is often considered costly or a sacrifice in light of profit maximisation. By demonstrating possible financial outlooks we underline the strength of the business case itself, which will increase the likelihood of adoption and scaling of climate smart technologies.

To clarify the cost and revenue streams for selling services for a package of CSA technologies constant and variable costs are considered. Constant costs includes costs of technologies, depreciation and maintenance. Tax and insurance are not included. Furthermore, costs of storage are not included, which would translate more in opportunity costs. Variable costs include expenses for fuel and labour and are estimated at 500 INR/acre for the different technologies. Sales and revenues include subsidy and sales.

Costs and revenues streams relate to current practice, which is the situation wherein a cooperative or service provider starts with one CSA technology and grows their business organically by adding new technologies through previously earned revenues. Technologies generating highest margin are rated on top, therefore the order for purchase is a Combine Harvester, the Turbo Happy Seeder, the Zero Tillage and the LLL. Technologies that generate highest margins also require the highest investments.

The first two dashed lines of the cooperative and service provider represent the net cash flow overviews earned over time (Fig. 3). The trends are based on organic growth with the revenues of an earlier purchased technology. A new technology is added until all four technologies are part of the offered services. A cooperative would start with the technology with the highest margin i.e. a Combine Harvester and is able to afford the next technology, which is a Turbo Happy Seeder in year six. This means that for 6 years, the cooperative or service provider has been able to purchase only one technology. The next technologies are purchased in year 7 and 8. Based on respondents' experience, subsidy is estimated at 33, 33% for both the Combine Harvester and the Turbo Happy Seeder.

The uninterrupted lines show the accumulated results over time. It was observed that the service provider is able to reach higher profits more rapidly, the return on investment is much faster as the service provider is better able to increase its market potential by optimally using the available time windows within the season. These numbers could be improved further by servicing 24 h per day through shifts (seasonal work). These numbers would be hampered by uneven level playing field, for example caused by subsidies.

A package of CSA technologies amount to an investment of 1,333,340.00 INR, where assumed 33,33% subsidy on the Combine Harvester and the Turbo Happy Seeder, and an annual revenue of 542,837.30 INR. For a cooperative, the payback period is 4,3 years and for a service provider approximately 1,6 years. For a cooperative, the Return on Investment (ROI) (without deducting salary, tax, insurance and storage) is 0.407 translating to 40,7%. This ROI is based on an eventual stable result of 542,837.30 INR with an investment of 1,333,340.00 INR and the assumption of 33,33% subsidy on the Combine Harvester and the Turbo Happy Seeder. For a service provider, the ROI is 0.993, which translates to 99.3%. This ROI is

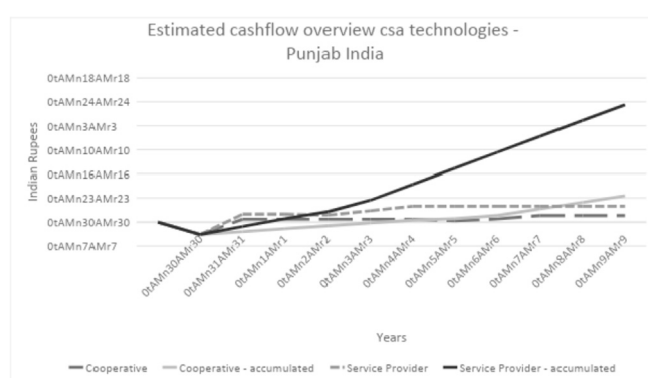

Fig. 3. Net result for a cooperative and service provider.

based on an eventual stable result of 1,323,730.16 INR with an investment of 1,333,340.00. A 33,33% subsidy on the Combine Harvester and the Turbo Happy Seeder is also assumed.

These figure and numbers suggest the business model is more promising to service providers as they are more capable to increase their market opportunity by being able to better exploit the available time windows. A service provider applies the technologies for 16 h per day (often in shifts with close family members). However, it is more difficult for a service provider to reach their market as they have less efficient networks compared to cooperatives.

Market potentials: Insight into potentials of the SME business model to scale CSA requires analysis of its market potentials, which is based on the following assumptions and starting-points:

- A focus on service providers and cooperatives in Climates Smart Villages where both providers and customers can fully benefit from research, advisory and government support;
- The package of technologies consists of a LLL, Turbo Happy Seeder, Zero-till multi crop planter and the Combine Harvester;
- Customers are marginal, small, semi-medium, medium and large farmers with a Rice – Wheat cropping system.

The potential of the market describes the estimated maximum total sales revenue in a market during a certain period. Maximum number of farmers in Punjab growing wheat and rice through a rotating system are considered. For the land-sizes, stratification as applied by the Department of Agriculture in Punjab is used. In total 2,560,000 ha are under rice and wheat rotating system in Punjab (Sharma et al., 2004).

Table 4 gives an estimation of the full size of the potential market in terms of customers. Service providers will most likely target large farmers as this is more efficient and increases the relative revenue in terms of time. This market consists of 46,200 farmers in Punjab. Cooperatives will be more likely to target smaller farmers who can benefit from the additional services provided. Their market consists of 238,000 farmers. Either medium-sized farmers will hire from a service provider or cooperative or they might become service providers themselves.

Though technologies are considered as a package, different technologies can be applied to a different amount of acreage per year, resulting in different required numbers of machines. Table 5 presents the market potential of CSA technologies per customer segment.

The full market potential in Punjab follows from Table 5. The column 'acres/year' is based on what cooperatives and service providers are currently able to service in a year. Therefore, the total required machines in Punjab also loosely represents the number of required cooperatives or service providers if they would offer one full package (one of each technology).

Above numbers are rough estimations based on current agriculture activities. Furthermore, currently there is no level playing field as some farmers are subsidised for technologies whereas other farmers need to save up for. This results in a form of unfair competition. Furthermore, a lack of market intelligence sometimes leads to harmful situations where SMEs are forced to lower their prices to below cost price in situations with excessive competition. These factors negatively affect their financial prospects. Respondents suggested several ways to increase their market potential for SMEs:

- Adding more technologies to their asset, which could increase production by 100% per technology;
- Full optimisation of the available timelines, for example by working shifts, optimising 24 h per day. For cooperatives this could lead to a market increase of 200% as cooperatives are currently providing service for 8 h per day;
- By moving to other districts and states for service provision as seasons differ across states.

Overall, it can be concluded there is potential for scaling, provided competition is healthy (efficient competitive market with realistic prices) and SMEs become better aware of market opportunities. The government could play an important role in facilitating the proper infrastructure and knowledge processes. SMEs' business model for selling CSA services is summarized in Fig. 4.

4.2. Drivers and critical issues of SMEs' business model supporting or hindering adoption

4.2.1. Drivers of SMEs' business model

Value proposition: Farmers significantly benefit from CSA technologies. The technologies address urgent environmental and social problems farmers are facing. All respondents put forward that application of CSA technologies increases rice and wheat yield reduces input costs (fuel, water, labour) and enables farmers to sow and plant at an optimum time. The combination of beneficial technologies and additional services such as relatively cheap loans for CSA services (cooperatives), flexibility in service provision (service providers) and after sale services (cooperatives and service providers) leads to a clear value proposition driving SMEs' business model and supporting adoption of CSA.

Key partners: The existence of key partners can be identified as a key driver for SMEs selling CSA services. For SMEs, CIMMYT, BISA, Punjab Agricultural University, the Department of Agriculture, the farmer training centres and the Agricultural Management Training Institute are important sources to acquire reliable knowledge and skills in the use of CSA technologies, which is essential to build trust with their clients.

Channels–customer relationship: A partnership with CIMMYT and BISA manifests in participation of SMEs' in research trials on CSA technologies in the Climate Smart Villages. SMEs' collaboration with farmers in trials and demonstrations can be identified as a driver of their business model, which is relevant for the channel and customer relations building blocks. These activities enable acquisition of new knowledge and skills, and enable the sharing of experience between SMEs and customers.

Table 4
Land holding size, no. of farmers and landholding in rotation Rice-Wheat (Sharma et al., 2004).

Farmer	Land holding size (in ha)	No. of farmers	Percentage of total	Land holding in rotation rice and wheat (in ha)
Marginal	<1	108,500	15.50%	396,800
Small	1 to 2	129,500	18.50%	473,600
Semi-Medium	2 to 4	217,000	31.00%	793,600
Medium	4 to 10	198,800	28.40%	727,040
Large	>10	46,200	6.60%	168,960
Total		**700,000**	**100%**	**2,560,000**

Table 5
Market potential of CSA technologies per customer segment.

Technology	Acres/Year	Total required machines in Punjab	Market potential - total machines per customer segment				
			Marginal farmers	Small farmers	Semi-medium farmers	Medium farmers	Large farmers
Land Laser Leveller	550	11,497	1782	2127	3564	3265	759
Zero tillage	200	31,616	4900	5849	9801	8979	2087
Combine Harvester	600	10,539	1633	1950	3267	2993	696
Turbo Happy Seeder	450	14,052	2178	2600	4356	3991	927

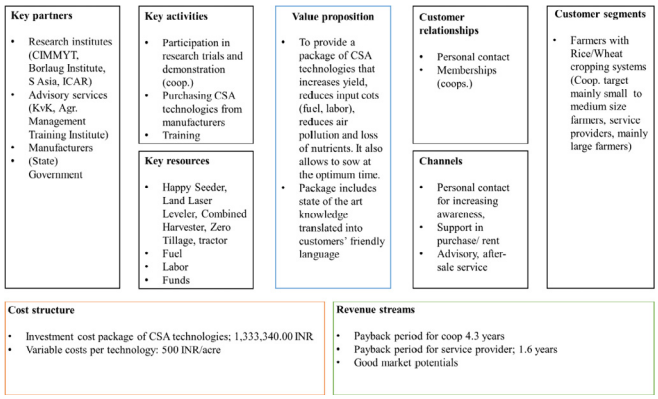

Fig. 4. Business Model Canvas for SMEs selling or hiring out CSA technologies.

4.2.2. Barriers hampering SMEs business model

Unfavourable technology features: The limited time window of the technologies is constraining the business. SMEs stated that outside the time window wherein CSA technologies can be applied, the machines are idle and stored. Concrete actions to increase the time window of some of the technologies by e.g. leasing machineries in other districts are practiced by service providers only, albeit at a limited scale. A society (Code 8) explains that they have implemented a policy stating the society cannot move to other states: "We would have to write a letter to the government of the other state we would like to move to and we have never tried this before".

Subsidy policies do not match SMEs' reality: Cooperatives considered the time-consuming application process and the timing of subsidy provision as weaknesses in the subsidy scheme adversely affecting their business. One respondent (Code 13) puts forward: "The government provides subsidy, but not in time. For the purchase of the Happy Seeder, we need to pay the whole amount up front. The government will start paying back after 6 months, but full compensation might be finalised after 6 years".

Limited access to finance: The access to finance as barrier for cooperatives and service providers is ambiguous. Both SMEs need funds to purchase new CSA technologies and provide loans to their customers (cooperatives). For cooperatives this need appears to be addressed by the government through subsidies which all interviewed cooperatives received. However, the provision itself is an arduous process. Since 2017, service providers are eligible to receive government subsidies as well but, the service providers who submitted a request had not received any approval. They instead go to banks or any other financial institution to obtain a loan, which in turn can be tiring processes as well. A service provider (Code 13) explains: "The government provides subsidy but not in time. I am still waiting for the subsidy on my LLL. On the other hand we need to pay the manufacturer instantly and without the possibility to pay in instalments".

From our interviews it appeared that subsidies would make it more attractive to invest, although the business case in itself is already promising. The financial prospects show financial viable investments, without subsidy they would just lead to a longer time to earn back the initial investment. Therefore, perhaps entrepreneurship is a more important driver than access to finance.

4.2.3. Drivers of SMEs business model supporting scaling of CSA technologies

Favouring regulatory landscape: Enforcement of the ban on residue burning supports the implementation and scaling of the business model of SMEs. The Government of Punjab has recently introduced enforcement of the ban on rice and wheat stubble burning in the farmlands of Punjab with the aim to improve air quality. Farmers and other stakeholders are increasingly becoming aware of the need to search for alternatives. Examples are CSA technologies such as the Zero-till multi crop planter, which can be used under anchored residue conditions and the Happy Seeder for all residue conditions. All interviewed service providers mentioned they will buy a Happy Seeder in case of strict enforcement of the ban on rice stubble burning. In the end of 2018, all Happy Seeders were sold out in Punjab. A manufacturer of Happy Seeder machines (Code 14) mentions: "The government should be used as a vehicle for small farmers to take up a technology. We feel subsidy is not really helping, but the ban on burning is of great help".

Youth as new niche market: CSA technologies are attractive to youth, which opens a possible niche market and favours SMEs business model. One respondent from a government body (Code 16) mentioned: "The youth does not like farming due to hard manual labour work, poor margins, and the lack of an intellectually challenging environment and the use of conventional methods". He suggested that the introduction of new CSA technologies such as Happy Seeder or Land Laser Leveller could trigger young farmers joining or remaining in agriculture.

4.2.4. Barriers hampering SMEs business model hindering scaling of CSA technologies

Perverse effects of government subsidy: Five respondents from government and research institutes stressed the perverse effects of subsidy on electricity. In the short term, the provision of free energy impedes farmers' interest in energy saving CSA technologies, which hinders SMEs business hiring out energy saving technologies such as the LLL. In the long term, energy subsidy leads to a steep increase in the use of pumps for groundwater, drastically decreasing the groundwater level. A service provider (Code 13) added: "The schedule of electricity is a waste of money. I would like to pay for energy as long as we receive it in time".

The lack of market intelligence: Lack of knowledge on market potential can be considered a barrier adversely affecting SMEs' business model. Cooperatives, neither service providers nor the government have accurate information on potential clients for CSA technologies. Likewise, information about competitors is lacking. As a government official (Code 12) explained: "An important aspect that is currently missing is market intelligence. The lack of this information is harming industrialists, entrepreneurs and farmers alike". Three service providers mentioned that for them the LLL is

not profitable anymore as nowadays there are too many levellers available in the region.

Decline in farm size: Respondents mentioned the continuous declining farm sizes as a structural bottleneck in farmers' capacity to invest in agriculture and as such can be considered a barrier for SMEs selling CSA services at large scale. One respondent from a government body (Code 16) mentioned: "The farm sizes are very small. Insignificant holdings do not generate adequate income and inhibit farmers to rent or apply CSA technologies". Farmers expect small farmers to quit farming and rent their land to bigger farmers. In the short term, this will affect the business of cooperatives more than that of service providers as customers of the latter mostly concern larger farmers. Furthermore smaller land sizes increase variable costs as the time and distance between serviced lands are enhanced.

Poor socio-economic situation: Respondents are concerned about the current socio-economic environment of the farming community in Punjab. One 17-year old man (Code 9, although not interviewed as farmer) explained: "I was not able to finish my education due to our economic condition. [...] I don't have any trust in pursuing agriculture as I don't own any land myself ". Farmers increasingly take up loans and currently more than 85% of the farmers is under debt. The use of loans for consumption and ceremonies are likely to increase debt rates hindering farmers to invest in new climate smart agricultural developments.

5. Discussion

5.1. Critical issues and drivers of SMEs' business model: comparison with previous literature

Previous literature highlights the value proposition as a critical issue for SME's business models. Difficulties in proving the value and demonstrating positive impact of CSA technologies to their costumers hinder SME in selling CSA services (Long et al., 2016; Westermann et al., 2015). Our study indicates, however, that SMEs selling CSA services have a clear value proposition for their customers. Due to the existence of a mix of enabling factors including scientific and practical evidence of CSA technologies, partnership between SMEs and research institutes, good customer relationships and effective channels through farmers' field trials and demonstrations, SMEs' business model creates a clear value.

Literature on business models supporting CSA in Europe stresses difficulties in accessing customers due to obstacles in the channel building block and customer relationships (Boons and Lüdeke-Freund, 2013; Long et al., 2017). Service providers experience difficulties to transfer knowledge on CSA technologies to farmers, which is aggravated by the use of obstructive terminology (Long et al., 2016). Our study demonstrates that membership of cooperatives facilitates good relationships between staff members of a cooperative and their customers. Farmers consider staff of cooperatives and service providers peers from whom they are willing to learn more compared to outsiders. The field trials and demonstrations in the climate smart villages provide good opportunities for both cooperatives and service providers to engage with their customers.

Lack of skills in the application of CSA technologies highlighted in previous work (del Río González, 2005; Montalvo, 2008) was identified as critical issue by a few cooperative members only when they mentioned problems to hire skilled drivers.

Different European scholars highlight that service providers experience the cost structure in relation to the revenues as another critical issue. CSA technologies appear to be expensive and have an uncompetitive return on investment. They suggest to minimise the cost structure through competitive pricing. Chances for profit maximising could be realised through shifting from 'pricing on the job' rather than per product (Boons and Lüdeke-Freund, 2013). Our study does not fully support these findings. Notably, however, the government subsidies on CSA technologies give a distorted picture of the relatively short payback periods, which may explain that cost structure is not highlighted as a key-issue. Cost structure is only indirectly identified as barrier for their business model when respondents from cooperatives criticized governments' subsidy scheme for CSA technologies. Difficulties for SMEs in accessing subsidies because of tiring procedures are in agreement with those obtained by Weiss and Bonvillian who consider this barrier to be also relevant to SMEs selling CSA services outside India (Weiss and Bonvillian, 2013).

Noteworthy, recent participatory research trials demonstrated positive financial effects of layered CSA technologies (Kakraliya et al., 2018). These trials tested more technologies than those included in the package analysed in this paper. This future outlook as well as further optimisation of the available timelines by working shifts, optimising 24 h per day (Jat et al., 2006) are promising options to make SMEs' business model more profitable.

Regulatory and policy difficulties hindering SMEs' business are noted by several scholars and can be linked to poor access to wider policy networks (Long et al., 2016, 2017; Senyolo et al., 2018). Our findings are consistent with previous results. Several respondents have highlighted the distortive effect of government subsidies on energy for their business model as they prevent farmers from investing in energy saving CSA technologies. As such, subsidies have a negative effect on the revenue stream of SMEs. The importance of a conducive regulatory environment for green innovations (Nair and Paulose, 2014) is confirmed by our study. Enforcement of the ban on residue burning supports the implementation and scaling of SMEs' business. Fig. 5 summarizes the critical issues and drivers of SMEs' business model as identified in this study.

5.2. SMEs and their business models as mechanisms to support adoption and scaling of CSA technologies

Despite critical issues for SMEs' business model, our findings show that selling/hiring out CSA services to farmers can be a profitable business in Punjab under certain conditions. To reflect on the business model as scaling mechanism for CSA, first, it is interesting to explore whether and how SMEs can be helpful in removing current obstacles in the adoption of CSA by farmers. Second, it is useful to study the changes to SMEs' business model that are required to transform SMEs into effective change agents supporting CSA.

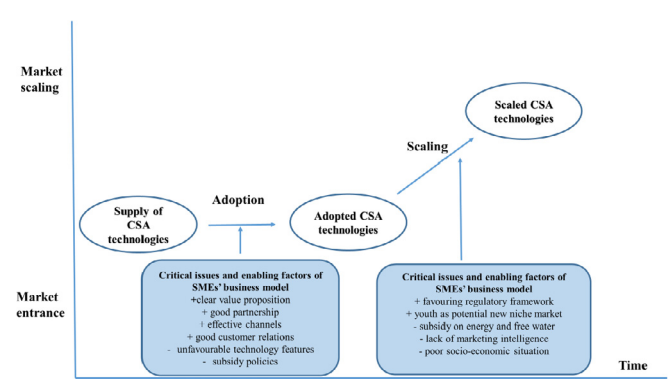

Fig. 5. Critical issues and drivers of SMEs' business model as identified in this study.

5.2.1. Can SMEs remove current obstacles in the adoption of CSA by farmers?

Farmers need access to finance to buy or hire CSA services for which they mainly use community based financial institutions. Cooperatives are amongst these institutions as they provide relatively cheap loans for renting and/or buying CSA technologies. In turn, cooperatives receive government subsidies for purchasing CSA technologies. This suggests that in the end government's subsidy is a driver enabling farmers to buy or lease CSA technologies rather than the cooperative itself. No evidence for service providers providing loans to farmers was found. However, the ability of service providers to access loans from banks, which benefits farmers as it enables them to agree on flexible payback regimes, partly addresses the financial obstacle faced by farmers.

Farmers' gaps in knowledge and skills are well addressed by cooperatives and service providers. They both acknowledge farmers prefer learning about new technologies from peers rather than from outsiders. This in line with previous research highlighting farmers' need for 'user friendly' information and after sale services (Long et al., 2017).

Obstacles for farmers such as declining farm sizes decreasing their investment capacity in agricultural innovation cannot be removed by SMEs. It is very likely that the current practice of cooperatives serving the relatively smaller farmers and service providers the larger farms will be reinforced.

5.2.2. What changes to the business model of the SMEs are required to transform SMEs into effective change agents supporting adoption and scaling CSA?

Favouring regulatory landscape, widening partnership and ensure access to finance: This study shows that SMEs' business model can benefit from a favouring regulatory landscape. The Punjab Government has agreed to fully ban residue burning by 2019–2020 to improve air quality (Tallis et al., 2017). The ban calls for a new crop residue management systems, for which the Happy Seeder and Zero-till multi crop planter are interesting options. Hiring out a package of CSA technologies including these technologies can be a profitable business if accompanied by factors such as access to capital and knowledge, good customer relationship and productive partnership. Supporting SMEs in knowledge acquisition on CSA is likely to increase the adoption rate of CSA technologies, but needs to be combined with experimentation and demonstration opportunities. Moreover, access to sufficient and adequate finance needs to be guaranteed to ensure the production and purchase by SMEs of these technologies.

Review subsidy scheme: The use of government subsidies and other governmental financial incentives for services providers is recommended to increase the adoption of new CSA technologies by several scholars (Senyolo et al., 2018; Tallis et al., 2017). Our study shows that the effect of government's subsidy on SMEs' business model is ambiguous. Government subsidies enable cooperatives to purchase CSA technologies and provide loans to their customers for renting of CSA technologies. But this study also shows that for both cooperatives and service providers, the CSA business model is viable even without subsidies.

There is need to better link government subsidy to market intelligence. Subsidy on the Land Laser Leveller has served its purpose, and it could be withdrawn. The savings would be considerable and could be diverted to supporting SMEs in delivering other proven forms of CSA technologies, which have yet to achieve widespread uptake (Gill, 2014).

Several scholars discussed the adverse effects of subsidies on inputs (Beddington et al., 2012; Grainger-Jones, 2011). In this study, government respondents and scientists put forward that subsidy on electricity and free use of water forms a critical issue preventing farmers to rent SMEs' services on water and fuel saving technologies.

To better use SMEs' business as mechanism for adoption and scaling CSA, existing government's subsidies should be modified on the basis of an assessment of market potentials and proven CSA technologies, which have yet to achieve widespread uptake.

Land reform: For decades, Punjab has been considered the granary of India. However, decline in landholdings in combination with other socio-economic and environmental developments creates negative growth rates in agriculture. This trend puts SMEs' business at risk in the near future. Some CSA technologies require a certain acreage to be effectively applied. (Jat et al., 2006) conclude that a LLL is less efficient for small sized fields. Gill (2014) also signals that fields of marginal farmers are too small to access a LLL, which adversely affects SMEs' market for this technology. In the short term, this effect will be larger for cooperatives compared to service providers as the farm size of cooperatives' customers is smaller compared to that of service providers' clients. In the midterm, this scale issue may be overcome through the trend that small farmers sell their farm to larger farmers or service providers (Gill, 2014).

More importantly, farming may become no longer a viable occupation due to fragmented and shrinking land holdings. Debt rate under small and medium size landholdings is relatively large (Singh et al., 2009). Decreasing capacity to invest in new CSA technologies again will affect cooperatives' business more than that of service providers. Options like liberalization of the land lease market and allowing for large holdings are beyond the scope of this study.

5.3. Limitations

Considering the nature of the study, some limitations surfaced. Initially the majority of respondents were identified and contacted by CIMMYT and BISA. The snowball method was used to interview stakeholders outside the network of partnering research institutes, but bias and Hawthorne effect may have been introduced. Second, interviewed SMEs interviewed were considered representative for Punjab. Large scale study to verify results has not been conducted. However, results were cross checked between respondents and research team members. Findings were also cross checked and complemented with other researchers, policymakers and private sector parties in national and international scientific events. Future research should seek to validate the above findings through larger samples, covering other Indian states and countries.

6. Conclusion

This paper starts from the premise that the business models of SMEs (farmer cooperatives and service providers) can be a mechanism for adoption and scaling of CSA. It responds the main question 'what are critical issues and drivers of SMEs' business models for the adoption and scaling of CSA technologies in a developing country context'.

The described case of Punjab shows that SMEs' business models can be seen as a mechanism for adoption of CSA technologies. This is enabled by the presence of a mix of drivers including scientific and practical evidence of CSA technologies, good partnership between SMEs and researchers, good customer relationships and effective channels through farmers' field trials and demonstrations in climate smart villages. All together creating a clear value to their customers, i.e. farmers and therefore supportive to the adoption of CSA. Distortive government subsidies on energy and the lack of market intelligence negatively affect the profitability of the business model and as such adoption.

SMEs' business models, as mechanism for scaling requiring favourable institutions and policies is less evident. Good partnership, customer relationships and effective channels in combination with favourable regulations facilitate SMEs to support scaling of CSA. However, a lack of market intelligence, difficult socio-economic circumstances and distortive government subsidies limit the role of SMEs business model as mechanism for scaling.

To strengthen SMEs' role as change agents for CSA, policy makers should reconsider current subsidy regime and ensure flexible and targeted (financial) incentives. Research and extension services can help SMEs in the acquisition of new knowledge and skills, which they can in turn share with their customers.

From a scientific perspective, the novelty of our study is the distinction between adoption and scaling of CSA technologies. Previous literature on business models supporting CSA focussed on adoption only. By introducing the concept of scaling, this paper explicates the institutional and political dimensions of large scale adoption at different levels involving multiple actors to bring about the societal changes needed to address climate change impacts and enhance food security.

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