

What is capacity to innovate and how can it be assessed? A review of the literature

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Abstract: 'Capacity to innovate' is an emerging concept, especially in agriculture and rural development. There is no universally agreed definition for this concept, but many authors agree that it refers generally to the ability of actors to continuously identify constraints and opportunities, and to mobilise capabilities and resources in response – i.e. to produce and sustain innovation processes in a dynamic systems environment. Increasingly, capacity to innovate (C2I) is recognised as playing a critical role in successfully responding to a changing external environment. Facilitating and building this capacity is therefore crucial for adaptable farming systems and for improving the resilience and livelihoods of poor farmers and other rural actors. This paper summarises the findings of a targeted literature review aiming to unpack the concept of C2I, exploring its meaning across all research sectors and ways to assess it in agricultural communities.

We propose that the various dimensions of C2I identified through the literature review can be a starting point for developing an assessment framework to measure changes in C2I. Specifically, we identify four core capacities that make up C2I: (1) to envision and create new ways of doing things; (2) to connect with others to access and understand new information and resources; (3) to experiment, test, assess, and adapt; and (4) to work with others to achieve action and change. We review previously described indicators to measure these concepts, and accordingly propose an initial set of metrics for use in agricultural communities. We conclude that the C2I concept puts a spotlight on process-driven approaches to innovation that have previously been undervalued.

Keywords: Innovation; capacity; agricultural innovation systems; capacity to innovate; metrics; capabilities

1. Introduction

Innovation plays a fundamental role in economic development and is considered a key factor in determining the 'success' of societies, sectors and firms (Bell & Albu, 1999; Freeman, 1987; Mytelka, 2000). Defined as "the new use of existing or new ideas or the combination of ideas that have social or economic significance" (Mbabu & Hall, 2012), innovation is increasingly seen as critical to achieving economic, social and environmental goals in a rapidly changing world (Jones, 2004). While not a panacea nor an end in itself (sometimes resisting change may be what is needed), agricultural innovation may be particularly vital for feeding a growing global population in a sustainable manner (FAO, 2014; Jones, 2004), and is especially important in developing countries where agriculture plays a critical role in the local and national economy (Thomas & Slater, 2006; World Bank, 2008).

Conventional approaches towards agricultural innovation involve the creation of new technologies by research and development organisations, and then "pushing" them to farmers and other end-users. This assumes that the lack of (adequate) technology is the primary obstacle to agricultural innovation and development. However, the limitations of this technology-led approach have been increasingly recognized (Clark, 2005; Hall *et al.*, 2007; Johnson & Segura-Bonilla, 2001). Many scholars and practitioners acknowledge that the constraints to agricultural innovation and development are not only the ability to produce new knowledge or technologies, but also the ability of stakeholders to put relevant knowledge and technological inventions into use. This includes adapting inventions and practices to rapidly changing conditions and locally-specific contexts, and often requires changes to social, economic, institutional and technological systems (Chataway *et al.*, 2005; Hall *et al.*, 2007; Schut *et al.*, 2015).

The understanding of the importance and nature of innovation led to the development of the innovation systems concept, defined as the complex networks of interacting actors (individuals, organisations and enterprises) involved in developing and putting an innovation into use, together with the institutions and policies that support this (World Bank, 2007). Innovation systems thinking is now commonly applied to agriculture, as Agricultural Innovation Systems (AIS) (Assefa *et al.*, 2009; Klerx *et al.*, 2012; Pant & Hambly Odame, 2009). Along with the emergence of innovation systems analysis, and reflecting the importance of actors' capacities to engage in innovation processes, over the past twenty years a related concept has emerged, that of 'capacity to innovate' or C2I.

As a concept, C2I is significant not only in the agricultural sector (Schut *et al.*, 2015) but also in business (Hult *et al.*, 2004), medicine (Caccia-Bava *et al.*, 2006), engineering (The Royal Academy of Engineering, 2012), education (Grogger & Hanson, 2011) and in relation to national innovation systems (Wonglimpiyarat, 2010). It is closely related to the concepts of adaptive capacity and capacities for social learning, and has been increasingly seen as playing a key role in helping local system actors respond effectively to rapidly changing external contexts, including climate change (Berkes, 2007; Lybbert & Sumner, 2012). Despite this, the lack of a universally accepted definition for C2I reflects a certain 'fuzziness' about what it means (Chuluunbaatar & LeGrand, 2015; Hall, 2005; Hall *et al.*, 2007).

With the greater focus on C2I has come an increasing concern over how to evaluate C2I (Furman *et al.*, 2002; OECD, 2012). Measuring C2I is important to evaluate the efficacy of interventions and to assess C2I changes over time, and for this more robust M&E tools are needed than those currently available.

This paper proposes an approach to developing metrics for assessing C2I. By taking a broad look at the growing literature on C2I and related terms, we review how this concept has been defined and identify its key conceptual components. From this, we identify the dimensions of the concept which are particularly relevant to agricultural innovation systems and propose a framework for understanding and for measuring C2I. This framework then serves as the starting point for

developing a proposed set of metrics and indicators for assessing C2I within the context of rural communities.

2. Searching the literature: methods and bibliometric data

2.1 Bibliographic searches

We searched for references on C2I across a range of peer-reviewed and practitioner publications, including in the Scopus, Web of Science, and AGRIS databases, and searching donor, implementer and research institution websites. Our search focused on keywords used in the literature, covering all terms related to “capacity to innovate”, including “capacity for innovation”, “innovation capacity”, and “innovation capability”. The resulting documents were screened for relevance if they made reference to:

- C2I concept and/or component capacities;
- interventions aiming (explicitly or implicitly) to improve C2I; **or**
- indicators or methods of assessment or evaluation of capacity to innovate

While reading these papers, relevant cited references were also added to the database, as were references suggested directly by a handful of knowledgeable resource persons.

2.2 Bibliographic results

From a total 2254 documents retrieved through the above searches, 748 passed title and abstract screening and 149 passed full text screening as referring to the C2I definition, concept/component capacities, interventions or indicators. As expected for an emerging topic, the number of documents retrieved by year of publication has increased sharply since 2000 (Figure 1). Of these, more papers used “innovation capacity” than “capacity to innovate”.

More literature was published¹ in China than any other country (**Error! Reference source not found.**), probably due to a strong national emphasis on it becoming an “innovation-oriented nation” by 2020 (Zhang & Wu, 2012). Other major sources of references include the USA and then Western European countries (UK, Spain, Germany, France). By subject, C2I occurs most in business and management literature (21%), followed by social science (18%) and engineering (14%). However, this varied by country, with over half of all publications from China being from in business and management sectors. Agricultural and biological sciences are only 7th on the list, illustrating that the C2I concept is used in a number of contexts beyond that of agricultural innovation systems.

¹ The country/territory detailed in Scopus is determined by the location of the publisher, see Scopus coverage guide

https://www.elsevier.com/data/assets/pdf_file/0007/69451/scopus_content_coverage_guide.pdf

Figure 1. Number of publications related to C2I by year (N = 749 papers passing title and abstract screen)

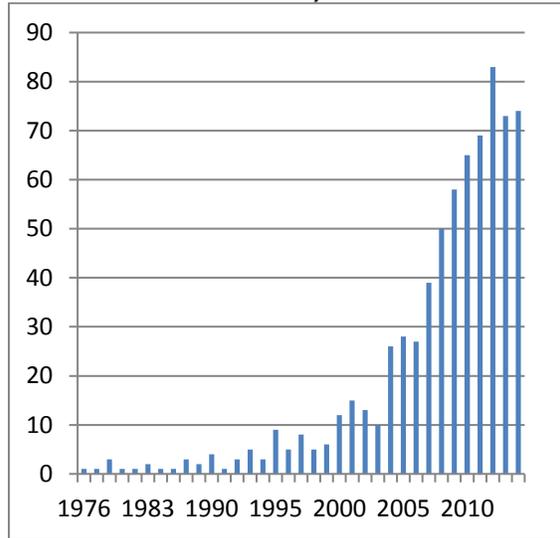
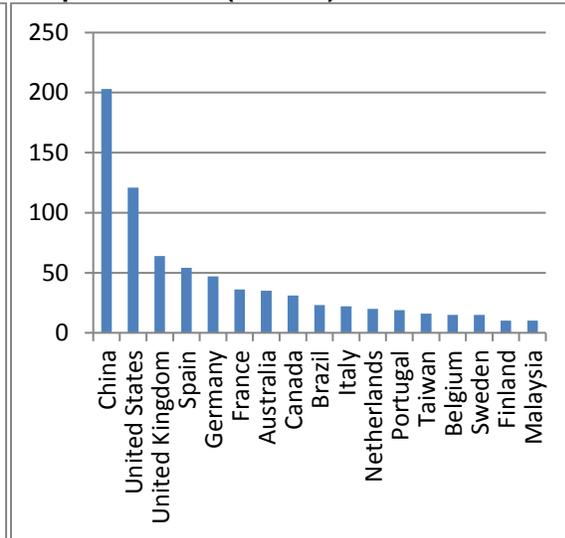


Figure 2. Number of publications by country from countries with 10 or more publications (N = 741)



3. Capacity to innovate: definitions and component capacities from the literature

3.1 Definitions of capacity to innovate

Coined by Burns and Stalker (1961)², the term *capacity to innovate* (C2I) has changed over time and across sectors of use. Early use of the term described it as the capacities “to successfully adopt and implement innovations”, seen as distinct from the capacities needed to “initiate and be receptive to innovations” which were termed *innovativeness* (Hurley & Hult, 1998; Hurley *et al.*, 2005). Modern use of the C2I term includes these two capacities and additional sub-capacities which are seen as integral to the ability to produce and/or to use innovation (Hall *et al.*, 2009; Leeuwis *et al.*, 2014; Mayne & Douthwaite, 2015).

For some, C2I is defined simply (and redundantly) as the increased capacity to be able to innovate. Others have chosen not to give a one-phrase definition, going straight into detailing what component capacities are encompassed by the C2I concept. The few non-redundant, one-sentence definitions describe the capacities to access new innovations and apply them over time, e.g. “the continuing ability to combine and put into use different types of knowledge” (Chuluunbaatar & LeGrand, 2015). See Table 1 for a list of distinct, relevant definitions identified.

Table 1. Definitions of C2I and IC (in chronological order)

Author	Definition or description of C2I or related terms	CI term ³	Research sector
Cohen & Levinthal (1990)	“the ability of a firm to recognise the value of new external information, assimilate it and apply it to commercial ends”	Absorptive capacity; Innovative capabilities	Business

² As reported in (Hurley & Hult, 1998)

³³ The principal term (C2I, IC, etc) used for the definition is listed first, with other terms used interchangeably in the same text listed afterwards

Hurley & Hult (1998)	“The <i>capacity to innovate</i> [...] is the ability of the organization to adopt or implement new ideas, processes, or products successfully” “ <i>Innovativeness</i> is the notion of openness to new ideas as an aspect of the firm’s culture [it] is a measure of the organization’s orientation toward innovation.” “Innovative capacity relates to [...] absorptive capacity”.	C2I; Innovativeness Innovative capacity; Absorptive capacity	Business
Neely & Hii (2001)	“Innovative capacity is the internal potential of a firm to generate new ideas, identify new market and technological opportunities, and implement innovations by leveraging resources and capabilities. In short, innovative capacity determines a firm’s ability to innovate.”	Innovative capacity	Business & management SME
Hult et al. (2004)	“Innovativeness is defined here as the capacity to introduce some new process, product, or idea in the organisation”	Innovativeness	Business
Caccia-Bava et al. (2006)	“the organization’s capacity to innovate (absorptive capacity), [is] the organization’s ability to recognize the value of new information, assimilate it, and apply it to productive ends...”	C2I Absorptive capacity	Health
Skiltere & Jesilevska (2013)	“the ability to generate new knowledge, new technology and new artefacts and to apply these novelties in a useful way. The concept of innovative capacity evaluates not only the current capabilities to innovate but also the innovative potentials that may affect innovativeness in the longer period of time.”	Innovative capacity; IC; Innovative potential; Innovativeness	Business & economics
Nair et al. (2014)	“Innovation capacity is the collective ability of a firm to look into future through the eyes of customer and reengineer products and services accordingly”	IC	Business
Chuluunbaatar & LeGrand (2015)	“the continuing ability to combine and put into use different types of knowledge”	C2I IC	Agriculture
Mayne & Douthwaite (2015)	“Capacity to innovate is then the ability to combine some or all of hardware, software and orgware to bring about innovation”	C2I	Agriculture
Turner et al. (2015)	“Innovation capacity is the capability of actors to continuously identify and priorities constraints, and in response mobilise new and existing capabilities and resources, i.e. adapt to realise opportunities in a dynamic systems context”. “to mobilise, combine and create resources and capabilities to successfully innovate”	IC C2I	Agriculture

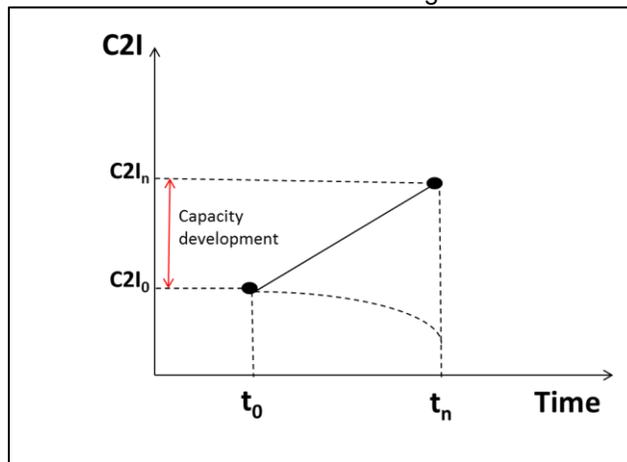
3.2 Key terms related to the concept of C2I

As Table 1 illustrates, the terms *innovation capacity* (IC) and C2I have often been used interchangeably (e.g. Chuluunbaatar & LeGrand, 2015; Turner et al., 2015). However, particularly in business and management research, IC may be used to refer to how many innovations an organisation can produce and implement successfully, rather than the capacities needed to do so. These definitions of IC may include ‘structural properties’ of an organisation (e.g. measures of organisation size, finance and machinery) that most definitions of C2I do not include, as well as ‘human qualities’ such as communication, tolerance for risk-taking, power sharing, learning, collaboration, and participative decision-making that do align with C2I capacities (Aiken et al., 1980; Hurley & Hult, 1998). Thus, understanding of IC may vary with sector from being comparable to C2I, to being something much broader. We have not seen C2I used in this broader sense, and so consider it as the less ambiguous and therefore preferable term.

Another area where terms may be ambiguous relate to the concept of *capacity* itself. In the literature, *competence*, *capability*, and *capacity* are used in relation to innovation, and yet the distinction is not always clear. Some authors use these in a nuanced way, differentiating between *capacity* as an overall ability of individuals, groups or systems to do something and *capabilities* as specific sets of skills (Mauerhofer, 2010; Pant, 2012; Sen, 1993; Skiltere & Jesilevska, 2013), while others use these interchangeably (Neely & Hii, 2001). While we appreciate the distinction, given that these related terms and concepts are not always used consistently, we have decided to pull all capacities, capabilities and competencies together in Figure 4.

The **process** by which individuals, organisations and societies obtain, strengthen, adapt and maintain capacity to set and achieve objectives over time has been called capacity development (CD) (UNDP, 2009), capacity strengthening (Hartwich *et al.*, 2007) or capacity building (DFID, 2008), each having slightly different meanings (Hambly & Sarapura, 2009; Pant, 2012). For the purposes of this paper, we will treat them as overlapping aspects within the same overall process, which we will call CD. Thus, CD for innovation can be thought of as the process by which C2I may be achieved (Figure 3). Some authors indeed specifically equate CD for AIS as C2I (TAP, 2016) or IC (Pound & Essegy, 2008).

Figure 3. Conceptual relationship between C2I (a state which changes dynamically over time) and CD (a process and set of activities which contributes to increasing C2I). The dashed line indicates that while the goal is to increase C2I, it may go up or down over time.



3.3 What specific capacities are needed to innovate?

The literature on C2I points to certain capacities and capabilities required by individuals, organisations and/or institutions which when combined create the capacity needed to innovate and sustain innovation processes over time. We sorted these into groups of capacities that were most alike or linked, giving four broad capacity groups each of which may occur at, or are supported by, individuals, organisations and the enabling environment, and which can be further divided into several sub-capacities (Figure 4):

- (1) **To envision, create and be open to new ways of doing things** - to individually and/or jointly envision something new and improved;
- (2) **To connect with others to access and understand new information and resources** – to form new connections and to use both new and existing relationships with diverse actors (individuals and entities) to obtain, share and understand information and resources;
- (3) **To iteratively experiment, test, assess, and adapt** – to conduct experimentation involving iterative learning and improved processes and results over time; and

(4) To work with others to achieve action and change - to work together formally and informally in order to take effective collaborative action and achieve common objectives.

The recognition of capacities to envision, generate and welcome new ideas **(1)**, as separate from capacities to adapt **(3)** apply **(4)** those innovations, reflects earlier definitions of *innovativeness* (Hurley & Hult, 1998; Hurley *et al.*, 2005), described as essentially a cultural trait (Woodside, 2005). Turner *et al.* (2015) named a similar grouping of capacities *innovation capabilities*, describing them as “processes for exploring and exploiting opportunities to innovate”, and encompass the capacities we describe in **(1)** while also overlapping with some of the capacities described under **(2)** and **(3)**.

The capacities to connect with others to access and understand new information **(2)** are most closely aligned with definitions of *potential absorptive capacity*, which is the capacity to acquire and assimilate knowledge (Zahra & George, 2002). Some authors have bundled the concepts of acquiring and assimilating knowledge together with the capacities to use and apply that information. Both are reliant on networks and encompassed by definitions of *absorptive capacity* (Cohen & Levinthal, 1990) or *absorptive capability* (Turner *et al.*, 2015). In this paper we have put the capacities to use and apply knowledge into a separate grouping - the capacity for collaborative action **(4)**. We consider that these two sets of capacities are inherently different as “to understand and know” does not automatically translate into “being able to do”.

Figure 4. Capacities to innovate

<h3 style="color: #0070C0;">1. To envisage, create and be open to new ways of doing things</h3> <p>1.1 To generate new ideas and foster creativity: •Capacity to generate new ideas, products, processes for action^{1,2,3,4,5,6}; •To foster creativity^{5,7,8,9,10}; •Entrepreneurial spirit⁸</p> <p>1.2 To be open to new ideas and actions (individuals, leaders and organisations)^{1,3,4,8}</p> <p>1.3 To identify and prioritise problems and opportunities and adapt/explore them accordingly^{6,11,12,13,14,15,16}</p>	
<h3 style="color: #0070C0;">2. To connect with others to access and understand new information & resources:</h3> <p>2.1 To link with others/network: •Develop, maintain and use effective networks^{5,9,11,12,14,17,18,19,20,21,22,23,24,25}; •To intermediate/facilitate/broker for linkages, interactions and networks^{12,22,26,27,28,29,30,31,32,33,34,25,6}; •Institutions support networks and collaboration, policy supports the development of networks³⁵</p> <p>2.2 To access, share and process information: •To have processes for acquiring, assimilating and transforming external knowledge^{12,13,36,15}; •Capacity to link with others to access, share and process information^{37,17,38,31,4,32,34,14,5,25}; •Institutions support knowledge sharing and interactive learning^{27,23,4,6}</p> <p>2.3 To understand and learn to process information: •Understand new knowledge (ideas, things, resources) and put to (productive) use^{1,17,11,39,9,25}; •Capacity for reflection and learning^{8, 39,12,26,22,4,5,25,40,41}; •Organisations and Institutions support learning^{1,27,23,4,5,6}</p>	<h3 style="color: #0070C0;">3. To iteratively experiment, test, take risks, analyse, assess</h3> <p>3.1 To test, experiment and assess •To experiment and assess arising trade-offs^{17,42,3,31,14}; •Institutions support social and technical experimentation^{12,42,43,30,31,23,33}; •Capacity to assess and take risks and a culture that supports that^{38,9,42,31,14,6}</p> <p>3.2 To adapt to change, be flexible: •Ability to change approach and partnerships/networks/ interactions in response to change^{44,11,12,13,45,30,22,5,15}; •Embed innovation and research activity in ongoing process of change^{22,14,6}; •Leadership, institutions and culture support & embrace change and allow for rapid response / adaptive management^{44,45,42,3,31,23,46,14,5,6}; •Flexible solutions to allow for revision^{12,43}</p>
<h3 style="color: #0070C0;">4. To work with others to achieve action and change</h3> <p>4.1 To be motivated and to motivate others: •Individuals motivated to participate^{11,9,30,14,40}; •Project champions^{47,26,30,31}</p> <p>4.2 To work with others effectively to achieve action: •Collaborate and work with others to achieve action^{38,18,32,14,25,16}; •Capacity to mobilise resources and form support coalitions around promising options^{22,23,14}; •Share risks and benefits/Diversify risks and share uncertainties^{38,22,3}; •Institutions for sharing risks and benefits^{12,31,23}; •Build a shared vision/goal and realise shared values^{5,25}</p> <p>4.3 To mediate and facilitate: •Actively manage interdependent and unpredictable interactions among network partners^{12,28,22,33}; •Leaders and facilitators orchestrate and facilitate to enable action, can understand how change happens and how to intervene effectively¹⁴; •Mediate diverse groups with different skills⁵, mediate power-imbalances⁴³; •Allow all members of the group to influence decisions¹; •Leadership able to balance individual and collective interests to meet individual and collective needs^{12,43,3,46}</p>	

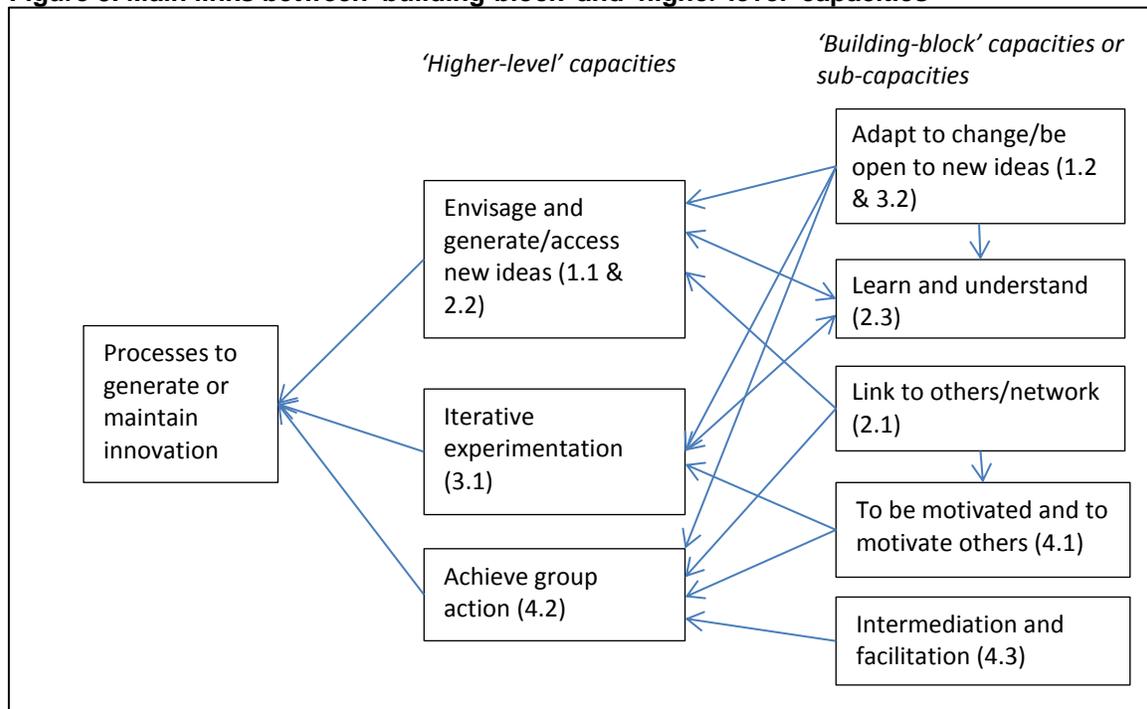
¹(Hurley & Hult, 1998); ²(Johnson & Segura-Bonilla, 2001); ³(Rufat-Latre *et al.*, 2010); ⁴(Pant, 2012); ⁵(Nair *et al.*, 2014); ⁶(Hueske *et al.*, 2015); ⁷(King & Anderson, 1990); ⁸(Hult *et al.*, 2004), ⁹(Howard & Gillies, 2009); ¹⁰(Yang & Konrad, 2011); ¹¹(Hall, 2005); ¹²(Smart *et al.*, 2007); ¹³(Wang & Ahmed, 2007); ¹⁴(Leeuwis *et al.*, 2014); ¹⁵(Turner *et al.*, 2015); ¹⁶(TAP, 2016); ¹⁷(Dalohoun, 2005); ¹⁸(Hartwich *et al.*, 2007); ¹⁹(Carlsson & Sandström, 2008); ²⁰(Rohrbeck *et al.*, 2009); ²¹(Chatenier *et al.*, 2010); ²²(Klerkx *et al.*, 2010); ²³(Musiolik *et al.*, 2012); ²⁴(Lambrech *et al.*, 2014); ²⁵(Chuluunbaatar & LeGrand, 2015); ²⁶(Douthwaite *et al.*, 2009); ²⁷(Klerkx *et al.*, 2009); ²⁸(Adner & Kapoor, 2010); ²⁹(Dijkman, 2010); ³⁰(Douthwaite & Gummert, 2010); ³¹(Trautler *et al.*, 2011); ³²(World Bank, 2012); ³³(Brusoni & Prencipe, 2013); ³⁴(Hermans *et al.*, 2013); ³⁵(Ugbe, 2010); ³⁶(Boly *et al.*, 2014); ³⁷(Hosmer, 1995); ³⁸(Adner, 2006); ³⁹(Caccia-Bava *et al.*, 2006); ⁴⁰(Mayne & Douthwaite, 2015); ⁴¹(TAP, 2016); ⁴²(Röling, 2009); ⁴³(Chatenier *et al.*, 2010); ⁴⁴(Senge, 1990); ⁴⁵(Fernandez-Gimenez *et al.*, 2008); ⁴⁶(Nettle *et al.*, 2013); ⁴⁷(Douthwaite, 2002).

3.4 Capacities are interlinked and multi-dimensional

The broad groups of capacities presented in Section 3.3 and Figure 4 can be organised in a multitude of ways: the proposed grouping is not definitive and these capacities are interlinked, overlapping and exist on different dimensions. For example, while we have considered that 'to learn and understand' (2.3) most closely aligns with our C2I group of capacities 'to connect with others to access and understand new information and resources' (2), learning and understanding is also necessary for iterative experimentation.

In trying to group capacities, it is useful to think of 'higher-level' capacities needed to produce or sustain innovation compared to 'building block' capacities or sub-capacities that underpin or precede them. For example, the 'higher-level' capacity to envisage, generate and access new ideas assumes the presence of 'building-block' capacities to form and access networks (from where to find new ideas), to learn and understand those ideas, and to identify opportunities (see Figure 5 which shows some of the main links between these capacities).

Figure 5. Main links between 'building-block' and 'higher-level' capacities



4. How to assess C2I

Evaluating C2I has become a concern for those working to strengthen AIS (Furman *et al.*, 2002), as well as within firms, and at regional and national levels (OECD, 2012). In addition to measuring the efficacy of interventions for reporting purposes, it is also important to assess C2I in order to inform organisational learning and the ability of programs and interventions to adapt (Mayne & Douthwaite, 2015). Measuring C2I is difficult as many of the desired results refer to processes and have no clear completion mark (Daane *et al.*, 2009). In addition, it is important that measures be useful and accurate, particularly given that the way in which something is defined and assessed often affects how it is managed (Chuluunbaatar & LeGrand, 2015).

4.1 Indicators proposed in the literature

The literature reviewed outlines two main types of indicators for C2I. Most common are measures to assess C2I as a whole, using outcome indicators reflecting the presence or change in this overall capacity. Also proposed are measures aiming to assess the capacity directly using indicators linked to essential elements of C2I.

4.1.1 Measurements linked to innovation outputs and outcomes

Given that C2I refers to the ability to produce innovation, overall capacity can be assessed by looking at innovation outcomes. Thus, if C2I has increased over a time, we should expect to see evidence of more or improved quality innovations, more effective innovation processes, and/or innovation activity spread more broadly.

This is essentially what most business, national and regional measures of C2I assess. Common measures include indicators of new product output or the number of patents and patent citations (proxy measures of new product development) (Skiltere & Jesilevska, 2013; Song *et al.*, 2014).

Outcome measures of C2I proposed in agricultural contexts include measures of up-scaling and out-scaling, such as a) interlinked technical and social-institutional innovations, b) innovations being tested outside the initial intervention area, c) growing coalitions for change, and d) lessons learned/principles/methods/strategies adopted elsewhere (Leeuwis *et al.*, 2014; Mayne & Douthwaite, 2015). Others use higher-level measures of development and well-being such as job creation and income (Dalohoun, 2005).

4.1.2 Measurements linked directly to C2I

Within firms, there has been a move away from innovation output-only metrics towards the evaluation of multiple factors, including indicators of C2I itself (Boly *et al.*, 2014). Similarly, most proposed measures of C2I within agricultural systems include indicators which seek to directly measure the component capacities of C2I. 'Opening the black box' allows us to see the extent to which C2I may have changed, even if innovation processes are still mid-course, which may be useful given that innovation processes typically take time, so there may be a considerable lag between the time when C2I is developed and the time when it manifests through specific measurable innovation outputs. It also facilitates understanding of which aspects of C2I have changed, which may be important for research, as well as for programs that seek to strengthen specific dimensions of C2I.

Indicators of C2I can therefore be categorised according to the type of capacities they measure, using the same general groupings proposed in Section 3. Thus indicators related to **(1) envisioning, generating or being open to new ideas** include measures of a change in mind-set, attitude, confidence or conducive modes of thinking (Leeuwis *et al.*, 2014; Mayne & Douthwaite, 2015; Van Veldhuizen & Water-Bayer, 1997); or responsiveness of organisations to innovation opportunities (Spielman & Kelemework, 2009).

Indicators related to **(2) connecting to others to access and understand new information and resources** focus on assessing a) the scale of networks (e.g. # networks and initiatives involved in social enquiry/learning, or the diversity of those networks) (FARA, 2014; Leeuwis *et al.*, 2014; Spielman *et al.*, 2011; Spielman & Kelemework, 2009; Temel, 2004; Van Veldhuizen & Water-Bayer, 1997); b) the use of those networks to access information (Clark, 2006; Dalohoun, 2005; FARA, 2014; Jang *et al.*, 2002; Leeuwis *et al.*, 2014; Michailova & Husted, 2003; Van Veldhuizen & Water-Bayer, 1997); or c) learning and development or changes in learning processes (Boly *et al.*, 2014; Dalohoun, 2005; Hurley & Hult, 1998).

Indicators of **(3) testing, experimenting and analysing** focus on the number of technical and social experiments done, which may include the number of novelties identified, tested, or

discarded, and changes in the way that selection decisions are made (Leeuwis *et al.*, 2014; Mayne & Douthwaite, 2015; Van Veldhuizen & Water-Bayer, 1997).

Finally, indicators to assess **(4) achieving action as a group** look at a) the number or scale of new ideas or practices adopted (Dalohoun, 2005; Hurley & Hult, 1998; Mayne & Douthwaite, 2015); b) organisational development (Van Veldhuizen & Water-Bayer, 1997) or coalition formation around promising initiatives (Leeuwis *et al.*, 2014); c) measures of power-equity and participatory decision-making (Hurley & Hult, 1998); d) measures of leadership (Van Veldhuizen & Water-Bayer, 1997); and e) resource mobilisation (Van Veldhuizen & Water-Bayer, 1997).

4.2 Proposed indicators to assess C2I

The conceptual outline of C2I and its component capacities and indicators developed in this paper are based on the review of the literature on C2I across all sectors. In this section, we apply this to the agricultural context, proposing an exploratory framework and set of indicators for assessing C2I directly in the context of agricultural communities.

4.2.1 Approaching the assessment of C2I: what makes a ‘good indicator’?

When developing a method of assessment that can be used by researchers as well as project implementers seeking to measure C2I in a community-based setting, we propose that the following principles be applied:

1. Where possible, use validated indicators for a specific capacity before creating new ones (e.g. tested methods of assessing individual and collective efficacy already exist);
2. When choosing among indicators, privilege those which can be readily measured;
3. To avoid wasting resources on unnecessary measurement, use as few indicators as possible – ‘bellwether indicators’ rather than complex sets of interacting factors.

Regarding the latter, to ascertain which indicators may be most suitable as ‘bellwether indicators’, it is useful to return to the idea of ‘higher-level’ and ‘building-block’ capacities described in Section 3.4. For example, if we find that a group of farmers has engaged in a series of experiments resulting in improved practices or prototypes over time (demonstrating iterative learning), we can assume that at least some of the precursor or underpinning sub-capacities (e.g. to identify opportunities for learning, to devise experiments and test different approaches, to analyse results of experiments and trials, and to reflect and learn from results) are present. If, however, we assess this group of farmers at the level of various sub-capacities—the capacity to devise experiments or analyse trade-offs emerging from experiment results, say—we may or may not find that this results in the higher-level capacity to conduct iterative experimentation. In complex, adaptive systems such as AIS, higher-level capacities—including the capacity to innovate itself—are emergent properties of systems dynamics and do not reliably or predictably emerge when only some lower-level system conditions are present. In developing metrics to assess C2I, we therefore propose an approach that focuses on defining indicators for the highest-level capabilities that are needed in order to produce and sustain innovation.

That said, we note that while bellwether indicators may be helpful to track aspects of C2I over time or space, in some cases it may be necessary to further unpack the C2I ‘black box’. For example where there is a lack of innovation and C2I at these higher-level capacities, understanding the development of some of the building block capacities may be necessary to ascertain obstacles and change practices accordingly.

In developing indicators of C2I, we should also be mindful of the final objectives of development projects such as those aiming to develop C2I. Collecting data on, or including indicators of, innovation and of development outcomes is important in order to understand whether innovation has actually taken place, and whether that innovation has been accompanied by improvements (or not) in well-being. Assessing C2I allows us to understand how and by what processes these

interventions have worked (and to continually develop and adjust interventions), while assessing development outcomes allows us to understand (eventually) if these interventions have worked. It may also be useful for local stakeholders themselves to reflect on their own C2I.

4.2.2 Defining components of C2I

The first task in developing metrics to assess capacity to innovate is therefore to define the core, high-level capacities within the C2I concept. Based on Section 3, we propose the following, which we consider as vital to C2I at the local community and local system levels:

1. **Creative drive and innovativeness**
2. **Networking and leveraging of linkages to access resources**
3. **Iterative experimentation**
4. **Collaborative action**

4.2.3 Selecting indicators

We suggest the following indicators in order to assess C2I. They reflect elements of the four core capacities listed in 4.2.2 as represented by, and to be measured, at the individual, community and local system levels.

At the individual level:

1. **Confidence** in ability to develop new and useful solutions to challenges and/or to experiment with and create new ways of doing things.
2. **Increased skills and abilities** associated with C2I at the individual level.
3. **Quantity and quality of experimentation**, e.g. more/better experiments or more/more diverse experimenters.

At the group/community level:

4. **Quality and effectiveness of stakeholders:** e.g. number/diversity of stakeholders, quality and effectiveness of their engagement
5. **Existence or growth in numbers of groups** or other organisations/community institutions with an innovation-related role
6. **Increased collective efficacy:** increases in strength and performance of these groups, such as a) increased confidence in the ability of groups to achieve objectives; b) improved inter-group dynamics; c) number of successful collective actions achieved by the group
7. **Quantity and quality of innovation output⁴:** more/better/more widely used innovations produced by groups or networks of people and individuals
8. **Increased and strengthened linkages:** network size, strength, effectiveness in sharing resources/support.

At the local system level:

9. **Strengthened enabling environment:** e.g. elements of the enabling environment are strengthened or added to; local people are better sustaining the various supportive elements of the local enabling environment.
10. **Changes in norms, attitudes, policies, rules, funding/resource availability** that reduced barriers to innovation and/or facilitated the ability of local people to advance innovation processes.

These indicators reflect a selection of what we consider to be the essential components of C2I, but we stress that these are not yet field tested. Some of these indicators specifically address 'higher-level' capacities (e.g. 3, 4, 6) while others are indicators of 'building-block' capacities that

⁴ Importantly, this occurs and could be measured at the level of the individual and the group. i.e. innovations may have been spearheaded by an individual "innovator" or from group activity

we consider to be critical and measurable capacities (1, 2, 5, 8, 9, 10). Finally, we also include measures of innovation outcomes (7). In addition to these, it may be important to add indicators directly measuring the **processes** which contribute to bringing about innovation and supporting ongoing C2I, as well as the presence, strength and effectiveness of certain **structures and conditions** that enable innovation to take place.

5. Discussion

In this paper we have used a focused literature review to develop a list of categories representing core elements of C2I. We suggest that these elements are a first step to developing M&E tools for measuring C2I, and then make steps towards describing indicators. We acknowledge that, as with many literature reviews based on the use of keyword searches, there are limitations to this approach. While we aimed to use a range of terms around this concept, and followed up on references through a snowball search, we are assuming that the finite number of terms searched are linked to the complex phenomena of C2I. In reality, these concepts are also discussed using different language, particularly in the wider social sciences and psychology literature. Thus, the approach taken here is likely to be a fair representation of the C2I concept amongst those using C2I terminology, particularly amongst those in the agricultural development field, but may not fully explore other interpretations of the concept, and so we should be wary of applying these conclusions and tools to other fields. Another limitation of this approach is that have restricted our search to literature which is online and relatively accessible. While we tried to search for practitioner publications as well as peer-reviewed publications, the former are not always as well-archived and bibliographic databases may be skewed towards the latter.

Having accepted the limitations to our approach, we can still make some valid conclusions. The importance of catalysing and strengthening innovation for development outcomes is now accepted (FAO, 2014). The dominant approach to this has been to focus on the development of new technologies through agricultural research, the adoption of which is assumed to generate outcomes and impact. The value of the C2I concept is that it puts emphasis on the causal power of the process component of innovation (which is often over-looked), rather than on the artefact (technology) component. Research processes can build all of the capacities to innovate, and yet some don't, or are not explicit about wanting to. C2I has the potential to increase the impact of agricultural research, in particular for more marginalised people for whom connectivity and capacity is more of an issue than available technology.

While some CD projects are moving towards developing capacities for innovation (e.g. the CD AIS project (TAP, 2016)), we argue that using the C2I concept bundles together a group of important capacities that conventional CD projects may overlook. Focus on the technology component of innovation has meant that conventional CD projects concentrate on scientific or technical capacities (TAP, 2016). These, while integral to innovation, are alone not sufficient to drive it (Dijkman, 2010). Instead, C2I approaches emphasise transferable skills such as those needed to learn and access knowledge (Pant, 2012) and to combine research-based knowledge with context-specific knowledge (often 'tacit knowledge'⁵ that may not be written down) (Chuluunbaatar & LeGrand, 2015) facilitating the adaptation of innovations to local settings (Hall *et al.*, 2009).

Projects focusing on, or recognising, C2I may also put more emphasis on cross-dimensional interventions, including improving capacities at different scales (TAP 2016) which ensures a more cohesive approach. In contrast, traditional CD interventions may fail to capture the full complexity of innovation processes (Aerni, 2013; TAP, 2016). Similarly, C2I approaches stress the importance of networking and participation (TAP, 2016), while traditional approaches may fail to strengthen inter-relational capacities (Gottret & Córdoba, 2004).

⁵ Knowledge based on knowledge based on experience in a specific situation and which is less likely to be codified

Key to making process outcomes of agricultural research more visible is rigorously showing that they exist and demonstrating their value. This requires measurement, and this paper has made steps towards developing a measurement system. The indicators developed here are targeted, measurable indicators linking to specific capacities to innovate. The next step will be testing and refining these indicators in the field, in order to develop a robust M&E tool, a work that is currently being done by the authors in a number of case studies.

6. Conclusion and perspectives

The literature shows that although the emerging C2I concept is not concretely defined, most scholars now agree that it involves the continuing ability to access or generate innovations and to successfully apply them. There are the beginnings of a consensus over what component capacities the term encompasses, with most focusing on the capacities to generate or access innovations through networks, test and adapt innovations, and work with others to apply and adopt them. Accurate indicators linked to C2I capacities, rather than innovation outcomes, will allow us to assess the efficacy of different intervention types for different capacities. Testing the indicators proposed here may allow us to improve interventions for greater C2I and thus improve development outcomes.

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