Optimizing for Health:
Linking & Leveraging Land Grant Knowledge Assets in Support of Healthy People, Food Systems & Communities

Fellowship Report

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Optimizing for Health: Linking and Leveraging Land Grant Knowledge Assets in Support of Healthy People, Food Systems & Communities

Land Grant Informatics Fellowship Report, Jeffrey Piestrak[1], April 2017

Summary

This report provides an assessment of why and how U.S. Land Grant (LG) programs and institutions[2] might more effectively link and leverage knowledge assets in support of their research, learning and outreach activities and continually evolving mission. More specifically it proposes several areas where we can strengthen and optimize socio-technical systems in support of community and regional agrifood systems. That includes facilitating networked learning and innovation across communities of interest, inquiry, practice[3] and place through the collaborative development of a "Land Grant Knowledge Graph". A focus on healthy, resilient agrifood systems supporting healthy people and communities is presented as a timely and compelling common ground for these capacity building efforts. It's further argued that such systems-oriented approaches can better enable transdisciplinary, community engaged research and adaptive practices increasingly identified as necessary for responding to a range of wicked problems[4] including climate change and food insecurity in a timely and appropriate manner.

Context

The context and impetus for this investigation are severalfold. That includes **priorities associated with the two sponsors** of the fellowship under which this work was pursued:

Cornell University Library (CUL), via its Digital Scholarship Fellowship program. Hosted by the Digital Scholarship and Preservation Services (DSPS) unit since 2012, the fellowship program aims to provide opportunities for CUL staff to expand their skills and experiences in developing, delivering, and assessing digital scholarship services. It supports CUL objectives of "empowering staff to explore gaps in their areas of expertise" and "promoting flexible staffing among the units."

Fellowship activities were also pursued within the context of activities and priorities of the CUL Repository Executive Committee[5], a body of representatives exploring issues associated with CUL's increasingly distributed and complex suite of digital services and platforms. This investigation responded to several goals outlined by CUL Public Services[6] as well, including:

- Positioning the library as a space where knowledge is not only consumed, but produced and disseminated.
- Facilitating new forms of technology-enabled research, teaching, and learning, enabling the effective production and dissemination of knowledge in the digital age.
- Responding to new forms of research and scholarly communication in the digital age. Monitoring larger higher education and social contexts to enable fast, nimble response.
- Provide opportunities for staff to innovate continuously, i.e. offer high-impact solutions to current and anticipated needs, in a safe environment.

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[1] Albert R. Mann Library, Cornell University, jmp36@cornell.edu

[2] Including Land Grant Universities, Cooperative Extension System, Agricultural Experiment Stations and United States Department of Agriculture (USDA). For further background information, see Colleges of Agriculture at the Land Grant Universities (1995)

[3] Including many if not most eXtension communities of practice (http://create.extension.org/group-list) who share some interest in health, agriculture and/or food systems. The eXtension Foundation is a supporter of this research.

[4] Popularized in a 1973 article *Dilemmas in a General Theory of Planning* (Rittel & Webber, 1973), the term wicked problem refers to a complex problem for which there is no simple method of solution, nor possibly even agreement on what the problem or source of it is.

[5] https://confluence.cornell.edu/display/culpublic/RepoExec

[6] Kornelia Tancheva, Associate University Librarian for Research and Learning Services, internal staff communications, June 16, 2015

The eXtension Foundation[7] also provided support through its own fellowship program, supporting innovations in the areas of technology, processes for "working differently", program development, business models, networking, marketing, branding and more. eXtension is particularly interested in how this research might inform and help align their data structures with emerging practices, better enabling evidence-informed practice and impact by Cooperative Extension System (CES) professionals, and eXtension's "i-Three" initiatives[8] supporting **I**nnovation and **I**mpact in response to key **I**ssues.

Using an online constellation of people, resources and tools, eXtension's recently revised strategy[9] is to provide Extension professionals–educators, agents, faculty and specialists–with resources that focus on:

- Increasing effectiveness in addressing issues of importance to the nation
- Fostering creativity and innovation in developing solutions and methods of work
- Advancing the visible and measurable impact of their work for the public good

As a professional development opportunity this fellowship has also provided the author an opportunity to gather and synthesize a broad range of information building on and complementing two decades of public service at Cornell University Library (including Cooperative Extension support), and another 20 plus years of private and civic sector agrifood systems experience, from farm and sea to plate. Intended to be more of an environmental scan than comprehensive analysis, an attempt has been made to identify areas of opportunity potentially warranting further investigation and implementation by the author and/or sponsors.

In surveying the possibilities for greater integration across an increasingly complex and dynamic social and technical landscape, an attempt has also been made **to identify potential shared themes, motivations and opportunities for "convening an ecosystem" of Land Grant actors around a common vision**[10], agenda and set of objectives. This represents perhaps the biggest challenge in translating technical needs and possibilities surfaced by this preliminary research into social action and impact, within what can be considered a "Systems of Systems" (SoS), "socio-technical systems composed of a number of interdependent resources, such as, people, processes, information, and technology that must interact with each other and their environment in support of a common mission" [11]. Adding to this complexity here are the translational challenges associated with bridging widely differing perspectives, approaches and capabilities.

A term used to frame this investigation, informatics, is in itself defined in various ways depending on the context. It commonly refers to the study and practice of connecting people, technology and information in support of their goals, including disciplinary ones (e.g. bioinformatics). Drawing on the related fields of social[12] and community informatics[13], the phrase "***Land Grant Informatics***", **used to define the focus of this fellowship, is defined as:**

> ***Linking people, technology and information in support of our Land Grant mission and the diverse communities of place, practice, inquiry and interest we serve.***

As will be asserted later in this report, the exact nature and mode of enacting that Land Grant mission has always been and still is contested and continually evolving. It is hoped that the ideas presented here might contribute in some way to that adaptive process, helping those of us working for and with the "People's Colleges" better respond to the changing needs and opportunities of a changing world.

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7 https://extension.org/
8 https://extension.org/i-three-initiatives/
9 https://extension.org/about/the-new-extension-strategy/
10 Aligned with GODAN's (Global Open Data for Ag & Nutrition) "theory of change" (http://www.godan.info/about/theory-of-change/) and their interest in realizing a data ecosystem for agriculture and food (Allemang & Teegarden, 2016)
11 http://sebokwiki.org/wiki/Socio-Technical_Features_of_Systems_of_Systems
12 Social informatics is the study and use of Information and Communications Technologies (ICTs) in cultural or institutional contexts (see https://en.wikipedia.org/wiki/Social_informatics)
13 Community informatics is the study and practice of enabling communities with Information and Communications Technologies (ICTs) (see https://en.wikipedia.org/wiki/Community_informatics)

Methods

Modes of inquiry and engagement included 1) a literature review[14], 2) consultation with key experts (technical and context, including stakeholders), 3) identifying and documenting relevant case-studies, 4) mapping out representative activities, assets, needs and relationships as they relate to the focus of this investigation, 5) periodic eXtension blog posts[15] exploring the broader context and relevance of this investigation, inviting dialogue and input and as part of a "working out loud"[16] sense-making process, 6) workshopping ideas via an eXtension hosted "designathon"[17], 7) formal presentations, via webinar[18] and on the Cornell University campus, and 8) this report. These activities were conducted as part of an iterative learning process, with mental models and ultimately recommendations herein evolving over time in response to each of the above activities.

Problem Statement: Shifting From Prescriptive Toward Facilitative Approaches

Since the first Morrill Act was signed into law by President Abraham Lincoln in 1862, the U.S. Land Grant system has grown into a large and complex body of interconnected institutions, today including the United States Department of Agriculture, Land Grant Universities, Agricultural Experiment Stations, and Cooperative Extension System. Through a combined tripartite research, education and extension mission (Figure 1), their reach and impact today extends into every county in the U.S. and around the globe.

Fig.1 USDA National Institute of Food and Agriculture (NIFA) Integrated Approach to Science (from NIFA Strategic Plan, https://nifa.usda.gov/strategic-plan)

Each institution and programmatic leg of this "three-legged stool" comprises a variety of people, programs and departments with a wealth of expertise and resources. Yet specialization of activities and siloing of outputs associated with those has contributed to a disconnect between researchers, educators, practitioners and communities served by the Land Grant system[19]. This can lead to unnecessary competition and/or duplication of effort while inhibiting innovation. **A lack of coordination ultimately makes it more difficult for Land Grant institutions to identify, assess and respond to complex societal challenges in a timely, systematic and effective manner**.

Between January 1996 and March 2000 the Kellogg Commission on the Future of State and Land-Grant Universities held numerous meetings and produced six reports to build awareness among public universities of the need for higher education reform. A 1999 report, *Returning to our roots: The engaged institution* (Kellogg Commission, 1999) suggested that **Land Grant Universities need to move beyond a one-way transfer of information and technology to communities and be more "sympathetically and productively involved with their communities"**.

Since that time concerns have continued to be voiced from both within and outside of Land Grant institutions regarding their ability to fulfill their knowledge with a public purpose mission.

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[14] Citations from this paper and other relevant resources are available through a new Land Grant Informatics Zotero Group @ https://www.zotero.org/groups/land_grant_informatics_interest_group/ in support of ongoing "social bookmarking" around this topic

[15] While some of the content here is drawn from these blog posts (@ https://extension.org/tag/solving-for-pattern/) they should be considered a complement to this paper, providing in some cases a less technical, broader social context to this research, including its specific relevance to Cooperative Extension. Reference will be made to these where relevant.

[16] John Stepper describes Working Out Loud (http://johnstepper.com/2014/01/04/the-5-elements-of-working-out-loud/), a professional development strategy actively supported and promoted by eXtension, as "making your work visible in such a way that it might help others. When you do that – when you work in a more open, connected way – you can build a purposeful network that makes you more effective and provides access to more opportunities." As will be noted later in this report, this simple act of "leaving a trace" has parallels in the biological world, supporting indirect communications and "emergent" expressions of collective intelligence.

[17] https://extension.org/2017/01/05/diversity-inclusion-issue-corps-designathon-planned-for-february/

[18] Video and presentation materials available at https://learn.extension.org/events/2927

[19] See my Solving for Pattern eXtension blog series for more details, particularly parts 2 (http://bit.ly/S4P-2) and 3 (http://bit.ly/S4P-3).

In his 2014 Choices Magazine article *Extension Reconsidered* (Peters, 2014) Land Grant scholar Scott Peters argues that that the dominant view of extension—the dissemination, application, and transfer of scientific information and technologies for economic ends—remains too narrow, and that there has been from its very beginnings and must continue to be a healthy debate about its role. In 2013 Cornell's Mann Library hosted a panel discussion[20] moderated by Peters looking at how Land Grant institutions might learn from their sometimes paternalistic past and better honor their Lincoln legacy. This coincided with the rerelease of Ruby Green Smith's 1949 book *The People's Colleges*, (Smith & Dillard, 2013) a history of Cornell University's extension work discussed by the panel. In it she states:

> *There is vigorous reciprocity in **the Extension Service** because it is with the people, as well as "of the people, by the people, and for the people." It **not only carries knowledge from the State Colleges to the people, but it also works in reverse: it carries from the people to their State Colleges practical knowledge whose workability has been tested on farms, in industry, in homes, and in communities**...Mutual benefits result for the people and for the educational institutions they support.*

That conversation was extended nationally via a year-long series of guest blog posts on the Imagining America - Extension Reconsidered site. In one post asking *Where does "legitimate" knowledge come from?*[21] Craig Hassel from the University of Minnesota suggests:

> ***Cooperative Extension [should provide] leadership in... creating space and building the trust needed for interfacing academic and non-academic forms of human knowledge**. Trust-building, deep listening, cognitive frame-shifting, open-mindedness, fair-mindedness, self-reflective and critical thinking [are] key skills and dispositions in learning from community how to navigate the sometimes challenging cultural terrain and complex knowledge commons.*

Others have also suggested that practitioners and public stakeholders be more actively engaged in the knowledge co-creation process, with Land Grant institutions reducing their emphasis on prescriptive recommendations, embracing a more facilitative approach leveraging local resources and networks in support of local solutions[22]. Those voices have been perhaps most loud within the context of "civic agriculture", a term first coined by the late Thomas Lyson, Liberty Hyde Bailey Professor in the Department of Development Sociology at Cornell University. In *Civic Agriculture and Community Problem Solving* (Lyson, 2005), Lyson defines civic agriculture as:

> *a locally organized system of agriculture and food production characterized by networks of producers who are bound together by place...[It] embodies a commitment to developing and strengthening an economically, environmentally, and socially sustainable system of agriculture and food production that relies on local resources and serves local markets and consumers... [and] is fundamentally about problem solving. **Taken together, the enterprises that make up and support civic agriculture can been seen as part of a community's problem-solving capacity**.*

This represents a distinct shift away from what some recognize as a problematic deficit model[23], emphasizing what's missing in individuals, communities, etc., and the one-way flow of information from experts to non-experts, toward more empowering asset-based approaches. Many practitioners view local and regional food systems as an arena for cultivating a variety of community capitals[24], including social capital (Warner,

[20] https://youtu.be/i9M24NC_2HY
[21] http://imaginingamerica.org/2014/03/10/where-does-legitimate-knowledge-come-from-an-answer-from-extensions-future/
[22] See my *Solving for Pattern* eXtension blog series, particularly parts 2 (http://bit.ly/S4P-2) and 3 (http://bit.ly/S4P-3)
[23] See Part 3 of my *Solving for Pattern* blog series (http://bit.ly/S4P-3) for more context.
[24] The Community Capitals Framework (Flora, Flora & Fey, 2003) supports healthy sustainable community and economic development by attending to and leveraging seven types of capital: natural, cultural, human, social, political, financial and built. Data and

Hinrichs, Schneyer, & Joyce, 1998) contributing to broader community health and resilience. Some have suggested Extension support this work by becoming "leaderful catalysts for change" (Colasanti, Wright, & Reau, 2009), and knowledge network boundary spanners, facilitating peer-to-peer knowledge exchange as well as researcher-practitioner exchange (Lubell, Niles, & Hoffman, 2014).

Drawing on a social constructivist[25] framework, R. David Lankes has called for similar shifts within the library world, moving away from a focus on information dissemination toward facilitating knowledge creation through conversation[26]. And by extension, because technology and particularly the internet is changing the role, form and location of our conversations, libraries should consider how they can support conversational, participatory network infrastructure supporting knowledge creation (Lankes, Silverstein, Nicholson, & Marshall, 2007). More recently[27], Lankes has proposed that THE grand challenge (a societal-level problem that is solvable and has high potential rewards) for librarianship is "coordinating the knowledge infrastructure to unlock the potential and passions of society".

Facilitative strategies such as these often recognize that many societal challenges including food systems related ones cannot be solved by treating them solely as technical, or "knowledge deficit" problems. Each are bound up with a variety of social, economic, environmental and psychological conditions and dynamics. That includes hidden biases and drives such as motivated reasoning and confirmation bias[28] which affect the ability and willingness of people, institutions, communities and entire systems to willingly accept and leverage information in a timely and effective manner.

Solving for Pattern: Generative Solutions

> *To the problems of farming, then, as to other problems of our time, there appear to be three kinds of solutions, [those which]...*
>
> *-Cause a ramifying series of new problems...arising beyond the purview of the expertise that produced the solution...*
>
> *-Immediately worsen the problem it is intended to solve, causing a hellish symbiosis in which problem and solution reciprocally enlarge one another...*
>
> ***-It is not until health is set down as the aim that we come in sight of the third kind of solution: that which causes a ramifying series of solutions... [based on and reinforcing] relationships of mutual dependence.***
>
> Wendell Berry, *Solving for Pattern*, in *The Gift of Good Land: Further Essays Cultural & Agricultural, North Point Press, 1981*

The above quote from Wendell Berry highlights some of the pitfalls associated with prescriptive approaches, often narrowly focused on "symptoms" of various ills, with the possibility of actually worsening problems at a larger systems level, even while achieving outcomes at a localized or programmatic level. In the following four sub-sections I explore several key themes emerging from this investigation which suggest more generative approaches for "solving for pattern", systems oriented solutions leading to further solutions.

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information resources including systems increasing access to other forms can be considered a community capital. WealthWorks (http://wealthworks.org) is a community capitals framework "building lasting livelihoods", including those related to agrifood systems.

[25] Social constructivism is a sociological theory of knowledge whereby knowledge is constructed through interaction with others.

[26] Lankes' focus of scholarship is envisioning the future of the library field through the lens of what he calls "New Librarianship" (https://davidlankes.org/?page_id=6352). He proposes that the mission of libraries is to facilitate knowledge creation within communities, through conversation, challenging the traditional role of libraries as keepers of knowledge artifacts.

[27] http://davidlankes.org/?page_id=671

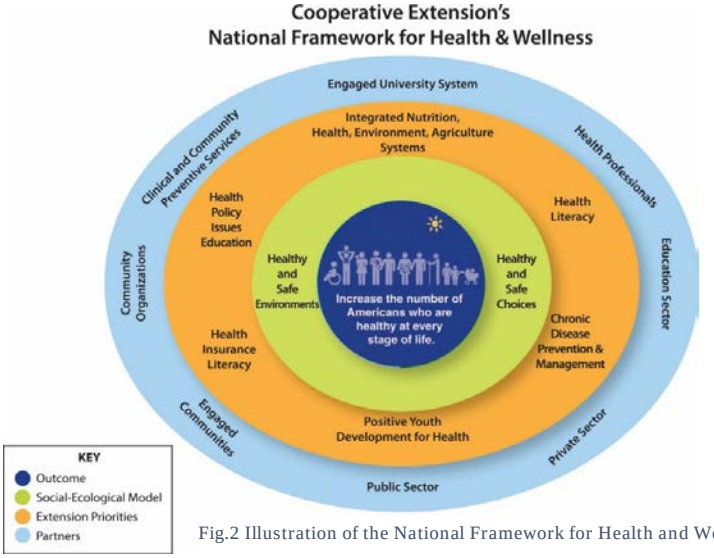
[28] I write about several of these issues in my *Solving for Pattern* blog posts 2 (http://bit.ly/S4P-2) and 3 (http://bit.ly/S4P-3).

Health as an Integrative Framework for Collaboration

One area of research and practice where this type of complexity is being acknowledge and approached most directly, with relevance to agrifood systems as a type of social-ecological systems of systems, is public health. There is in fact a growing chorus of calls for greater integrative research and practice in response to wickedly complex and increasingly intertwined health issues like climate change, sustainable agriculture and food security.

In its report, *Cooperative Extension's National Framework for Health and Wellness* (Braun et al., 2014), the Extension Committee on Organization & Policy (**ECOP) Health Task Force identified several strategic priorities for Cooperative Extension**, including support of:

- **Integrated Nutrition, Health, Environment, and Agricultural Systems** projects spanning the boundaries of what some have viewed as closed and separate systems;
- **Health Literacy**, the ability to obtain, understand, and act on health information and services which is clear and easy-to-understand; and
- **Health Policy Issues Education**, working in new ways to inform decisions about policy, including the outer rings of a socio-ecological model shown below (Figure 2), shaping the context in which people grow, learn, work, and play.



The framework's adaptation of Urie Bronfenbrenner's Social-Ecological model as its theoretical base is illustrated here. The model takes into consideration the complex interplay between individual, community, societal and environmental factors, spanning what's referred to as micro, meso, exo and macro-systems. Partners identified as critical to the achievement of overall health goals include those shown in the outermost ring of the model framework. Systems oriented models such as this are reducing the distinctions between health at the individual and larger family, community and societal scales.

Fig.2 Illustration of the National Framework for Health and Wellness, from ECOP Health Task Force (Braun et al., 2014)

ECOP Health Task Force **recommendations include**:

- **Enhancing Leadership and Professional Development**, including identifying internal and external sources of expertise to present high-quality training sessions via webinar or other technology-based systems.
- **Build Partnerships and Acquire Resources for Extension's Framework for Health to support the enhanced infrastructure and capacity needed** to expand Extension's existing health programming, including:
    - **LG University partnerships** fostering interdisciplinary and collaborative research, teaching and engagement.
    - **Community-based partnerships**, between Extension and health departments, centers, plans, local providers, and health-related private and public organizations
    - **NIFA support/coordination**

Worth noting here is complementary work by others such as Stokols, Lejano and Hipp (2013) which builds on and extends Bronfenbrenner's social-ecological model, suggesting that the resilience of people and places are influenced by the interplay of "multiple facets of the physical environment" and forms of capital, defined as any resource or asset that social actors can employ to further their goals, including information and technological capital.

Directing this focus more squarely on food systems, recently the Association of Public and Land-grant Universities (APLU) published the *Healthy Food Systems, Healthy People* (HFSHP) report (APLU, 2016). It highlights several needs and opportunities for "making a positive difference on human health", calling for:

> ***collaborations and integration among agriculture, food, nutrition, and health care systems that have never before been explored or optimized.*** *Working across these systems and developing solutions that combine multidisciplinary research and education efforts is a new and essential way to approach the issues facing human health and chronic disease prevention.*

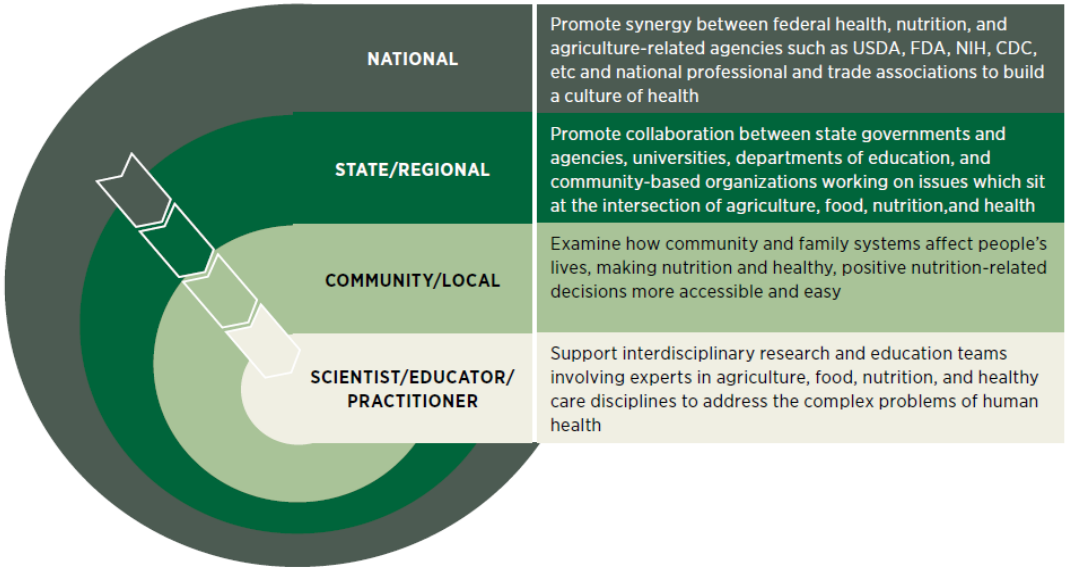


Fig. 3 Integration must occur at many societal levels, including national, state/regional, community/local, and scientist/educator/practitioner. *Healthy Food Systems, Healthy People* report (APLU, 2016)

This graphic from the HFSHP report illustrates nicely the complexity of recommended work across multiple scales. Note however the uni-directional arrows across spatial scales. Perhaps inadvertent but this and Figure 1 above seem to indicate a persistent tendency toward favoring top-down prescriptive approaches.

New multidisciplinary fields based on integrative models of health can help inform this work, including Environmental Nutrition which seeks to comprehensively address the health and sustainability of food systems (see Sabaté, Harwatt, & Soret, 2016). Environmental nutrition broadens the definition of healthy food beyond a focus on nutrients to consider social, economic, and environmental factors across the entire food system and their impact on public health. This also expands the focus beyond personal responsibility to include social responsibility for creating healthy food systems. As a result, environmental nutrition approaches may be useful in responding to wicked challenges such as the concurrent "triple burden of malnutrition" -consumption of too much food, insufficient access to food, or consumption of food lacking essential micronutrients[29].

Health is also being used as a lens for informing and guiding coordinated international responses to climate change. In its report *Health and climate change: policy responses to protect public health* (Watts et al., 2015), the Lancet Commission on Health and Climate Change suggests tackling climate change could be the "greatest global health opportunity" of the 21st century. It refers to several interrelated issues including food insecurity to frame this call to action, while pointing out that:

> *...institutional fragmentation, lack of coordination and communication... are overly common. Strengthening institutions at multiple levels is vital, and institutional capacity needs-assessment and collaboration are critical for health adaptation to climate change.* ***The support of bridging organisations, as well as partnerships through networks, are critical as a means to overcome fragmentation and improve collaboration, information flows, and learning.***

The Commission goes on to suggest leveraging a variety of processes and mechanisms to support this work and more informed decision making, while addressing "information asymmetries". It also calls for multifunctional

[29] It's estimated that over 40% of the global population is affected by this burden, leading to substantial economic losses, perhaps 10% of global GDP. (International Food Policy Research Institute, 2016).

food production systems managed for benefits beyond yield, including ecosystem services, improved nutrition, and resilience to shocks such as crop failure or pest outbreaks. Similar to concerns outlined earlier, the report emphasizes the need to move beyond a reliance on top-down technical solutions focused on addressing "knowledge deficits", which fail to recognize the social dimensions of wicked problems like climate change, stating...

> ***For scientists to engage effectively with the public … they need to seek a greater understanding of prior knowledge and belief systems, and communication skills radically different from those of academia****. They must move beyond traditional scientific discourse to convey a big picture… with which members of the public can engage; this can then provide a context and framing for the discussion of new scientific results and their consequences.*

Even more recently the APLU established the *Challenge of Change Commission*[30] to examine challenges and make recommendations on actions required by public research universities to meet global food needs by 2050. Objectives will be addressed through the work of interdisciplinary working groups focusing on both production and non-production issues, including those related to equity, health, knowledge and education. A key charge of the commission is identifying how public universities can best align their resources, structures and research functions to respond to these complex challenges, recognizing that:

> ***Many of the challenges likely to be identified may be interdisciplinary, involve large amounts of data and use an array of new technologies that may push our institutions to consider new forms of organization and faculty engagement****. A wide array of approaches already exist that may be instructive in this regard and new approaches may emerge that will increase the effectiveness of our efforts.*

UN Millennium Development Goals[31] (MDGs) similarly seek to mobilize global commitments to promote health. Yet trends indicate that the health MDGs have been difficult to achieve, in part because of insufficient coordination of efforts addressing a range of interrelated personal, social, economic, and environmental factors influencing health (Bircher & Kuruvilla, 2014), sometimes referred to as determinants of health[32].

In response to such challenges initiatives like *One Health*[33] and the *Planetary Health Alliance*[34] (already informing and shaping activities at a number of LG institutions, including Cornell) are promoting integrative frameworks like Bronfenbrenner's Social-Ecological model and the Meikirch Model of Health (Fig.4, illustrated below) to strengthen cooperation across sectors and improve individual and population health. Using a "complex adaptive systems" perspective the Meikirch Model views:

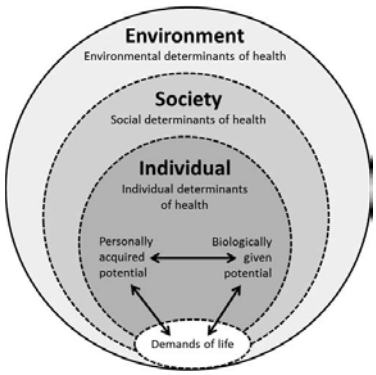


Fig.4 The Meikirch Model of health (Bircher & Kuruvilla, 2014)

> ***health as an 'emergent property' that results from different interactions among components of a complex, adaptive system. Together the individual determinants of health, and the system as a whole – including social and environmental determinants – can develop a high degree of adaptive capacity, resulting in resilience*** *and the ability to address ongoing and new challenges… To achieve and maintain health over long periods, individuals must continually readjust how they… respond…to the changing demands of life…* ***Social action also is required to create circumstances that can promote individual and population health*** (Bircher & Kuruvilla, 2014).

[30] http://www.aplu.org/projects-and-initiatives/international-programs/challenge-of-change/index.html
[31] http://www.unmillenniumproject.org/goals/
[32] Personal, social, economic, and environmental factors that influence health status are known as determinants of health. See https://www.healthypeople.gov/2020/about/foundation-health-measures/Determinants-of-Health
[33] See www.onehealthcommission.org/en/why_one_health/what_is_one_health/, and Allen-Scott et al. (2015)
[34] http://planetaryhealthalliance.org/

A new ten year partnership between Cooperative Extension and the Robert Wood Johnson Foundation[35], building a "Culture of Health"[36], provides one opportunity for leveraging Land Grant assets and expertise in support of such social action. The Action Framework for achieving that goal (illustrated in Figure 5 to the right, from the report *Vision to Action: Measures to Mobilize a Culture of Health*[37]), aligns well with the approaches and recommendations in this report. That includes greater attention to:

- Equity as a foundation of health,
- Cross-sector/discipline collaboration,
- Effective leveraging of data and information resources, and
- Civic engagement and civil discourse.

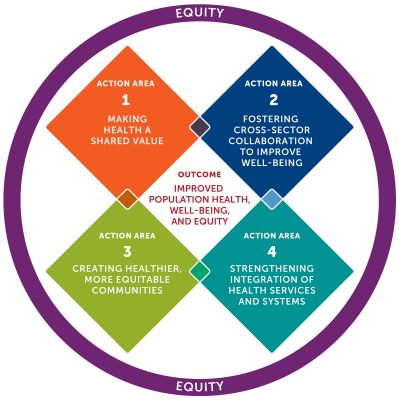


Fig.5 **RWJF Action Framework for realizing a "Culture of Health"**

Networked Information Structures and Flows in Support of Healthy Systems

The concept of complex adaptive systems (CAS) the Meikirch Model refers to draws from and informs several disciplines seeking to understand the dynamic structures and relationships of complex systems[38]. CAS can be described as collections of entities or "agents" whose patterns of interaction over time can feed back on the system in a way which informs future interactions. Emergent, self-organized[39] responses to a changing environment can increase survivability or health of the macro-structure (e.g. a community or food system). Because these processes are distributed and spontaneous, such systems are typically better able to survive or self-repair than ones overly dependent on external, top-down control or resources.

The study of complex systems is revealing reoccurring patterns in what could be called healthy or "fit" systems. These can exhibit the ability to 1) maintain functionality without fundamental changes (robustness), 2) recover or bounce back to a previous state (resilience), or 3) change (adapt) in the face of challenges, with examples found in a variety of social, ecological and technological systems, including agrifood systems. **Systems and networks able to maintain a balance of factors contributing to both resilience and efficiency, optimized for health and sustainability are said to exist within a "Window of Vitality"** (Goerner, Fiscus, & Fath, 2015).

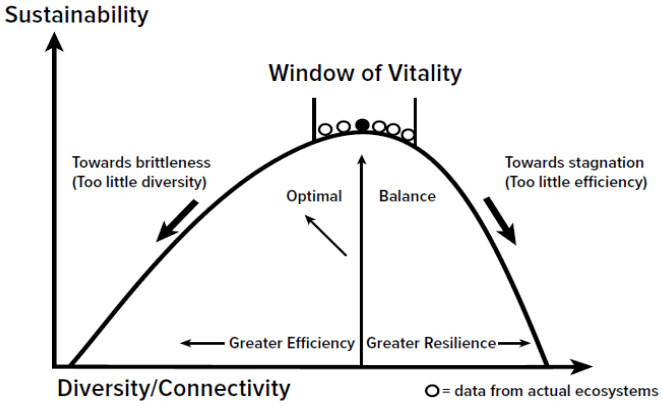


Fig. 6 System sustainability is highest when there is a balance of efficiency and resilience, slightly favoring resilience. Natural ecosystems tend to stay in this "window of vitality". **Maintaining optimal levels of diversity and connectivity are key**. From *Resilient Agriculture* by Laura Lengnick (Lengnick, 2015)

Sally Goerner and her colleagues at the Research Alliance for Regenerative Economics (RARE)[40] are illustrating (Figure 7) the universal importance of connectivity and flow (of materials, finances, information, etc.) to the health of economies, communities, ecosystems, individual organisms and many other systems. These healthy flows are sustained through technical as well as social systems, or "metabolic networks". It's worth noting here the complementarity between this emphasis on flows and the previously mentioned Community Capitals framework focus on stocks, or "capitals". And the implications that has for public data,

[35] http://www.aplu.org/members/commissions/food-environment-and-renewable-resources/board-on-agriculture-assembly/cooperative-extension-section/ecop-members/ecop-documents/ECOP%20July%202016%20minutes.pdf#page=15
[36] http://www.cultureofhealth.org
[37] http://www.rwjf.org/content/dam/COH/RWJ000_COH-Update_CoH_Report_1b.pdf
[38] See http://www.trojanmice.com/articles/complexadaptivesystems.htm and Solving for Pattern post 4 (http://bit.ly/S4P-4) for more background
[39] https://en.wikipedia.org/wiki/Self-organization
[40] http://capitalinstitute.org/research-alliance-for-regenerative-economics/

information and knowledge stores currently siloed and inaccessible (or unusable in a practical sense) to those who might benefit from as well as contribute to those.

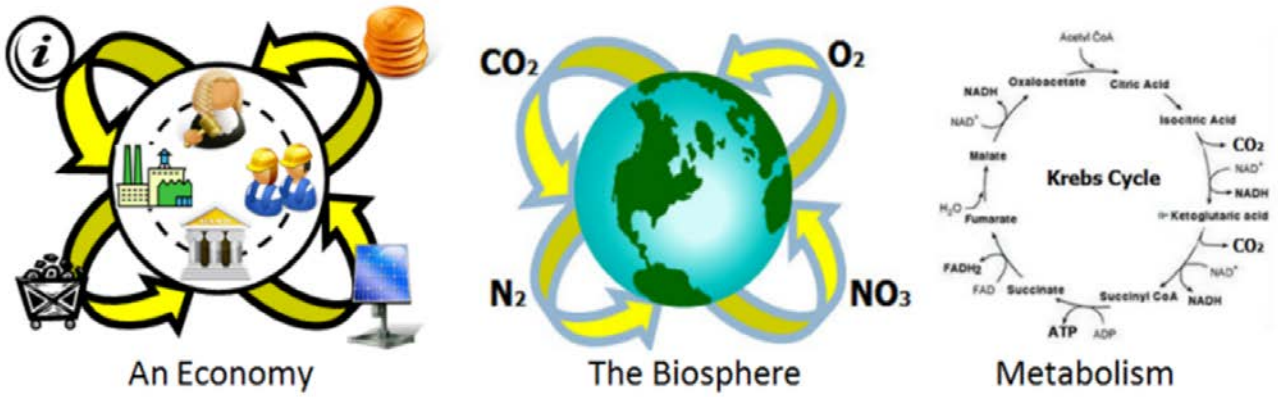


Fig. 7 An economy, the biosphere and metabolism as flow networks. Today's expanded energy research studies the behavior of flow networks, systems built around circulating matter, energy and information throughout their entire being. From Goerner, Fiscus, & Fath (2015)

Political scientist Jenna Bednar uses a complex adaptive systems framework in assessing institutional health and resilience. In her article *What Makes Some Institutions More Adaptable and Resilient to Changes in Their Environment than Others*? (Bednar, 2016) she outlines several internal and external barriers to institutional change, even as the context in which they operate changes. **Three design characteristics, diversity, modularity, and redundancy can contribute to institutional fitness**. Elsewhere Bednar and Scott Page (Bednar & Page, 2016) argue that the **collective intelligence of a community depends on network structures linking diverse perspectives, and that those structures may depend on institutional ensembles**. Federated systems are presented as being particularly robust, with institutional complementarity and subsidiarity offering fitness advantages.

Relevant to community and regional food systems, Graham Marshall from the Institute for Rural Futures looked at how this principle of subsidiarity, decentralizing tasks and decision making to the lowest level with the capacity to conduct those satisfactorily, might guide efforts supporting and scaling up community-based environmental management (Marshall, 2008). Building on Elinor Ostrom's analysis of common-pool resource (CPR) management cases (Ostrom, 1990) he explores how her related "nesting principle" might inform the design of nested multi-level governance systems addressing large-scale environmental problems. Seven lessons are identified, focused on capacity building and incentives or disincentives for that at each level.

Donella Meadows, co-author of the groundbreaking 1972 book *The Limits to Growth* (Meadows, 1972), pioneered the application of complex systems analysis toward sustainability challenges. In the paper *Leverage Points: Places to Intervene in a System* (Meadows, 1999) she outlined a series of specific system properties which could be targeted to proactively change a system (or even transform it entirely). Meadows arranged these "leverage points" (Figure 8) along a continuum from those most easily altered but with relatively weak impacts (left end of lever) to those more challenging to alter but extremely influential (right end). These represented what she called "places within a complex system where a small shift in one thing can produce big changes in everything", a nonlinear trait[41] of complex systems. Most relevant to this study is lever number 7, the structure of information flows (who does and does not have access to information), and the affect that might have on the other levers.

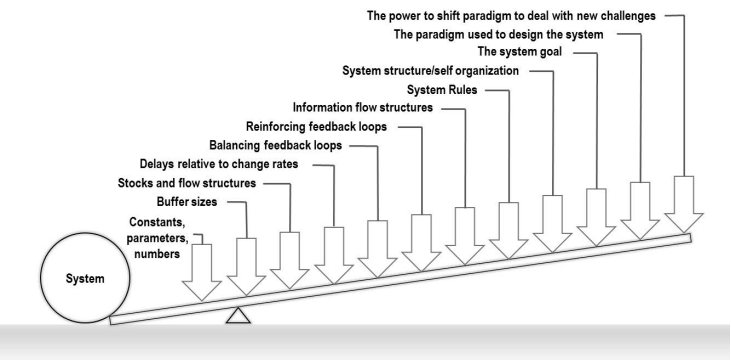


Fig. 8 Systems leverage points identified by Donella Meadows in *Leverage Points: Places to Intervene in a System* (Meadows, 1999)

[41] https://en.wikipedia.org/wiki/Nonlinear_system

Innovations in networked communications and information systems are today being applied in support of "network-centric" strategies promoting health and resilience across a broad range of contexts, including the military[42], business[43] and community development. Bill Traynor, former Executive Director of Lawrence CommunityWorks[44] defines a network centric approach within a community development context (Traynor, 2007) as,

> *An alternative logic model for understanding placed based community building based on relationships of trust and mutual benefit, facilitating the cumulative capacities for collective decision-making, problem solving, mutual support, collective action, information sharing, and the creation and exchange of value* [e.g. time, goods, services, and knowledge]

And from the Knight Foundation and Monitor Institute report "*Connected Citizens: The Power, Potential and Peril of Networks*" (Scearce, 2011):

> *A network-centric model of mutual support begins by connecting members directly with one another, encouraging them to discover the community's existing assets, and then coordinating their needs and offers through trusted and reciprocal relationships.*

Another Knight Foundation resource, the Community Information Toolkit[45], focuses on three broad elements of a healthy "community information ecosystem" – supply, infrastructure and skills, illustrated in Figure 9. The Toolkit provides concrete ways to assess and improve the flow of information in communities, enabling community leaders to harness that for a better community. Recent initiatives like Open Referral[46] are advancing this work by developing new data standards and open platforms that make it easy to share and find information about community resources.

Fig. 9 **Community Information Ecosystem**
(Knight Foundation, http://infotoolkit.org)

Yet in spite of these advances many aspects of our Land Grant system remain limited by out-of-date models of knowledge creation and dissemination. John Gerber, Professor of Sustainable Food and Farming at the University of Massachusetts, has stated that greater attention to these changes is critically important if Land Grant institutions are to remain relevant, stating[47]:

> *New communications technologies coupled with the emergence of societal networking and community-focused action groups will continue to erode the monopoly universities hold on advanced learning... universities must adapt quickly if they are to thrive in a world of rapid, interactive information flow... The pattern of increasing competition, public distrust, and declining support is likely to continue unless a new defining vision for public universities emerges...* ***The next phase in the development of the public university will be a community-focused learning network*** *that extends access to all citizens through university outreach and online instruction in the communiversity of the 21st century... public universities able to build on the land grant ideal, re-engage with the larger community, and take advantage of communications and societal networking technologies will thrive in the 21st century.*

Members of the University of Minnesota Extension Health and Nutrition programming team have been exploring ways Cooperative Extension might support networked learning through statewide food networks like the Minnesota Food Charter Network[48]. In their 2015 report, *Cultivating collective action: The ecology of a*

[42] https://en.wikipedia.org/wiki/Network-centric_warfare
[43] http://knowledge.wharton.upenn.edu/article/the-network-revolution-creating-value-through-platforms-people-and-digital-technology/
[44] http://www.lawrencecommunityworks.org/
[45] http://infotoolkit.org/
[46] https://openreferral.org/
[47] *Communiversity: Beyond the Land Grant*, http://people.umass.edu/jgerber/newlgu.htm
[48] http://mnfoodcharter.com/the-network/

statewide food network (Harden, Bain, & Heim, 2015), they describe how these can facilitate the exchange of information, creating intentional spaces where diverse stakeholders can come together to learn and collaborate, identifying potential solutions to wicked food systems problems. To avoid the perception of imposing their own agenda or co-opting the process, academic and other more formal institutions must cultivate trusting relationships. They may also have a different role in the network than other members, including providing servant leadership in the form of support systems for local and regional networks.

Milburn, Mulley and Kline (2010) suggested Extension better leverage technology in "creating interactive paths for information flow to and from information users...brokering informational exchange using many platforms". Jim Langcuster has also written about how Cooperative Extension can support this type of work on his *Mission Extension* blog[49], including the need to transform itself into an emergent, generative, "open source platform" (Langcuster, 2011), developing "adaptive digital networks... responsive to the needs of contemporary learners"[50]. Though applied here more generally, it's worth noting the importance of "open source" solutions. Open source software means that its source code is made freely available with a license (such as the CC-BY license applied to this paper) providing the rights to study, change, and distribute the software to anyone and for any purpose[51]. This is often closely associated with the terms open access and open standards. Brought together (frequently in the library world –see Corrado, 2005), these can facilitate the free flow of information and ideas in support of open innovation ecosystems[52].

Author and innovation consultant John Hagel recently wrote about[53] harnessing the potential of platforms (or what he prefers to call "performance ecosystems") for this. He outlines four types of platforms: aggregation, social, mobilization and learning. Learning platforms offer uniquely generative network effects[54]. Like the others they can support the exchange of knowledge. But more importantly and relevant to this investigation, they (intentionally) support the knowledge creation process itself.

Hagel's post builds on ideas from an earlier book, *Power of Pull: How Small Moves, Smartly Made, Can Set Big Things in Motion* (Hagel, Brown, & Davison, 2010). In that he and his co-authors describe how a "Big Shift" is taking place requiring successful organizations to move away from top-down, command-and-control structures optimized for "pushing" out mass produced products and services, toward bottom-up, collaborative structures better suited for faster cycles of learning and innovation. This requires moving away from an emphasis on knowledge stocks toward knowledge flows, embracing digital tools in creating ecosystems of diverse, widely distributed users, designers, and suppliers. The authors describe the power of pull[55] in terms relevant to Cooperative Extension and the Land Grant system as a whole:

> *By positioning themselves to take advantage of growing networks internally and externally, companies gain access to flows of knowledge and information that allow them to 'scale learning' in their organization and across their ecosystem. This fundamental change unlocks the potential of individuals and organizations that allow them to stay on the edge of their field–regardless of how quickly change happens.*

Linking People and Information through a "Web of Data"

Land Grant institutions (particularly libraries), Cooperative Extension and associated/federated bodies like eXtension, APLU and ECOP are already exploring ways to enhance information flows and structures. Tools and approaches from those efforts are available to support this ecosystem oriented work.

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[49] https://missionextension.wordpress.com/category/future-of-cooperative-extension/
[50] https://missionextension.wordpress.com/2014/11/18/the-coming-extension-extinction/
[51] See the Open Source Initiative for a more detailed definition: https://opensource.org/docs/osd
[52] https://creativecommons.org/2016/06/21/open-innovation-creation-commons/
[53] www.marketingjournal.org/john-hagel-harnessing-the-full-potential-of-platforms/
[54] The network effect refers to how the value of a network or platform increases as more participants join. See https://en.wikipedia.org/wiki/Network_effect
[55] https://www2.deloitte.com/us/en/pages/center-for-the-edge/articles/power-of-pull.html

At an institutional level there are challenges in maintaining discoverability and access to a growing body of content generated and disseminated in increasingly diverse and disconnected ways across the scholarly ecosystem (Figure 10). In some respects the ability for individuals, programs, projects, etc. to "self-publish" using web-based tools has made it more difficult for libraries and others who maintain the kinds of indexes, catalogs, databases and other finding aids once considered essential to the inquiry process. Using sophisticated technology "solution stacks[56]" like Hydra[57] (Figure 11) advances are being made in reconnecting disparate content creation and (re)use activities through well-managed, robust, shared data and information stores, connected to multiple "heads" or front end interfaces customized to particular user needs.

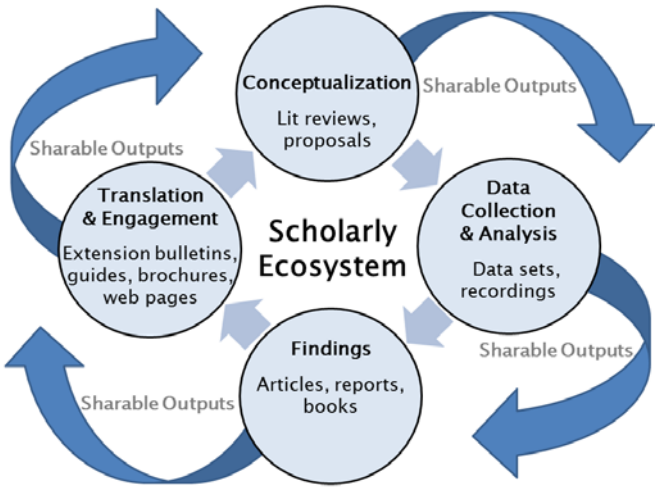


Fig. 10 -The Scholarly Ecosystem. Land Grant University systems generate a wide variety of content through their research, learning and outreach activities. These can be distributed through an equally varied number of channels and platforms of varying discoverability and accessibility.

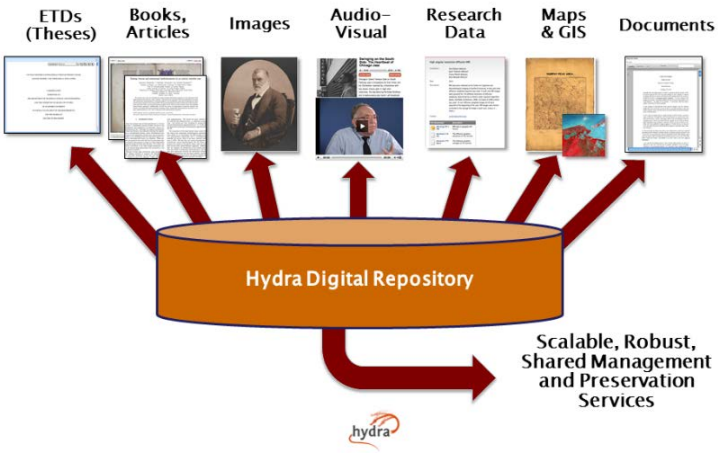


Fig. 11 - Hydra Digital Repository Stack, enabling the storage and management of many different content types within one robust, multifunctional "body" connected to multiple front end interfaces or "heads". Image from *Hydra for CNI Spring 2014 Meeting*, www.slideshare.net/Tom-Cramer/hydra-for-cni-spring-2014-33003596

Fig. 12 Yale Digital Collections Center Digital Ecosystem (http://ydc2.yale.edu/digital-ecosystem)

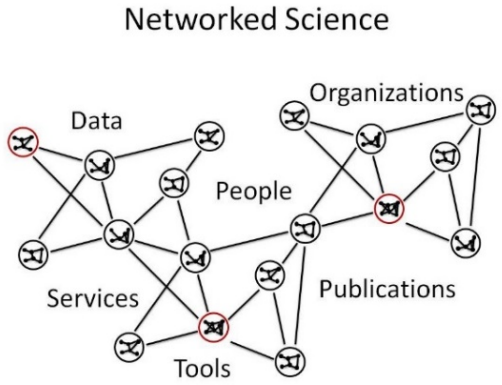
Digital ecosystem approaches like those coordinated by the Yale Digital Collections Center[58] are modeling institutional strategies for linking (not necessarily aggregating) distributed content in support of communities of practitioners and experts (Figure 12). Shared modular tools, platforms, policies and practices are essential in realizing and sustaining such ecosystems. Cross Collection Discovery (CCD)[59] provides a framework for Discover Yale Digital Content (DYDC) – a collaborative service allowing a single faceted search[60] and discovery of related content held by different campus units. The Open Access Initiative Protocol for Metadata Harvesting (OAI-PMH)[61] is used to harvest metadata from University departments and in turn made publicly accessible so specialized discovery services or "apps" can be built using that metadata.

These efforts at formatting, managing and sharing data and information resources at an institutional level in standardized and reliable ways are adding both immediate and longer term value to those. As in the case of DYDC, that includes making "machine

[56] https://en.wikipedia.org/wiki/Solution_stack
[57] https://wiki.duraspace.org/display/hydra/Hydra+Stack+-+The+Hierarchy+of+Promises
[58] http://ydc2.yale.edu/digital-ecosystem
[59] http://ydc2.yale.edu/projects/cross-collection-discovery
[60] Faceted search, navigation or browsing is a technique for accessing information organized according to a faceted classification system, allowing users to explore a collection of information by applying multiple filters. https://en.wikipedia.org/wiki/Faceted_search
[61] https://www.openarchives.org/OAI/openarchivesprotocol.html

readable"[62] data and/or metadata describing them more freely available. Efforts like these have already enabled libraries to collaborate in creating the world's largest bibliographic database, the Worldcat[63] "union catalog" linking the collections of 72,000 libraries in 170 countries and territories. This has in turn made those materials much more discoverable, sharable and accessible (e.g. via interlibrary loan).

Collaborative multi-institutional initiatives are also making digital resources more discoverable and accessible through shared (e.g. Hathi Trust[64]) and distributed (e.g. the Shared Access Research Ecosystem, or SHARE[65]) information stores. Sophisticated web-based research networking tools[66] like VIVO[67] and Profiles[68] are making it easier to discover these outputs as well as details about their creators and their scholarly activities. Many of these allow new forms of discovery and analysis (some even unforeseen by the original creators), including the generation of collaboration network maps and "maps of science" [see Appendix A for VIVO examples].



The EarthCollab project[69] is an initiative linking these systems to improve the discovery and sharing of information across disciplinary and geographic boundaries to advance networked science. The VIVO software suite is one tool being used by the project to create structured, interoperable data, permitting the interlinking of information and data across platforms and projects.

Fig. 13 – The EarthCollab project is linking a diversity of data and information about and in support of networked research projects and virtual organizations, across institutional and geographic boundaries.

To promote improved knowledge creation and sharing best practices like these, the Future of Research Communications and e-Scholarship, or FORCE11, has proposed a set of FAIR principles[70] to make data more **F**indable, **A**ccessible, **I**nteroperable, and **R**e-usable. Realizing this goal requires that both data and richly descriptive metadata about it be:

1) Assigned unique, persistent identifiers, e.g. DOIs[71],
2) Retrievable via standardized communications protocols, e.g. HTTP[72], from
3) Reliable, accessible and searchable resources/locations, e.g. Dataverse[73] and other institutional repositories.
4) That metadata use formal, shared language and vocabularies following FAIR principles, meeting domain-relevant community standards, with
5) Qualified references to other metadata (e.g. links to author ORCID registry records[74] via Open Researcher & Contributor IDs), and
6) Providing clear licensing and provenance information.

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[62] A structured format that can be read automatically by a web browser or computer system (e.g. xml). Traditional word processing and PDF documents are easily read by humans but typically difficult for machines to interpret. See www.data.gov/developers/blog/primer-machine-readability-online-documents-and-data
[63] www.worldcat.org
[64] www.hathitrust.org
[65] http://www.share-research.org/
[66] https://en.wikipedia.org/wiki/Comparison_of_research_networking_tools_and_research_profiling_systems
[67] Developed by Cornell University Library in collaboration with many partners across the globe, VIVO is used by over 100 organizations (including the USDA) to manage information related to researchers. http://vivoweb.org/
[68] http://profiles.catalyst.harvard.edu/
[69] https://www.earthcube.org/group/earthcollab
[70] https://www.force11.org/group/fairgroup/fairprinciples FORCE11 is a community of scholars, librarians, archivists, publishers and research funders that has arisen organically to help facilitate the change toward improved knowledge creation and sharing.
[71] Digital Object Identifier –see https://en.wikipedia.org/wiki/Digital_object_identifier
[72] https://en.wikipedia.org/wiki/Hypertext_Transfer_Protocol
[73] http://dataverse.org
[74] http://support.orcid.org/knowledgebase/articles/463380-overview-of-your-orcid-record

This work making data and information more easily found, reusable and connectable is helping realize the vision of a "semantic web[75]" the creator of the World Wide Web Tim Berners-Lee had in mind when he wrote:

> *The vision I have for the Web is about anything being potentially connected with anything...that provides us with new freedom...unfettered by the hierarchical classification systems into which we've bound ourselves.... bringing the workings of society closer to the workings of our minds.*
>
> *Tim Berners-Lee, in Weaving the Web: The Original Design and Ultimate Destiny of the World Wide Web by its inventor (Berners-Lee, 1999)*

A goal of those working to fulfill this vision is enabling the existing "web of documents" to become a "web of data". As the structure and interoperability of materials and their descriptions becomes more formalized, the lines between what most consider "data" and "information" (e.g. documents), or data and metadata (descriptive information about that data) are increasingly blurred. In some cases metadata itself may be a primary source for research activities like text mining[76].

From Figure 14, we can imagine how this evolution, from print to digital, from webs of documents to webs of data, from centralized to highly distributed, non-hierarchical networks, might now provide a kind of "networked platform" (light gray lines on far right) uniquely suited to support the emergence of self-organized health promoting actions and networks (black lines and nodes) spanning geographic and disciplinary divides.

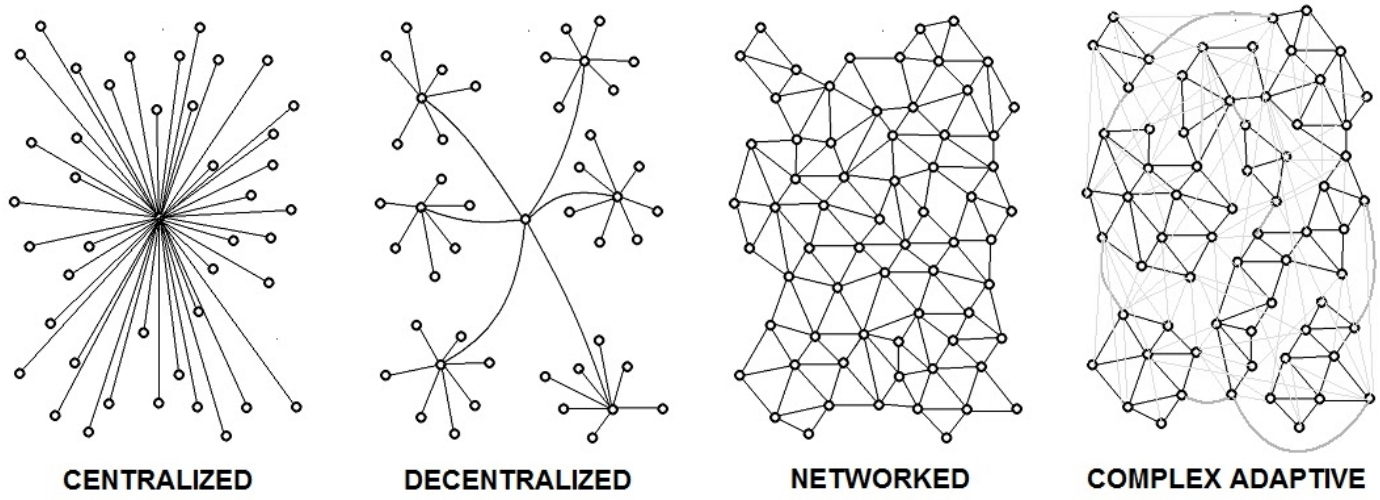


Fig. 14 Different kinds of networks, serving different kinds of needs. The semantic web could be considered a type of networked platform ideally suited to supporting the emergence of complex adaptive networks. (Image from http://thewisdomeconomy.blogspot.com/2011/08/opportunities-in-chaos.html)

Indeed the semantic web enables serendipitous discovery, emergent learning and self-organization in ways not possible in more closed, rigidly structured knowledge systems designed for consistency, control and "push" models of dissemination. Graph theory[77] helps explain how these pathways of discovery are enabled. It starts with the modeling of pairwise relations between entities or objects. "Objects" in this context represent what could also be called vertices, nodes, or points (things), which are connected by edges, arcs, or lines (relationships between things). A graph may be undirected, meaning that there is no distinction between the two vertices associated with each edge, or directed from one vertex to another (and potentially back again).

[75] "The Semantic Web is an extension of the current web in which information is given well-defined meaning, better enabling computers and people to work in cooperation." From World Wide Web Consortium (W3C): https://www.w3.org/RDF/Metalog/docs/sw-easy
[76] https://en.wikipedia.org/wiki/Text_mining
[77] https://en.wikipedia.org/wiki/Graph_theory

The image below (Figure 15) is a graph illustrating how people are connected to other entity types as modeled by the VIVO ontology and represented in associated data stores. Ontologies[78] formally name and categorize entities and their properties as well as their interrelationships within a particular domain of discourse. These codified relationships (and additional linked information in the form of controlled vocabularies or sets of rules), can be used in turn as a type of virtual bread crumbs, supporting what is called semantic reasoning or inference[79]. This allows the "discovery" (by people through user interfaces and via machine learning[80]) of new resources as well as relationships and connections between them. Note the linkage to a person's ORCID ID at the bottom center of image –this allows inferences to be made about that person based on information from their ORCID registry record maintained elsewhere.

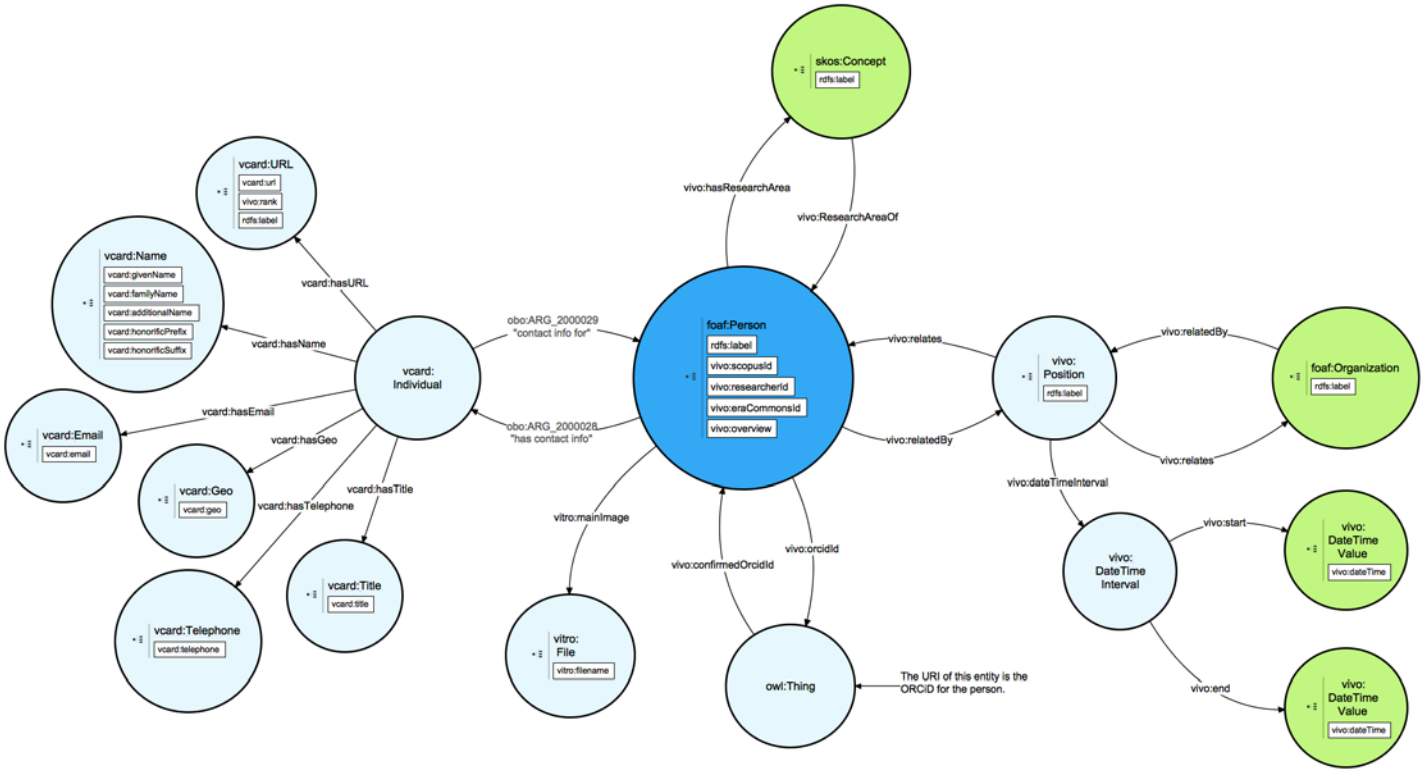


Fig. 15 **VIVO Ontology "Person Model"** from October 12, 2016 (Image from https://wiki.duraspace.org/display/VIVODOC19x/Person+Model)

Many institutions are now using VIVO and ontologies like this to support discovery of research expertise and outputs across institutional (e.g. Cornell[81] and USDA[82]) and international (e.g. AgriProfiles.net) boundaries. Structured and shared in this way, web accessible content and descriptive information about it can also be repurposed and linked into larger "knowledge graphs". A Knowledge Graph could be described most simply as a network of knowledge concepts and objects, sometimes focused on a specific domain or organization[83]. Google's Knowledge Graph[84] may be the most fully realized example.

[78] https://en.wikipedia.org/wiki/Ontology_(information_science)
[79] https://www.w3.org/standards/semanticweb/inference
[80] https://en.wikipedia.org/wiki/Machine_learning
[81] Including Cornell Cooperative Extension Associations: http://vivo.library.cornell.edu/organizations#http://vivoweb.org/ontology/cornell-cooperative-extension#CornellCooperativeExtensionAssociation
[82] https://vivo.usda.gov/
[83] This blog post (Blumauer, 2014) provides a nice overview of taxonomies, ontologies and knowledge graphs: https://blog.semantic-web.at/2014/07/15/from-taxonomies-over-ontologies-to-knowledge-graphs/
[84] https://en.wikipedia.org/wiki/Knowledge_Graph

A Google search for "Liberty Hyde Bailey" (one of the founding fathers of Cooperative Extension), reveals the practical value of this graph in the form of a "Knowledge Graph Card" (Figure 16) aggregating and displaying content and links from widely dispersed sources. One way Google identifies, ranks and links web content is through structured data "markup"[85] embedded within web page source code (e.g. HyperText Markup Language, or html), explicitly identifying things described on that page and their properties[86].

Fig. 16 **Google Knowledge Graph Card** returned as Google search results for "Liberty Hyde Bailey"

While the precise definitions of and strategies for realizing this web of data are varied, the underlying architecture supporting the Semantic Web is commonly represented as a stack of layers, each building on the one below. In Figure 17 below we see some of these illustrated, including ontologies. Note that the user interface and applications layer (e.g. Google search tools) built on top of this stack are dependent on all the others. The lower layers include elements of Linked Data[87], a method of structuring and sharing data so that it can be more easily located, understood, linked and queried by computers automatically. Linked Open Data (LOD) is Linked Data made freely available under an open license with no restrictions on its reuse. The DBpedia knowledge base[88] is one of the largest and most well-known examples of LOD, enabling sophisticated queries to be made against Wikipedia data, and the linking of other data sets on the Web to that.

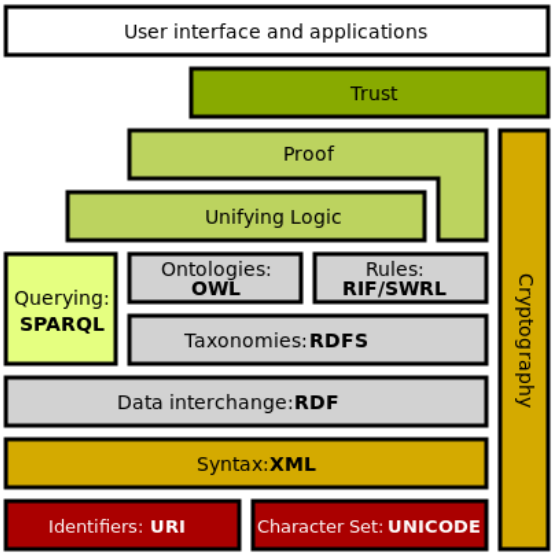


Fig. 17 **Semantic Web Stack,** from https://en.wikipedia.org/wiki/Semantic_Web_Stack

This stack also includes trust, in the source as well as the formal logic used for deriving new information. As a trustworthy source of research-based knowledge, Land Grant institutions and intermediaries like Cooperative Extension need to consider their role and value proposition within this semantic web stack. Implementing and scaling these efforts within Cooperative Extension and across the Land Grant system will require greater attention to and investment in systems and capabilities quite different than what has been required or expected in the past. That includes social competencies and governance structures supporting more effective collaboration across organizational boundaries, as well as technical capabilities facilitating the free flow of data, information and knowledge. Appendix B provides several case studies illustrating the need and context for these, within the Land Grant system and those it engages with.

[85] https://developers.google.com/search/docs/guides/intro-structured-data
[86] For example schema.org "microdata" tags -see http://schema.org/docs/gs.html
[87] https://www.w3.org/standards/semanticweb/data
[88] http://wiki.dbpedia.org/about

The World Wide Web Foundation has suggested[89] that data intermediaries can play a crucial role in translating complex data sets into formats more easily put to use by end-users, including Linked Open Data. Multiple intermediaries with "complementary configurations of capital" working together are more likely to be successful in connecting data providers and users (Figure 18).

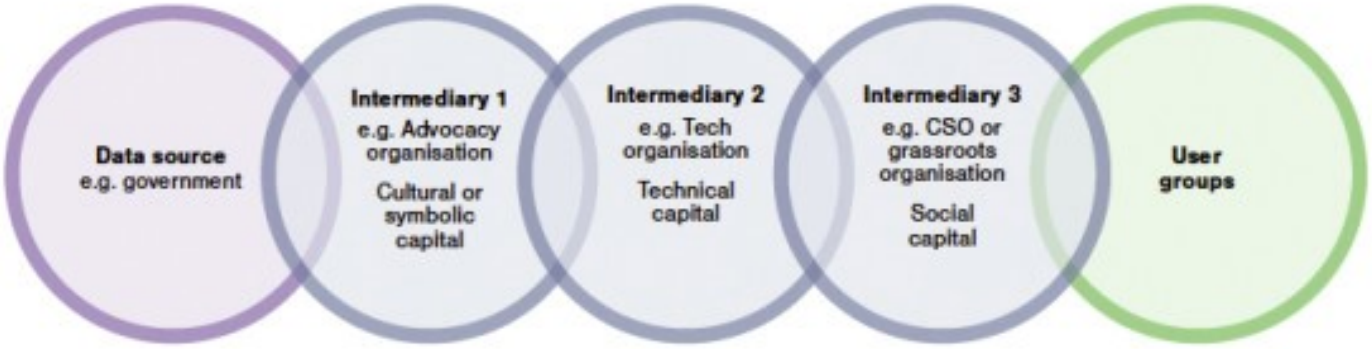


Fig. 18 **A model of data intermediaries connecting a data source with users** (from the World Wide Web Foundation, *Open Data Intermediaries: Their Crucial Role*, http://webfoundation.org/2015/08/open-data-intermediaries-their-crucial-role/)

Parallels can be found here with the community capitals and metabolic network frameworks referred to earlier. Indeed one of the primary modes of intervention for the WealthWorks community capitals development approach is the cultivation of mutually beneficial value chains. A WealthWorks value chain[90] is a coordinated network of people, businesses, organizations and agencies building, linking and leveraging their assets in support of both individual and common interests. Figure 19 below illustrates what that might look like for a vegetable soup value chain, and the role of the value chain coordinator.

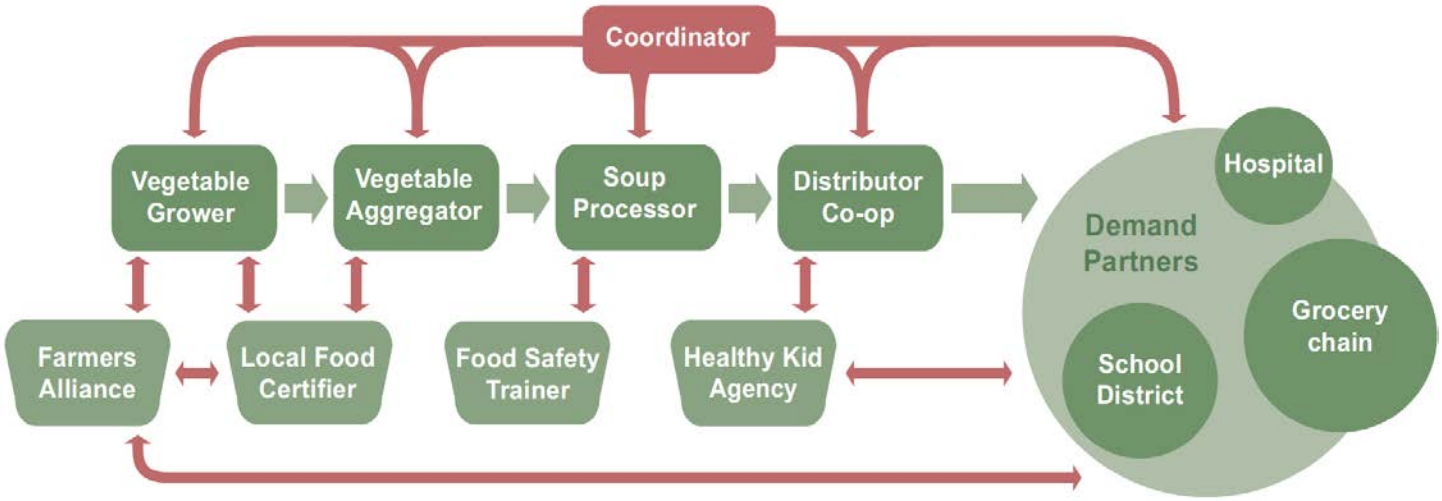


Fig. 19 **Diagram illustrasting what a WealthWorks tomato soup value chain might look like**, and role of the VC coordinators (from http://wealthworks.org/basics/construct-wealthworks-value-chain/wealthworks-value-chain-defining-characteristics, courtesy of the WealthWorks Initiative Partners and the Aspen Institute Community Strategies Group)

Many Cooperative Extension professionals already play similarly supportive roles within community and regional food systems work. They can also play a critical role in more generalized knowledge networks, like those described by Mark Lubell and his colleagues engaged in "Extension 3.0" work[91]. In their paper *Extension 3.0: Managing Agricultural Knowledge Systems in the Network Age* (Lubell, Niles, & Hoffman, 2014), they provide several recommendations, suggesting why and how...

[89] http://webfoundation.org/2015/08/open-data-intermediaries-their-crucial-role/
[90] http://wealthworks.org/basics/construct-wealthworks-value-chain/wealthworks-value-chain-defining-characteristics
[91] See the *Extension 3.0: Knowledge Networks for Sustainable Agriculture* project page at http://environmentalpolicy.ucdavis.edu/project/extension-30-knowledge-networks-sustainable-agriculture

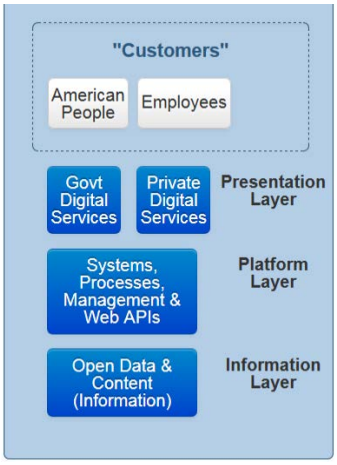
> ***agricultural extension should…capitalize on the networked structure of knowledge systems… strategically manag[ing those] to synergistically integrate*** *social, technical, and experiential learning pathways… highlight[ing] the importance of* ***networks of actors who cooperatively work together to deliver relevant knowledge to the right people at the right time and place****. Linking such knowledge to action…may enhance the sustainability and resilience of agro-ecological systems…*

Socio-Technical Systems Supporting Problem Solving & Collective Intelligence

Combining several of the constructs mentioned -networks, stacks, and value chains - one can envision information and communications infrastructure supporting such work as an evolving "functional stack" of networks, or value networks[92]. The entities within each strata linked horizontally with others having relatively similar data/information/knowledge assets and roles, and vertically with those having complementary needs and assets. Each layer in this stack would serve as a type of platform for the ones above, enabling them to "pull" data and information as needed to support emergent learning and innovation, while simultaneously providing feedback and insight to others in the same and underlying layers. Brought together these technologies and the "stacks" from which they are constructed can be seen as ecosystems, making data and information more available when, where and how it is most needed. [See Appendix B for a visualization of this]

In *Open government: collaboration, transparency, and participation in practice* (O'Reilly, 2010) technology thought leader Tim O'Reilly[93] suggests government not only has an opportunity but obligation to support such stacks, "on which we, the people, can build additional applications." He emphasizes that government should move away from trying to provide end user tools serving all needs for all users, shifting its focus instead toward more robust and open infrastructure and policies making public data and information not only more accessible but reusable. Echoing many of the themes and principles presented earlier, he suggests:

> *There is a new compact on the horizon: information produced by and on behalf of citizens is the lifeblood of the economy and the nation; government has a responsibility to treat that information as a national asset.* ***Citizens are connected like never before and have the skill sets and passion to solve problems affecting them locally as well as nationally. Government information and services can be provided to citizens where and when they need them. Citizens are empowered to spark the innovation that will result in an improved approach to governance.*** *In this model, government is a convener and an enabler rather than the first mover of civic action.*



The Obama administration embraced such a role through its Digital Government initiative[94]. Illustrated here in Figure 20 are the **three "layers" of digital services[95]** described by that:

- **Information Layer** -Includes structured information/data such as census data, plus unstructured information such as fact sheets and recommendations.
- **Platform Layer** -Includes all the systems and processes used to manage this information.
- **Presentation Layer** -The way information is organized and delivered digitally (e.g. interactive visualization tools).

Fig. 20 **Three layers of digital services,** from *Digital Government: Building a 21st Century Platform to Better Serve the American People*, accessible from Obama White House Archives, https://obamawhitehouse.archives.gov

[92] Moving beyond simple linear value chains, in value networks, "value is co-created by a combination of players in the network" (From Peppard & Rylander, 2006)
[93] Founder of O'Reilly Media who popularized the terms open source and Web 2.0.
[94] https://obamawhitehouse.archives.gov/sites/default/files/omb/egov/digital-government/digital-government.html
[95] Roughly corresponding to the producer, management and consumer entities of the Open Archival Information System (OAIS) Reference Model (https://public.ccsds.org/publications/RefModel.aspx).

Civic technologist Lorelei Kelly has suggested[96] that Land Grant institutions and libraries can play an important role as intermediaries, helping create ”an Information Age infrastructure that receives a broad scope of credible input from all stakeholders, synthesizes it and provides output that facilitates a comprehensive, common understanding of the issues so leaders can deliberate and develop sound public policy.” To do this she suggests new, more decentralized knowledge-gathering systems at the state level. Working closely with others, including citizens and local professional organizations, these “public interest curators” would support broader participation and representation in the public policy process.

Land Grant institutions, including libraries and information specialist networks such as USAIN[97] (U.S. Agricultural Information Network) and AgNIC[98] (Agriculture Network Information Collaborative) are indeed well positioned to help advocate for and support this kind of work in collaboration with Extension and related entities such as eXtension. Previous efforts offer potential lessons and insights to build upon, including an AgNIC led Library-Extension-Experiment Station Collaboration initiative in 2003[99], and more recently, a Land-Grant University Knowledge Discovery System Virtual Planning Workshop[100]. The latter was organized with the aim to “collaboratively develop a plan to build and strengthen openly accessible LGU digital repositories of key agriculture-related information, data, and resources that will be available for sharing and discovery for current and future generations.”

Such capacity building can provide benefits beyond enhancing discoverability and accessibility. In his recent paper *Data Science and Management for Large Scale Empirical Applications in Agricultural and Applied Economics Research* (Woodard, 2016), Cornell Faculty member Joshua Woodard illustrates how data intermediaries can reduce “massive duplication in efforts, inefficient data sourcing, and great potential for error”. In response he and his Cornell colleagues have developed a functioning prototype *Ag-Analytics* open data platform, aggregating and normalizing data from a wide variety of sources, making it more readily available and useful for researchers, policy makers and farmers alike, via several platform layer services (illustrated in Figure 21 below).

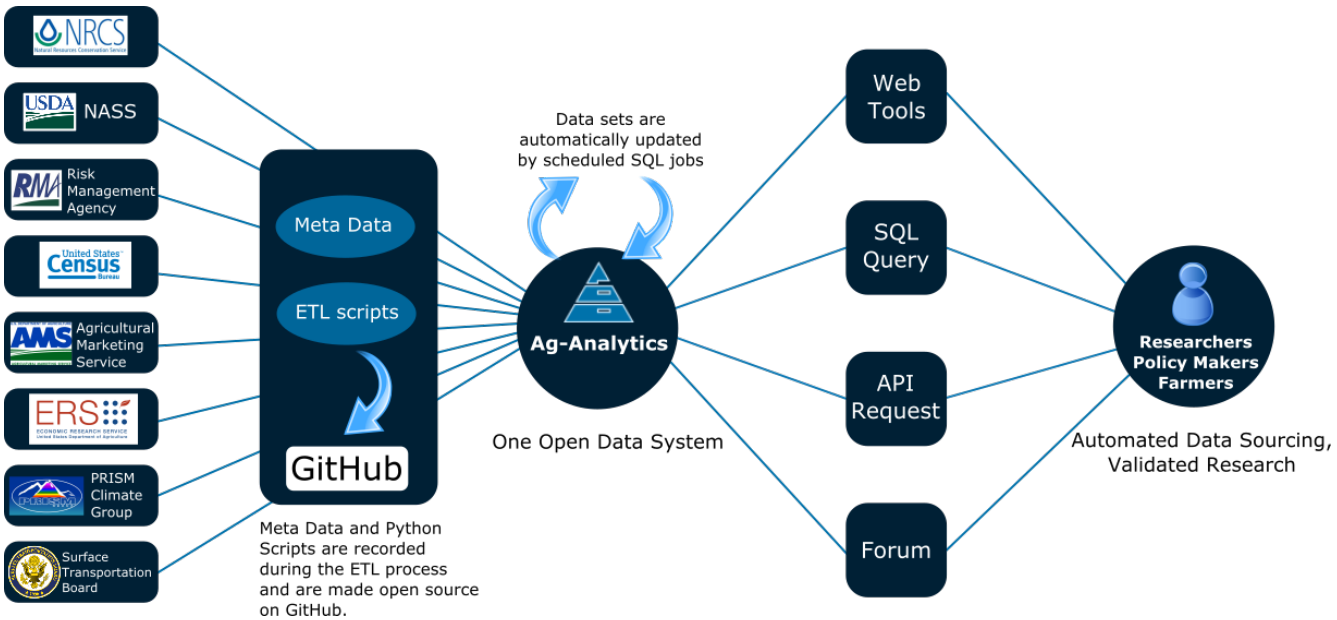


Fig. 21 **Analytics Conceptual Framework**, illustrating stack of technologies and services making a wide range of data sets more accessible/usable via various tools and services (from https://www.ag-analytics.org/AgRiskManagement/About)

[96] https://techcrunch.com/2016/10/23/the-banana-republic-of-big-data/
[97] http://usain.org/
[98] https://agnic.org/
[99] Documented here http://usain.org/library_extensioncollab/lib_extcollabindex.html
[100] http://cals.arizona.edu/agkds-workshop/

Yet effectively integrating this highly technical and increasingly distributed capacity building with locally developed and informed solutions still presents many challenges. Sociotechnical systems[101] (STS) approaches offer one potential framework for guiding such harmonization efforts. Insights related to STS were first popularized by Eric Trist and Ken Bamforth based on action research[102] with workers in English coal mines (Trist & Bamforth, 1951). Though the concept has evolved and sometimes diverged since then, a key focus remains "joint optimization", where both social and technical subsystems are optimized to support organizational performance and worker well-being, without sacrificing one for the other. That often includes promoting group cohesion and what Trist and Bamforth called *responsible autonomy*, the capacity of groups for self-regulation and innovation. This socio-technical approach may prove useful in finding ways to better optimize the social and technical systems and tools Cooperative Extension interact with and use in their work, including support for civic agriculture and similar community and values-based food systems work.

Another historical body of work relevant to sociotechnical approaches t0 problem solving and eXtension's new Issue Corps[103] focus is that of Horst Rittel and Werner Kunz. To support community and political decision-making, and the social "argumentative process" viewed as critical for better understanding wicked problems, they introduced the concept of Issue-Based Information Systems (IBIS) in their paper *Issues as Elements of Information Systems* (Kunz & Rittel, 1970). IBIS is described as:

> *a type of information system meant to support the work of cooperatives like governmental or administrative agencies or committees, planning groups, etc., that are confronted with a problem complex in order to arrive at a plan for decision...**IBIS guides the identification, structuring, and settling of issues raised by problem-solving groups, and provides information pertinent to the discourse**. It is linked to conventional documentation systems but also activates other sources. Elements of the system are topics, issues, questions of fact, positions, arguments, and model problems.*

IBIS are based on the belief that complex problems require meaningful conversations amongst all stakeholders, who bring their respective expertise (including implicit or tacit knowledge) and viewpoints to the resolution of those issues[104]. One way IBIS structures this is through a process called dialogue mapping. Issues and problem solving processes related to those are captured through specialized IBIS facilitation and notation, eliciting and documenting:

- Issues or questions, typically framed as something like "What should we do about X?"
- Ideas, on how to respond to those issues, represents the range of perspectives on the issue.
- Arguments, for or against each of those suggested ideas, again representing the full range of viewpoints.

Each of these elements can lead to further questions, requiring additional information to be gathered in order to answer them.

Though IBIS was introduced before the arrival of modern computing systems, the manner in which the argumentation process is structured and mapped as a graph makes it very conducive for that environment. In fact a variety of computer assisted and often web based tools supporting this kind of sensemaking[105] have been

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[101] https://en.wikipedia.org/wiki/Sociotechnical_system
[102] "A reflective process of progressive problem solving led by individuals working with others in teams or as part of a "community of practice" to improve the way they address issues and solve problems." https://en.wikipedia.org/wiki/Action_research
[103] https://extension.org/what-is-an-extension-issue-corps/
[104] Similar to social constructivism views of knowledge creation mentioned earlier.
[105] Sensemaking is an active two-way process of fitting data into a frame (mental model) and fitting a frame around the data. (http://en.wikipedia.org/wiki/Sensemaking)

developed by others since then[106]. Figure 22 shows how one IBIS software tool, Compendium[107], has been used to illustrate elements of the IBIS dialogue mapping process itself.

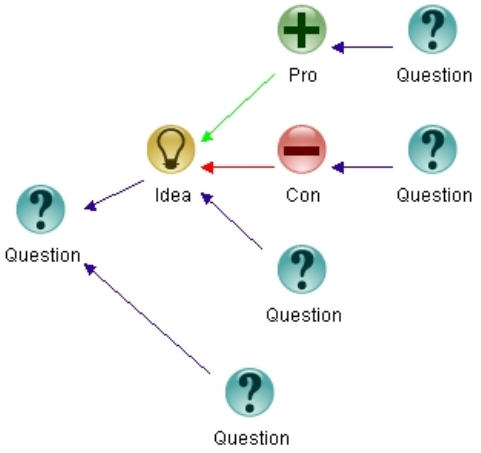

Fig. 22 **Elements of a Issue-Based Information System (IBIS)**. From http://eight2late.wordpress.com/2014/11/24/from-information-to-knowledge-the-what-and-whence-of-issue-based-information-systems/, courtesy of Kailash Awati and Eight to Late

Sophisticated tools and associated data stores like this enable the hyperlinking, literally and figuratively, of issues and associated elements (including information resources) across diverse communities. Some are exploring ways these types of sensemaking processes can be supported and linked globally via semantic web approaches. That includes the development and use of new ontologies, such as those based on the Argument Interchange Format[108] specification supporting a "World Wide Argument Web" (Schneider, Groza, & Passant, 2013). This evolution of "graph databases", able to encode and transmit the content of conversations as well as the context, inputs and outcomes of those, offers interesting avenues of opportunity for developing networked data stores and platforms supporting healthy, adaptive food systems and communities.

Yet the dialogue mapping process can be challenging even with these new tools. Issues, ideas and arguments must be teased out and linked to each other and the existing, continually evolving map, often in real time. Skilled facilitation is needed, someone who is able to translate the groups deliberations using the IBIS grammar, while "holding the space" in a way which allows people to collectively focus on and explore different perspectives on the problem[109].

Though not often framed in these terms, the need for such sociotechnical problem solving capabilities is being identified by a growing number of researchers, practitioners, learning communities and networks working across agrifood system disciplines and sectors, including eXtension Communities of Practice/Learning Networks[110] (many directly or indirectly focused on agriculture, food, or health). Innovative network-centric knowledge management practices such as *Extension 3.0* knowledge networks for sustainable agriculture, and farmer research networks (Figure 23) are emphasizing the need for making data and information, including the insights of peers, more readily findable and usable when, where and how they are most needed through the effective (and appropriate) leveraging of networked information and communications technology (ICT).

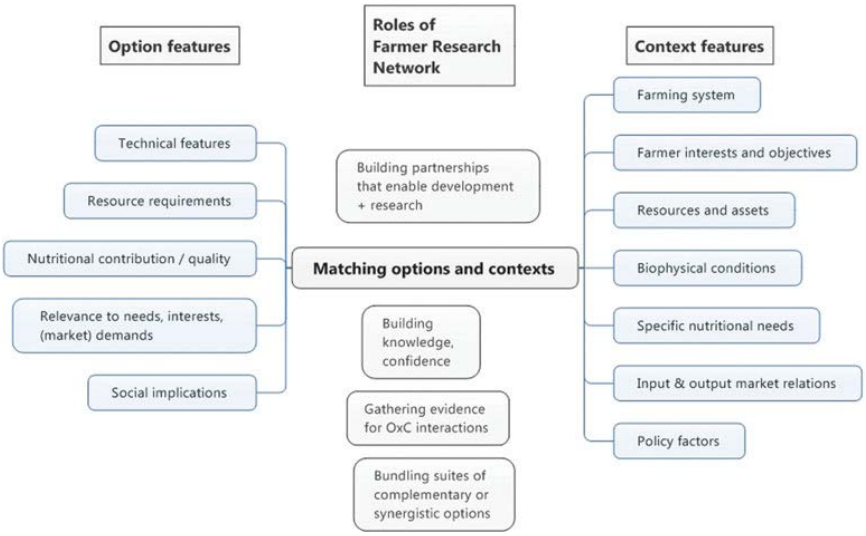

Fig. 23 Functions of a farmer research network (FRN) An FRN should be built on partnerships that effectively match the features of social and technical innovations (types and characteristics of "options" as indicated at left) with the features of farmers' contexts (types and characteristics of farms and farmers and their environment as indicated at right). From *Farmer Research Networks as a Strategy for Matching Diverse Options and Contexts in Smallholder Agriculture* (Nelson, Coe, & Haussmann, 2016).

[106] This blog post provides a very useful overview of IBIS: http://eight2late.wordpress.com/2014/11/24/from-information-to-knowledge-the-what-and-whence-of-issue-based-information-systems/
[107] http://compendium.open.ac.uk/institute/
[108] "The Argument Interchange Format (AIF) has been devised in order to support the interchange of ideas and data between different projects and applications in the area of computational argumentation" (Bex, Modgil, Prakken, & Reed, 2013).
[109] For an expanded description, see http://www.cleverworkarounds.com/2009/09/10/the-practice-of-dialogue-mapping-part-1/
[110] http://articles.extension.org/main/communities

The authors of the above paper go on to explain how such networks can be part of a larger shift away from agrifood systems optimized for simplicity (reliant on monocultures grown in environments homogenized through the use of energy, irrigation, fertilizer and pesticide inputs) toward agroecological systems optimized for complexity (in terms of the number and diversity of components, and their context specific applications and interactions over time and space). To support this "post-modern" transition from cheap energy inputs to cheap information inputs[111], investment in social and communications innovation infrastructure is recommended. That includes systems supporting integrated data collection, aggregation, analysis, interpretation and communication which are easy to use by farmers, Extension and other ICT non-specialists. It's emphasized that Extension workers must change their approach to better facilitate this work, facilitating active research and learning in the field rather than just providing prescriptive answers.

Episode 3 of the GODAN Documentary Web Series, titled OPEN FARMS[112], showcases how open data technologies and Internet of Things[113] (IoT) strategies (e.g. low cost, networked sensors) can be part of a sociotechnical approach transforming modern farms into research farms by leveraging open-source tools (a Drupal farm management solution called FarmOS[114] in this case). These efforts relate to several priorities identified in the recent eXtension initiated Horizon Report for Cooperative Extension (Freeman, Adams Becker, & Cummins, 2016), including Citizen Science and IoT. Such topics are also the focus of at least two eXtension CoPs and *Journal of Extension* article (Hill & Hino, 2016) by two other recent eXtension fellows.

Another priority of the Horizon Report and past and current eXtension Fellows[115] is "big data", which increasingly prevalent IoT devices and networked data collection systems are contributing to. An additional sensemaking strategy worth considering, these extremely large data sets can be analyzed computationally to reveal patterns and trends (including health related ones) not readily visible to humans or traditional data processing applications. GODAN/eXtension Fellow Justin Smith is developing one such approach, a prototype "Unified Knowledge Translation Framework" for integrating interdisciplinary research and scholarly activity related to climate resilience and food security. This represents a first step toward realizing a semi-automated system that can organize and link relevant information from diverse domains of knowledge, institutions, and other sources for use by Cooperative Extension and its partners. USDA's National Institute of Food and Agriculture (NIFA) is using tools like Lingo4G (https://carrotsearch.com/lingo4g/) and PushGraph (http://chalklabs.com/?page_id=865) to identify patterns and trends in its own Current Research Information System (CRIS)[116] data, helping surface emerging priorities including food systems related ones.

Tools and systems like this are also being employed as a way to identify, aggregate and scale local insights and innovations in support of "Collective Intelligence"[117] responses to larger scale wicked problems. In their paper *Solving Wicked Social Problems with Socio-computational Systems* (Introne, Laubacher, Olson, & Malone, 2013), Joshua Introne and his colleagues describe one such effort, Climate CoLab[118], as

> *representative of a general approach to melding human intelligence and social technology to solve wicked social problems. It is a sociotechnical system writ large, that leverages not only the intelligence of thousands of community members, but also the knowledge and capabilities of many pre-existing human systems. The platform itself is merely a nexus in which we hope our vast potential collective intelligence may be applied to solve the problem of climate change.*

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111 See also this Center for Investigative Reporting post: http://cironline.org/blog/post/are-we-ready-post-modern-farming-4037
112 http://www.godan.info/news/open-farms-godan-documentary-web-series-episode-3
113 The Internet of things (IoT) is the inter-networking of physical devices, buildings and other items embedded with electronics, software, sensors, actuators, and network connectivity that enable these to collect and exchange data (From https://en.wikipedia.org/wiki/Internet_of_things)
114 http://farmos.org/
115 https://extension.org/innovation-lab/2016-extension-fellows/
116 http://cris.nifa.usda.gov/
117 https://en.wikipedia.org/wiki/Collective_intelligence
118 http://climatecolab.org/

Work of this nature can draw from the same insights and biological models informing complexity science. Relevant to the work of Extension: a mechanism of indirect coordination supporting the emergence of complex structures without the need for central planning or even direct communication between agents, called stimergy[119]. "Trace" left in the environment informs subsequent actions by the same and other agents, reinforcing and building on each other over time. One example are the pheromone-marked trails ants leave, in a sense supporting networked discovery and access to resources for other ants. The basic ability to both leave and detect such trace, and to adjust one's own behavior in response to that, can lead to elaborate structures such as termite mounds. In some ways, this type of adaptive behavior is similar to the process of Working Out Loud mentioned earlier in this paper, "making your work visible in such a way that it might help others".

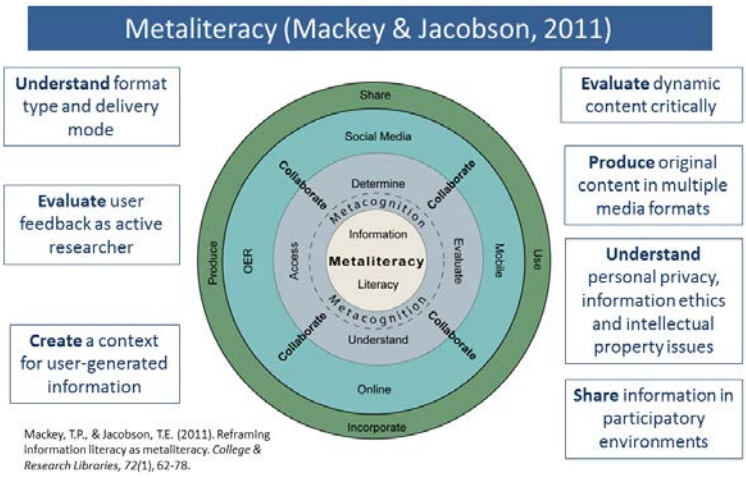

Fig. 24 **Metaliteracy** -From http://metaliteracy.cdlprojects.com/what.htm

Some[120] recognize similarities between this type of distributed but highly efficient sensemaking in the natural world and the role modern databases, wikis, and social media sites can play in supporting collaborative knowledge creation and sharing, as a type of "stigmergic landscape". From a sociotechnical systems perspective these principles have relevance to the design of knowledge systems used by Extension educators and other resource constrained agents. Capabilities like metaliteracy[121] (Figure 24), can help them more effectively and collaboratively identify and contribute "digital trace" in such environments, furthering individual and collective goals simultaneously.

Following up on several earlier points, one valuable element of that digital trace is context. Contextual information makes it easier for Extension professionals and others engaged in development work to identify research and replicable evidence-based models most relevant to their own programming needs and context. Traditional systematic reviews approach this through literature searches that collect and analyze multiple research studies or papers. Yet it can be difficult to search by and identify context from these in a consistent and reliable way, even when using modern search tools. "Grey literature"[122] (project reports, etc.) produced outside of formal publishing channels can be even more problematic, yet materials like these can help identify sources of valuable but difficult to translate tacit and embedded knowledge (as opposed to explicit knowledge encoded within research literature[123]). The Bronfenbrenner Center for Translational Research (BCTR) Systematic Translational Review (STR) process[124] is a hybrid model combining a traditional systematic review with the inclusion of practitioner input for the translation of evidence to an applied practice question.

In their article *Cultivating Capability: the socio-technical challenges of integrating approaches to records and knowledge management* (Jones & Vines, 2016) Michael Jones and Richard Vines describe knowledge management efforts in Australia specifically seeking to capture context. They outline challenges faced by the agricultural section within the Victorian Government's Department of Economic Development, Jobs, Transport

[119] https://en.wikipedia.org/wiki/Stigmergy
[120] For example: http://www.evolutionofcomputing.org/Multicellular/StigmergyInComputing.html
[121] Metaliteracy, a major influence on the new Association of College and Research Libraries (ACRL) Framework for Information Literacy for Higher Education (ACRL-ALA, 2015), "expands the scope of traditional information skills (determine, access, locate, understand, produce, and use information) to include the collaborative production and sharing of information in participatory digital environments." (Mackey & Jacobson, 2014)
[122] https://en.wikipedia.org/wiki/Grey_literature
[123] This article provides a basic overview of the knowledge types: http://www.knowledge-management-tools.net/different-types-of-knowledge.html
[124] https://www.bctr.cornell.edu/resources/systematic-translational-reviews/

and Resources (DEDJTR) in complying with information management policies at state and national levels, while meeting the needs of various audiences. Compounding those difficulties are the absence of a present-day Extension system[125], and highly distributed nature of content creation, storage and dissemination. They state:

> *the skills needed to address these challenges are both specific and complex. It is our contention here that the capabilities required for knowledge curation work of this type are socio-technical (requiring more than just the introduction of a new tool) and are more akin to those found in information management professions – archival science, librarianship, metadata management and records management – than those usually found or expected in organisations where these professions and their functions are not perceived to be "corebusiness".*

Informed by findings from several previous action research projects including collaborations with eXtension, (partly documented in Vines, Jones, & McCarthy, 2015), two technology components were developed to help address these issues:

- EMMA (Enhanced Metadata Management Application), a custom-built backend database with an interconnected metadata registry and metadata repository; and a
- KCT (knowledge curation tool), a series of user interfaces for the capture and curation of metadata for storage in EMMA, including information supporting locating and retrieving materials.

The successful introduction of these tools into what is referred to as the Department's "infrastructure stack" in support of "contextual information networks" relies upon highly skilled input of well-structured, standards-based metadata[126] describing information resources and their context. One larger goal is the creation of overlapping personal and public knowledge spaces by working within "complex adaptive systems where knowledge creation results from the co-existence and co-evolution of both top-down and bottom-up processes". Six general levels of capability are suggested as necessary to support the collections curation and management process and "knowledge curation culture" more broadly[127].

Enhancing capabilities for sharing data, information and knowledge can have transformative effects on a variety of complex systems and sectors that produce goods and provide services, including health related ones. In their article *If we only knew what we know: principles for knowledge sharing across people, practices, and platforms*, (Dearing, Greene, Stewart, & Williams, 2011) James Dearing and his colleagues describe a collective intelligence approach related to healthcare. Drawing on the Cancer Research Network as an example, they outline "how a loosely structured consortium of healthcare delivery organizations could create and grow an implementation registry to foster innovation and implementation success by communicating what works, how, and which practitioners are using each innovation." This registry would help identify and capture knowledge in existing communities of practice, enabling the sharing of that knowledge within those and between other CoPs across trans-institutional networks. It would also facilitate the sharing of practitioner insights and innovations with researchers.

Potentially drawing on many of the tools and strategies mentioned earlier, including IBIS and research networking tools like VIVO, such a registry could have great practical value in supporting and linking a broad

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[125] For a historical overview, see *The Many Turnings of Agricultural Extension in Australia* by Hunt et al., (2012). The authors frame historical changes in terms of four reoccurring cyclical "turnings" perhaps relevant to current conditions in the U.S. and globally. Unravelling, a downcast period of weakening institutions as older orders decay, is followed by Crisis, a decisive period of upheaval, where a sense of urgency drives deep institutional transition followed by new Highs and Awakenings.

[126] Two standards were brought together: 1) The Australian Government Locator Service (AGLS) metadata standard, used to capture information about resources themselves; and 2) International Standard Archival Authority Record for Corporate Bodies, Persons and Families (ISAAR(CPF)), to encode information about entities associated with those resources (e.g. creators, strategies, programs, projects, places, events and other concepts) and the complex networks of relationships that exist between them and resources.

[127] This author had the opportunity to learn more about these efforts and the importance of associated technology socialization processes firsthand while hosted by DEDJTR as a Visiting Fellow in the Spring of 2016, as well as co-present with Vines at the 2016 National eXtension Conference.

range of practitioners, including eXtension's CoPs and Learning Networks. There is particular relevance to eXtension's Issue Corps, where many of the teams working on complex problems like food security in their own communities would greatly benefit from the sharing of knowledge of "what works" across geographic and disciplinary divides.

Informed by a similar body of inquiry[128] Dearing and his colleagues drew from, the new science of "Learning Health Systems" (LHS) (Friedman et al., 2014) represents a more recent formalized effort seeking to promote health through a coordinated sociotechnical systems approach. A key LHS strategy is developing new collaborative infrastructure able to support the rapid generation and sharing of knowledge, informed decision making, and transdisciplinary, cross-sector work. Creating better connections between research or "afferent" processes (blue arrows in Figures 25 & 26 below) and practice or efferent processes (in red) is critical. That includes addressing an overreliance on journal articles (often inaccessible to practitioners) as a means of research dissemination (step 4 in Fig. 26), which can result in many years if not decades of latency before research-based learning makes its way into practice[129]. To realize these goals, **Learning Health Systems seek to marry people, technology, process and policy in developing and maintaining "socio-technical platforms", making a broad range of data and information available in support of virtuous learning cycles supporting health and well-being.**

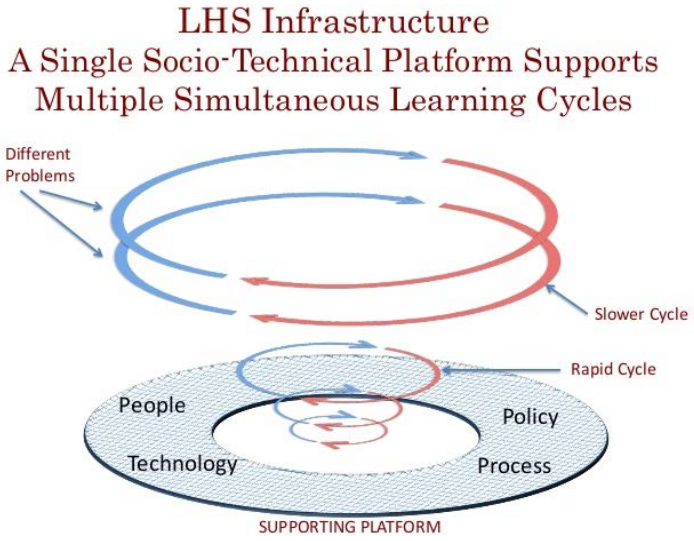

Fig. 25, Learning Health System infrastructure, from www.slideshare.net/learninghealthsciences/learning-health-system-briefing

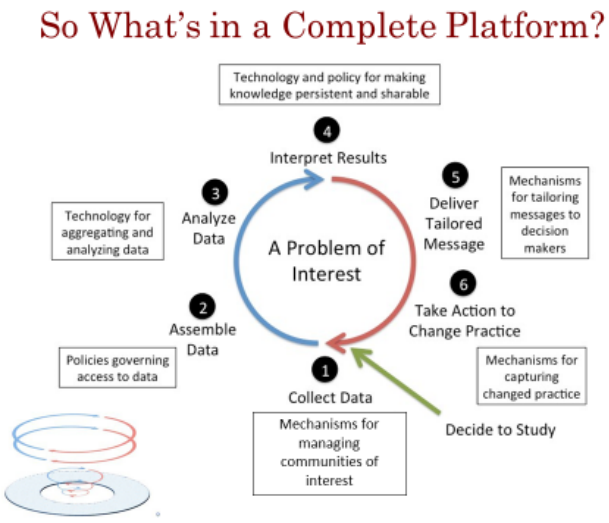

Fig. 26, From www.slideshare.net/learninghealthsciences/realizing-a-learning-health-system-a-vision-for-education-to-transform-the-future-of-health

Combined with complementary efforts like Extension 3.0 and other network-centric strategies shared in this paper, work like this **promoting and advancing sociotechnical platforms and capabilities, supporting "systems which learn", continuously, offers a compelling model for reimagining the Land Grant system as a whole in a more modern and responsive light**. The recommendations below suggest initial approaches and actions steps for implementing and scaling these ideas in support of agrifood systems learning and innovation. More importantly, it's hoped that this report will stimulate further thinking and collaborative action, perhaps linking and scaling up efforts already underway.

[128] Including the concept of a continuously *Learning Health System* (LHS). First expressed by the Institute of Medicine in 2007 (Institute of Medicine, 2007) and catalyzed by a 15-volume Learning Health System Series published by the National Academies Press, is now being rapidly adopted across the country and the world.

[129] http://www.learninghealthcareproject.org/section/evidence/41/50/professor-charles-friedman-interview

Recommendations

A coordinated multi-institutional effort is recommended, transforming Land Grant data, information and knowledge systems into a networked, multilayered sociotechnical platform or knowledge graph "optimized for health", making a broad range of resources and expertise more readily available when, where and how they are needed in support of healthy and resilient people, communities and food systems. FAIR data principles, maximizing Findability, Accessibility, Interoperability and Reusability should help guide these efforts. Attention should also be paid to issues of reliability (e.g. trustworthy resources with clear provenance, as well as technically reliable), sustainability (including socio-culturally, financially, and administratively), and privacy[130].

Drawing on applied fields such as social and community informatics, participatory approaches[131] engaging stakeholders in the iterative design, implementation and assessment of these interventions is recommended, supporting "learning in communities" (Carroll & Bishop, 2006). Such methodologies are needed to develop networked (Nelson, Coe, & Haussmann, 2016; Blay-Palmer, Sonnino, & Custot, 2016; Lubell, Niles, & Hoffman, 2014), resilient[132] knowledge systems many are suggesting as necessary for realizing sustainable, secure, just and self-determined agrifood systems (Colasanti, Wright, & Reau, 2009) while enhancing related resilience assets like social capital through participatory research methods (Tritz, 2014; Warner, Hinrichs, Schneyer & Joyce, 1998).

Aside from the nontrivial but not insurmountable technical challenges, the **success of these efforts will ultimately depend on cultivating and socializing, broadly:**

1) **A systems-oriented definition of health**, including agrifood systems health, based on an understanding of complex adaptive systems and related emerging transdisciplinary frameworks like the Meikirch Model and One Health initiative.
2) **A shared understanding of and ability to effectively leverage information and communications tools and systems**, including through transdisciplinary approaches like Learning Health Systems. Acknowledging cautionary notes[133] related to concerns around inclusion, ensuring equitable (not just equal or open) access and contribution to the knowledge commons (Hess & Ostrom, 2007) created through these approaches is also essential.
3) **Trust and mutual understanding** between Land Grant personnel and those they serve.

Action Steps

The following represent a range of action steps which might be taken at and across various scales, from individual programs/projects, institutions, and communities, to regions, states, the nation and globally. In keeping with the emergent, graph-oriented approaches suggested in this paper, ideally these would build on and connect existing efforts and assets as much as possible. Doing this work "Out Loud", making it accessible and reusable to others, will be critical to the collective impact and success of these efforts.

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[130] Including those voiced in the Mauritius Declaration on Internet of Things (ICDPPC, 2014a), Mauritius Resolution on Big Data (ICDPPC, 2014b) and Mauritius Resolution on Privacy in the Digital Age (ICDPPC, 2014c)

[131] Including participatory design (https://en.wikipedia.org/wiki/Participatory_design, http://publicsphereproject.org/content/participatory-design)

[132] See Anderson, M.D., (2015). Anderson argues that "forms of knowledge generation, transmission and access must be participatory, multi-actor, iterative and transparent in order to build food security resilience." To support this, she advocates for greater public investment in public food system knowledge, and open access/open source dissemination platforms.

[133] In a Special Section Commentary (Naumova, 2014) responding to Bircher & Kuruvilla's article (2014), the author expresses concerns about an emphasis in the Meikirch Model of Health on personal responsibility for using one's own "biologically given and personally acquired potentials" to realize a healthy standard of living. A greater emphasis on the groups and organizations accountable for providing common goods and reinforcing health and environmental policies is suggested.

Assessment

Conduct state and national surveys to assess/map current:

- **Definitions**, terminology and mental models of "healthy" people, food systems, communities[134]
- **Current areas of food systems research & practice** (connected to creation of Land Grant directory –see below)
- **Sociotechnical capabilities** and gaps (including those related to metaliteracy)
- **Social and professional network connectivity** (including Social Network Analysis[135])
- **Agrifood data and information needs and assets**, including community based ones

Competency Development

A concerted and coordinated effort **cultivating a broad set of interrelated sociotechnical capabilities** is suggested, potentially using eXtension's Competency Based Education tools[136] (ideally linked to each other, and existing frameworks such as Working Out Loud[137] and Climate Literacy[138]). These include:

- **Health Literacy[139]**, understanding all the dimensions and determinants of health, including economic, cultural and environmental ones.
    - **Agrifood Systems Health Literacy**[140]
- **Complex Systems** thinking[141], literacy and leadership[142]
- **Network Literacy & Leadership** competencies, applicable to a variety of emergent community and regional processes, including agrifood systems capacity building, network-centric program evaluation tools and approaches[143]
- Fostering **Civil Dialogue**, including
    - **Issue-Based Information System competencies**, e.g. dialogue mapping
- **Metaliteracy**, including an ability to harness the transformative potential of information and communications systems like IBIS in realizing healthy food systems goals

Best Practices

Much can be accomplished simply through best practices facilitating greater discovery, access and linking of materials across distributed networks/knowledge graphs, including:

- **Deposit materials in FAIR[144] compliant repositories** including LGU institutional repositories which...
- **Adopt/use shared vocabularies**, taxonomies and ontologies (e.g. GACS, the Global Agricultural Concept Scheme, http://agrisemantics.org/gacs/) to describe content, as well as...
- **Richly descriptive metadata** capturing details about the content and the context of its creation
- **Registration with ORCID** or similar persistent digital identifier registry, linking authors/contributors to metadata records for above
- **Add machine readable (e.g. microdata) tags** to web content, making that more easily found, and potentially linked via semantic reasoning

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[134] Perhaps building on similar work like this: http://environmentalpolicy.ucdavis.edu/briefs/mental-models-sustainable-agriculture
[135] See www.orgnet.com/sna.html and Bartholomay, Chazdon, Marczak, & Walker (2011)
[136] https://extension.org/tools-for-extension-professionals/competency-based-education/
[137] http://eduworks.com/cfd/wol-facillitator/
[138] http://eduworks.com/cfd/climate-learning-network/
[139] A recommendation of the ECOP Framework for Health and Wellness (Braun et al., 2014)
[140] Ideally this would link to complementary efforts like a Food Systems Certification program under development through a partnership between the eXtension Community, Local and Regional Food Systems CoP and NAFSN (http://foodsystemsnetwork.org/)
[141] Also a recommendation from the Technology Outlook for Cooperative Extension 2016-2021 Horizon Report (Freeman, Adams Becker, & Cummins, 2016)
[142] https://ssir.org/articles/entry/the_dawn_of_system_leadership
[143] For example, Grudinschi et al. (2015), https://core.human.cornell.edu/research/systems/netway.cfm, http://wenger-trayner.com/resources/publications/strategic-evaluation-of-network-activities/
[144] www.force11.org/fairprinciples

Collaborative Actions

Recommended larger scale, longer term actions, including the development of shared services and infrastructure supporting informed, collaborative decision making:

- **Ongoing *Land Grant Informatics* webinar series** allowing others to share their work and ideas related to this area of inquiry and practice, potentially catalyzing new collaborations
- **Federated directory of Extension and other Land Grant personnel**, leveraging VIVO and other research network tools, potentially including CTSAsearch, a federated expertise discovery search engine using Linked Open Data (http://research.icts.uiowa.edu/polyglot/)
- **Establish formal network of Land Grant data and information repositories** optimized to support a foundational Land Grant knowledge graph (working with APLU, ECOP, GODAN, USDA, USAIN, AgNIC, and eXtension). Potentially working with SHARE[145], COAR[146] and Google
- **Specialized "middleware" tools** like KCT/EMMA (Jones & Vines, 2016) enabling eXtension CoPs and other LG communities of inquiry and practice to contribute, curate and track content in those repositories
- **Shared vocabularies, taxonomies and ontologies**[147] enabling consistent tagging, discovery, access and repurposing of materials across distributed platforms
- **New Agrifood Systems schema.org extension**[148]
- **Convene a national summit**[149] to explore this work in more detail, perhaps leading to...
- **Pilot projects or other collaborations** exploring ideas presented here, potentially including development and/or application of:
    - **An eXtension Issue Corps "implementation registry",** in coordination with IBIS and other capacity building efforts described above, potentially including...
    - **Further development/implementation of open source designVUE tool** (http://www3.imperial.ac.uk/designengineering/tools/designvue-1) for dialogue mapping/IBIS integration, which is able to seamlessly connect with the larger Land Grant Knowledge Graph
    - **Other front end tools/interfaces** making data and information more accessible and usable in support of community problem solving, potentially including
        - Enhanced eXtension Cooperative Extension Search tool (https://search.extension.org/)
        - Community Platforms (http://communityplatform.us/) or similar tools linked to Open Referral and LG formatted/managed data and information (e.g. via API[150])
    - **Agrifood systems data collection systems**, platforms (e.g. FarmOS), exchange protocols and open standards via Internet of Things (IoT) devices/sensors and sensor networks[151].
    - **New "digital knowledge object" and knowledge cluster constructs** (used in Learning Health Systems[152]) able to carry computable representations of agrifood systems knowledge, supporting discovery and (re)use across the agrifood systems research-learning-outreach continuum and beyond.
    - **Big data approaches** (e.g. machine learning and natural language processing) for generating additional value/intelligence from data and information brought together through these efforts.

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[145] SHared Access Research Ecosystem (http://www.share-research.org), building a free, open, data set by gathering, cleaning, linking, and enhancing metadata that describes research activities and outputs from distributed repositories

[146] Confederation of Open Access Repositories (www.coar-repositories.org), including Aligning Repository Networks committee (www.coar-repositories.org/activities/advocacy-leadership/aligning-repository-networks-across-regions/) and Next Generation Repositories Working Group (www.coar-repositories.org/activities/advocacy-leadership/working-group-next-generation-repositories/)

[147] Potentially mapped to NIFA Knowledge Areas (https://nifa.usda.gov/resource/crosswalk-nifa-knowledge-area-classification-five-nifa-priority-areas), leveraging efforts like Global Agricultural Concept Scheme (GACS): http://agrisemantics.org/gacs/, and the International Conference for Food Ontology, Operability, Data & Semantics (IC-FOODS): http://www.ic-foods.org)

[148] See http://schema.org/docs/extension.html. Potentially linked to other extensions, including Health-Life Sciences (http://health-lifesci.schema.org/) and external ones like GS1 (http://gs1.org/voc/)

[149] Perhaps part of national workshop recommended in Healthy Food Systems, Healthy People implementation plan (APLU, 2016b)

[150] Application Programming Interface, https://en.wikipedia.org/wiki/Application_programming_interface

[151] https://en.wikipedia.org/wiki/Wireless_sensor_network

[152] See Flynn, Shi, Fischer, & Friedman (2016)

Closing Remarks

The world today is radically different from when our Land Grant system was founded over a 150 years ago. It asks us to reimagine not only how we carry out our mission but the nature of that mission itself. And to critically reflect on the design (intentional or by default) of our programs and institutions in light of those changes.

Responding to the many challenges we face will require solving for pattern, enacting systems level solutions which lead to more solutions. That means working together on addressing the root causes of an unhealthy food system. Andrew Fisher, former Executive Director of the Community Food Security Coalition, explores this in his new book, *Big Hunger* (Fisher, 2017). In that he lays out a vision[153] for not just treating hunger, but ending it, through a focus on equity, public health, economic justice, and economic democracy. Focusing on broad indicators and determinants of health, not just treating the symptoms of disease.

The network-centric approaches outlined here offer a sensible strategy for such work by enacting greater sensibility within increasingly complex environments. They suggest a shift away from outdated top-down knowledge dissemination models optimized for simplicity and control, toward more decentralized ones optimized for complexity, conversation and "emergent health". By leveraging modern technology like the semantic web stack as well as our inherent sociability, we can make research-based knowledge resources more readily and reliably available when, where and how they are most needed to support learning and innovation "in place", while at the same time drawing on the experience and insight of those we serve.

Recent events and issues[154] show us there is some urgency to this work, yet that it should not be blinded by techno-optimism. Ensuring that the benefits of what some are calling the "fourth industrial revolution"[155] are equitably realized within the agrifood system and beyond will demand greater attention to issues like digital inclusion and sociotechnical capacity building[156]. Many jobs offered by second and third industrial revolution organizations no longer exist, including those within an increasingly mechanized, automated and capital-intensive agrifood system. That livelihood issue may be one of the more wicked problems we face as a nation, setting into motion a cascade of other social, economic and environmental ills related to an increasingly uneven playing field. Klaus Schwab, Founder and Executive Chairman of the World Economic Forum, framed it this way[157]:

> *The Fourth Industrial Revolution can compromise humanity's traditional sources of meaning – work, community, family, and identity – or it can lift humanity into a new collective and moral consciousness based on a sense of shared destiny. The choice is ours.*

At the same time the rise and reach of phenomenon like fake news in both new and old media, intended to confuse, distract, or even deceive is challenging our ability to make sense of the world, and to make well informed decisions motivated not by bias and fear but the greater good. Tim Berners-Lee, the original developer of the World Wide Web has recently called attention[158] to the dangers associated with these issues, and the urgent responses needed if we are to preserve democracy itself. He outlines three main areas of concern: loss of control of our personal data, the spread of misinformation on the web, and the need for greater transparency and understanding around political advertising. He and others at the World Wide Web Foundation are now embarking on a new five year strategy for Delivering Digital Equality[159] – "researching the

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[153] Fisher shared portions of that vision in a recent webinar hosted by the North American Food Systems Network: http://foodsystemsnetwork.org/index.php/webinars

[154] Including those I refer to in part 3 of my blog series: www.bit.ly/S4P-3

[155] www.weforum.org/agenda/2016/01/the-fourth-industrial-revolution-what-it-means-and-how-to-respond/

[156] A focus of several recent eXtension Innovation Lab funded projects.

[157] https://www.weforum.org/agenda/2016/01/how-can-we-embrace-the-opportunities-of-the-fourth-industrial-revolution/

[158] http://webfoundation.org/2017/03/web-turns-28-letter/

[159] http://webfoundation.org/2017/02/delivering-digital-equality-the-web-foundations-2017-2022-strategy/

problems in more detail, coming up with proactive policy solutions and bringing together coalitions to drive progress towards a web that gives equal power and opportunity to all."

Through his efforts with Time Well Spent[160], "a movement to align technology with our humanity", former Google design ethicist Tristan Harris has also been raising awareness around issues related to today's "attention economy" and what he calls a "race to the bottom of the brain stem". To illustrate how technology designers like magicians can exploit our blind spots or vulnerabilities in perception (without us even realizing it) Harris points to the work of Cornell professor Brian Wansink. Wansink and his colleagues at the Cornell Food and Brand Lab have demonstrated[161] that you can trick people into continually eating soup by giving them a bottomless bowl that automatically refills as they eat.

Harris makes a distinction[162] between Attention companies such as Facebook and Snapchat who may employ whole teams of experts focused on exploiting weaknesses in our mind to maximize attention on their products (to the point of addiction), versus Platform companies like Apple and Google, which make tools and systems which connect people and the apps and websites who want our attention. The latter seek designs which find more of a balance between what people need and what businesses need. Yet even that "balance" is problematic when search results and advertising are based on algorithms essentially designed to serve and reinforce existing interests and biases in order to maximize clicks/revenue. Land Grant institutions have a responsibility and an obligation in not ceding their place within the attention economy, by becoming Platform companies themselves. But in this case, societal health and well-being the revenue maximized.

Before founding Cornell University Ezra Cornell was a farmer and mechanic who went on to achieve great success helping implement what was has been called the Victorian Internet[163], the telegraph[164]. He directed profits from these endeavors toward his philanthropic interests in public prosperity and universal fairness, where technology and wealth could benefit all[165]. That included endowing a free and public library whose mission was of great "breadth and largeness"[166]. He also founded what was a radical proposition unheard of in his day, "an institution where any person can find instruction in any study", including women, minorities, and the foreign born. It was there that another advocate for libraries (Bailey, L. H., 1908), Liberty Hyde Bailey, helped envision and bring into being today's Cooperative Extension system. One can't help but wonder how those early visionaries would leverage the many tools available today for connecting people, technology and information in support of the greater good they worked so hard for. Harnessing their potential to transform our People's Colleges into a networked knowledge commons truly "of the people, for the people and by the people". Current events and conditions require nothing less of us today.

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160 www.timewellspent.io/
161 http://foodpsychology.cornell.edu/discoveries/bottomless-bowls
162 https://medium.com/swlh/how-technology-hijacks-peoples-minds-from-a-magician-and-google-s-design-ethicist-56d62ef5edf3
163 https://en.wikipedia.org/wiki/The_Victorian_Internet
164 http://rmc.library.cornell.edu/ezra/exhibition/telegraph/index.html
165 http://rmc.library.cornell.edu/Ezra-exhibit/EC-life/EC-life-1.html
166 http://cornellalumnimagazine.com/prologue/2/

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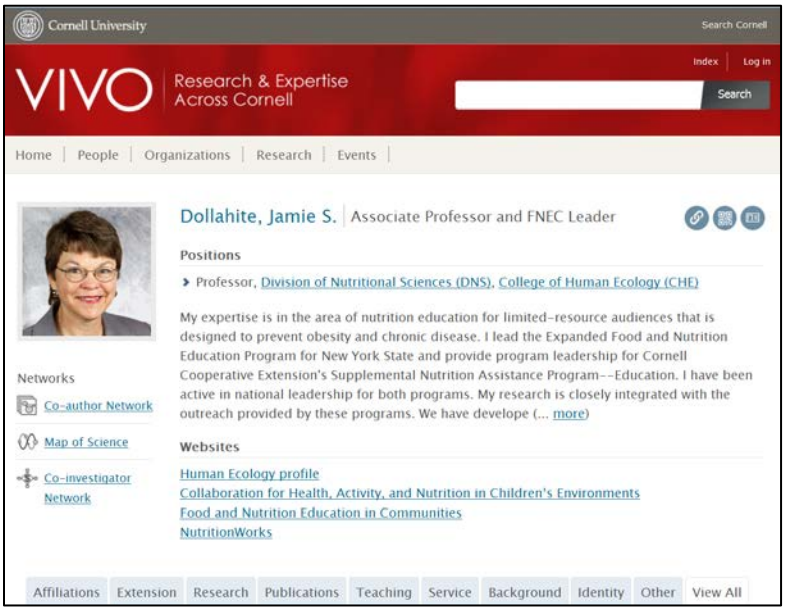
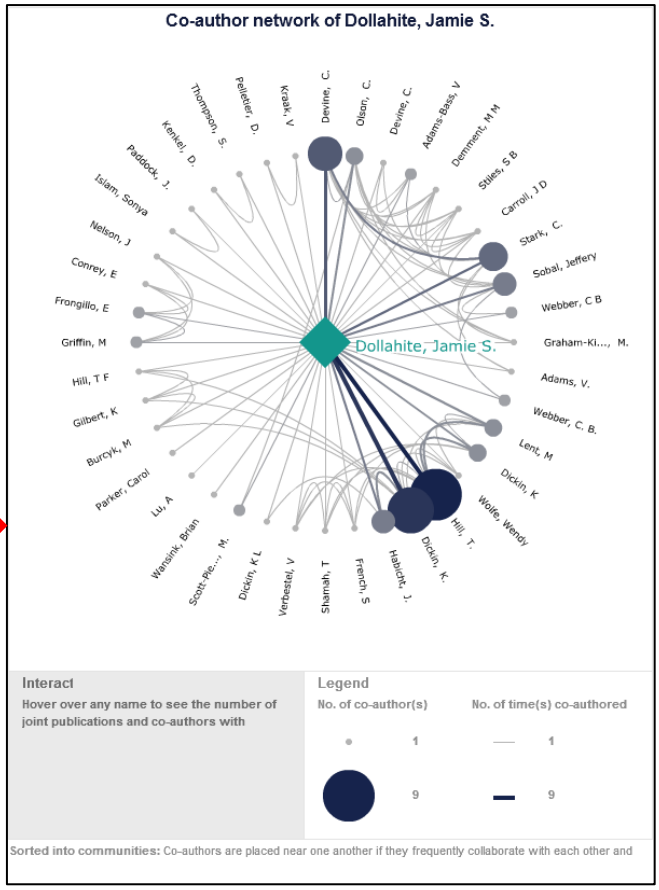
Appendix A – VIVO

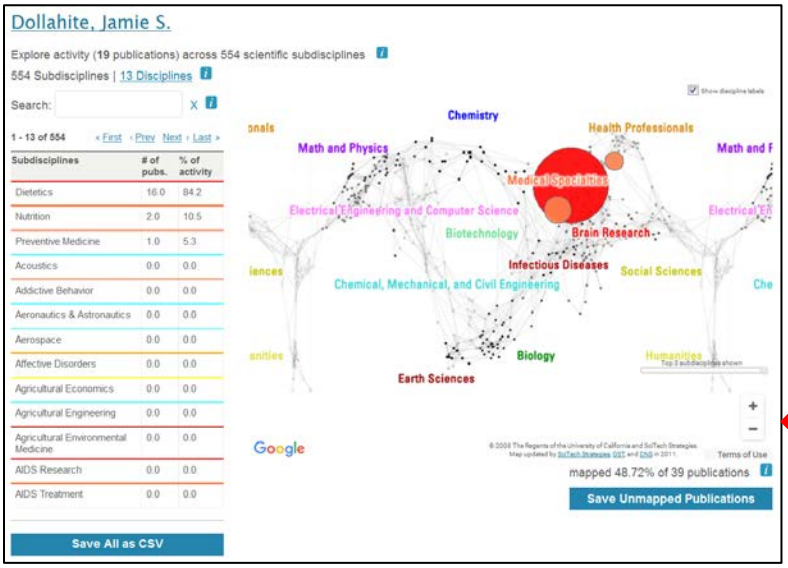
The following screenshots were taken from Cornell's VIVO website in early 2017, illustrating some of the ways VIVO "person" data can be displayed (in this case Cornell faculty member and Extension program leader Jamie Dollahite, http://vivo.library.cornell.edu/display/individual5512)[167]. VIVO at Cornell is currently undergoing a transition to "Scholars@Cornell"[168], which will reposition VIVO as one component of a larger stack incorporating other technologies such as Symplectic Elements (http://symplectic.co.uk/products/elements/integrations/). The result will be a more tightly integrated, usable and easier to maintain system drawing in and aggregating machine readable data directly from a variety of other sources, relying less on "scraping" data from other websites[169], and introducing potential errors associated with that process.



The main profile page providing a narrative description of the person, along with links related to a variety of activities and outputs.



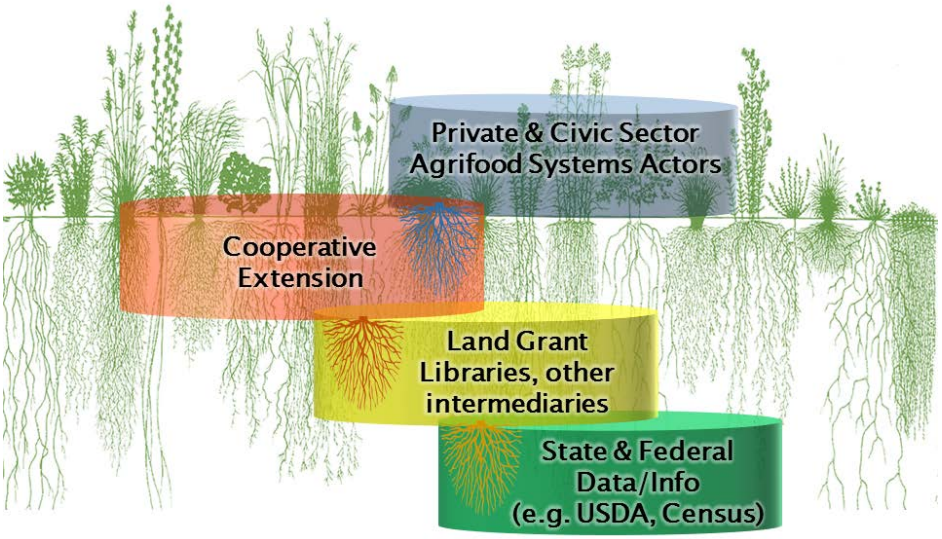
Interactive co-author network map. Each of the co-author names can be clicked to reveal additional information about them, including links to their own VIVO profile



Interactive, searchable "**Map of Science**", here illustrating areas of scholarly activity for Professor Dollahite (19 publications) across 13 Disciplines and 554 subdisciplines.

[167] Cornell Cooperative Extension personnel, including those employed by county based Associations are now in VIVO
[168] http://mannlib.cornell.edu/projects/scholars-at-cornell
[169] https://en.wikipedia.org/wiki/Web_scraping

Appendix B – Sociotechnical Stack Examples



Land Grant "Sociotechnical Stack"

Several programmatic and institutional entities informed the direction and findings of this fellowship. Described below are just a sampling of those representing different typologies across the "Information-Platform-Presentation" stack described earlier. The graphic to the left visualizes that in terms of Land Grant related entities. Of course this is greatly simplified, as each may in fact be engaged in activities at any or all levels, simultaneously.

Storage, or "Information" Layer

While there is considerable uncertainty as to what the situation might be going forward, past U.S. open/digital government[170] policies and directives have made a considerable volume of public data and information more widely accessible and reusable. Notable examples include:

Data.gov

Data.gov is currently a publicly accessible catalog providing information about and access to many government data and information resources, with several from the USDA available via API (Application Programming Interface)[171]. That includes GIS web services[172] available from the Food Access Research Atlas, enabling data to be directly and seamlessly "pulled" into GIS (Geospatial Information Systems) applications for visualization and analysis. Data.gov is powered by free and open source applications like the robust multi-purpose data portal platform CKAN (https://ckan.org/).

Ag Data Commons

Ag Data Commons provides access to a wide variety of open data relevant to agricultural research, using another open source platform (and CKAN "clone"), DKAN (https://www.drupal.org/project/dkan). ADC is a centralized directory or "registry" for data already available elsewhere on the web, as well as a repository for new data being published for the first time (e.g. "Long Term Agroecosystem Research" data sets referenced in research papers discoverable via PubAg, another USDA search tool). In terms of its foundational information layer capabilities, computer applications can get most ADC metadata and data in machine readable formats, formatted to facilitate interoperability and repurposability.

Management, or "Platform" Layer

Ag-Analytics Platform

The previously described Ag-Analytics platform (www.ag-analytics.org) developed by Cornell faculty member Joshua Woodard and his colleagues represents one example of a "platform layer" which aggregates and normalizes data precisely like that above, making it available in a more FAIR compliant format. Relevant to its potential function as a platform layer, that includes making data available via API. Woodard's 2016 AEPP paper (Woodard, 2016) provides a good overview of the role such platforms can play within the scholarly research and outreach data ecosystem.

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[170] https://obamawhitehouse.archives.gov/sites/default/files/omb/egov/digital-government/digital-government.html
[171] https://catalog.data.gov/dataset?q=&sort=score+desc%2C+name+asc&res_format=API&organization=usda-gov
[172] https://en.wikipedia.org/wiki/Web_service

Albert R. Mann Library

Opening its doors in 1952 (consolidating several smaller departmental agriculture and life sciences libraries), Cornell University's Albert R. Mann Library (http://mannlib.cornell.edu) went on to literally write the, or perhaps more appropriately "a" book on *Becoming a Digital Library* (Barnes, 2004). Published in 2004 it drew on the insights of several seasoned staff members, providing guidelines for building and managing digital collections and the services supporting them. That included highlighting the critical importance of "scouting the frontier", identifying new directions for "mainstreaming and hybridizing the building of a digital library" [one intent of this fellowship]. Since that time Mann Library has remained an innovator in this arena, developing several renowned tools and collections across all three storage, management and presentation layers, including VIVO and others supporting USDA and international development initiatives[173].

One challenge faced by the Library is maintaining convenient and reliable access to increasingly diverse and distributed knowledge resources for the on and off campus communities it serves. Many of those are not maintained by the Library nor FAIR compliant, making it even more difficult to track and maintain access to them. To facilitate discovery of disparate food systems related activities and resources, in 2009 this author created a Local and Regional Food Systems reference guide (http://guides.library.cornell.edu/local_food/). While remaining a popular Cornell University "LibGuide" accessed by users from across the globe, it has been difficult to maintain due not only to the constantly changing landscape of food systems research and practice, but the relative impermanence of platforms and materials associated with those. That includes the dreaded *404 Not Found*[174] broken links common when an organization or project changes its website, or ceases operation. The difficulties in maintaining that guide helped define the problem space this fellowship is concerned with, identifying alternate knowledge structures and curation norms and capabilities supporting sustained discovery, access and use of distributed data and information stores.

Efforts are underway across the Cornell University Library system to encourage Cornell content creators to deposit their materials within Library maintained institutional repositories while still providing their own branded "front end" access to those materials[175]. Repository platforms like Cornell's eCommons provide a variety of value adds to that content[176], including enhanced discoverability and persistence (e.g. via persistent URLS and Digital Object Identifiers (DOI)). Implementation of the Hydra platform described earlier is also active, in its foundational form and with Sufia front end tools. Sufia (http://sufia.io) provides a user interface around common Hydra repository features as well as social features. Examples of Sufia implementation include a new Gates Foundation supported AgriKnowledge site (https://www.agriknowledge.org/), with active development on a new Mann Library maintained USDA Economics, Statistics and Market Information System (ESMIS) site (http://usda.mannlib.cornell.edu). The Library is also archiving University related web sites/pages in partnership with the Internet Archive[177], creating copies of web based content.

Another way Mann Library is enhancing access and use of its holdings is through upgrades to its CUGIR[178] (Cornell University Geospatial Information Repository) platform. Soon that site will operate on an open source Geoserver[179]/GeoBlacklight[180] stack. That will provide expanded access to its geospatial data via web services, enabling users to stream that data directly into web and desktop tools of their choice, including web sites, lowering barriers to (re)use of specialized GIS data.

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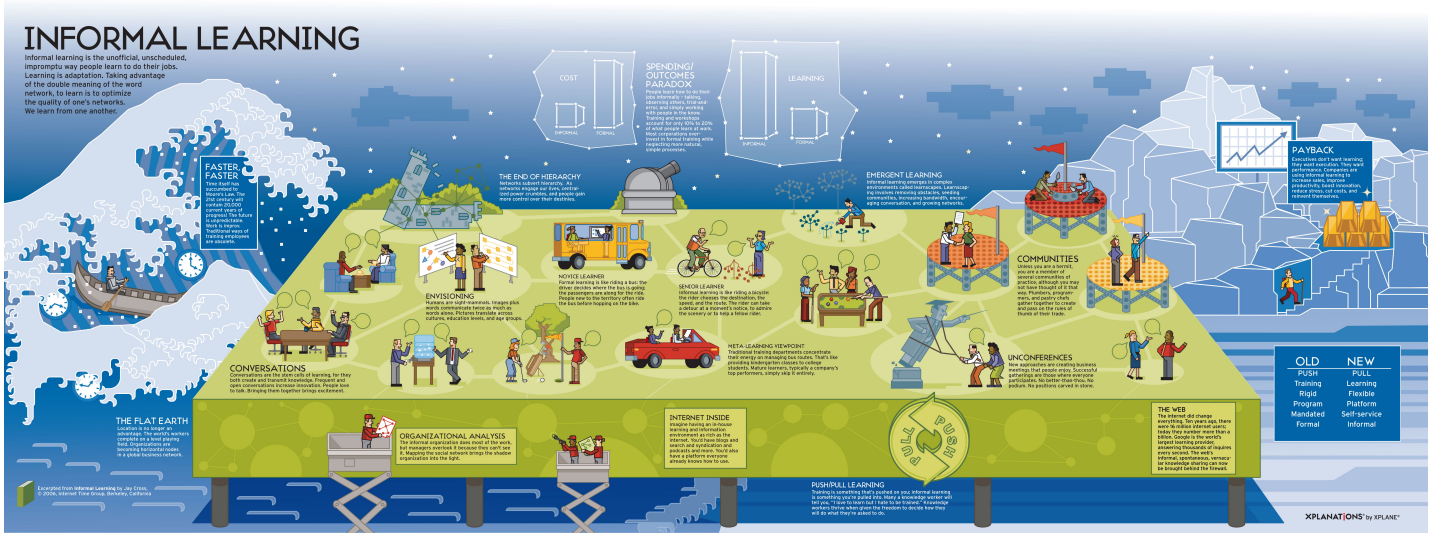
[173] A sampling of these can be found here: http://mannlib.cornell.edu/use/collections/digital, and here: http://mannlib.cornell.edu/projects
[174] https://en.wikipedia.org/wiki/HTTP_404
[175] Like the New York State IPM Project has already done: https://nysipm.cornell.edu/resources
[176] http://guides.library.cornell.edu/ecommons/
[177] https://archive-it.org/organizations/529
[178] http://cugir.mannlib.cornell.edu/
[179] http://geoserver.org/
[180] http://geoblacklight.org/

Presentation Layer

The "top" presentation/use layer includes those (like Cooperative Extension) often working within less formal learning environments where "emergent learning" processes are exhibited. The image below illustrating some of those is from Jay Cross' Informal Learning Blog (now archival due to his unfortunate passing), and book of the same title (Cross, 2007).



The following examples provide a sampling of initiatives which might build on or draw from resources and services provided by underlying storage and management layers in support of informal food systems related learning and problem solving.

Cornell Cooperative Extension (CCE)

Agricultural Marketing and Community Development Program Work Team

Cornell Cooperative Extension Program Work Teams (PWT) are groups of faculty and staff, extension educators, and external stakeholders who collaborate to identify issues, study needs, and create educational materials. Team members design learning experiences that address issues and needs within specific content areas. The Agricultural Marketing and Community Development Program Work Team (AMCD PWT) identifies and implements research, extension, and professional development activities designed to strengthen agriculture and food systems, including their contributions to community and economic development. A survey of the PWT revealed several data and information needs, related to helping its membership:

- Better understand the needs and interests of its clientele, and communities
- Support more informed decision making
- "Tell the story" of agriculture and its value, including economic impacts
- Illustrate the complex nature of resilient, sustainable food systems
- Evaluate need and demonstrate impact of its programming
- Do more with less, reducing duplication of effort

Though there is still much to be done in addressing these needs, an initial "beta" New York Agricultural and Food System Data tool (https://pad.human.cornell.edu/ag/) was developed in partnership with the Cornell Program on Applied Demographics. That proof of concept tool offers summary statistics and visualization tools drawing from a variety of sources, including the USDA Ag Census and Cropscape. One goal of this fellowship is to identify additional, perhaps more dynamic approaches for linking PWT members with each other and the data and information resources they need.

One recent effort the AMCD-PWT has been collaborating with is the Cornell Local and Regional Food Systems initiative, described below.

Cornell Local & Regional Food Systems initiative

Over the last year and a half several faculty and staff members have been exploring ways to support greater connection and collaboration between those engaged in local and regional food systems work at Cornell and CCE. With the assistance of directory tools like VIVO and a number of campus entities including the Community and Regional Development Institute (CaRDI), over 200 individuals were identified, convened and queried through a combination of events and conversations.

Through those sense-making processes it was learned that many do want more connection with their colleagues, including better communication with those working in similar areas. Greater access to financial and informational resources is desired as well. They are also interested in greater collaborative opportunities and spaces that inspire and inform their work, but have concerns about how that might impact already heavy workloads.

Increasing opportunities for communication and collaboration without increasing existing workloads/meetings was a common theme heard from other initiatives looked to as models[181]. Network-centric approaches are a common strategy employed by those. Many are represented by members of the eXtension Community, Local and Regional Food Systems Community of Practice, an important practitioner/researcher nexus. I had the opportunity to visit one model, MSU's Center for Regional Food Systems in the summer of 2016. CRFS' work includes "catalyzing collaboration and fostering innovation among the diverse range of people, processes, and places involved in regional food systems". One way that is done is by connecting local and statewide food systems initiatives with each other through a variety of convenings and support services, with CRFS often playing a servant leadership role.

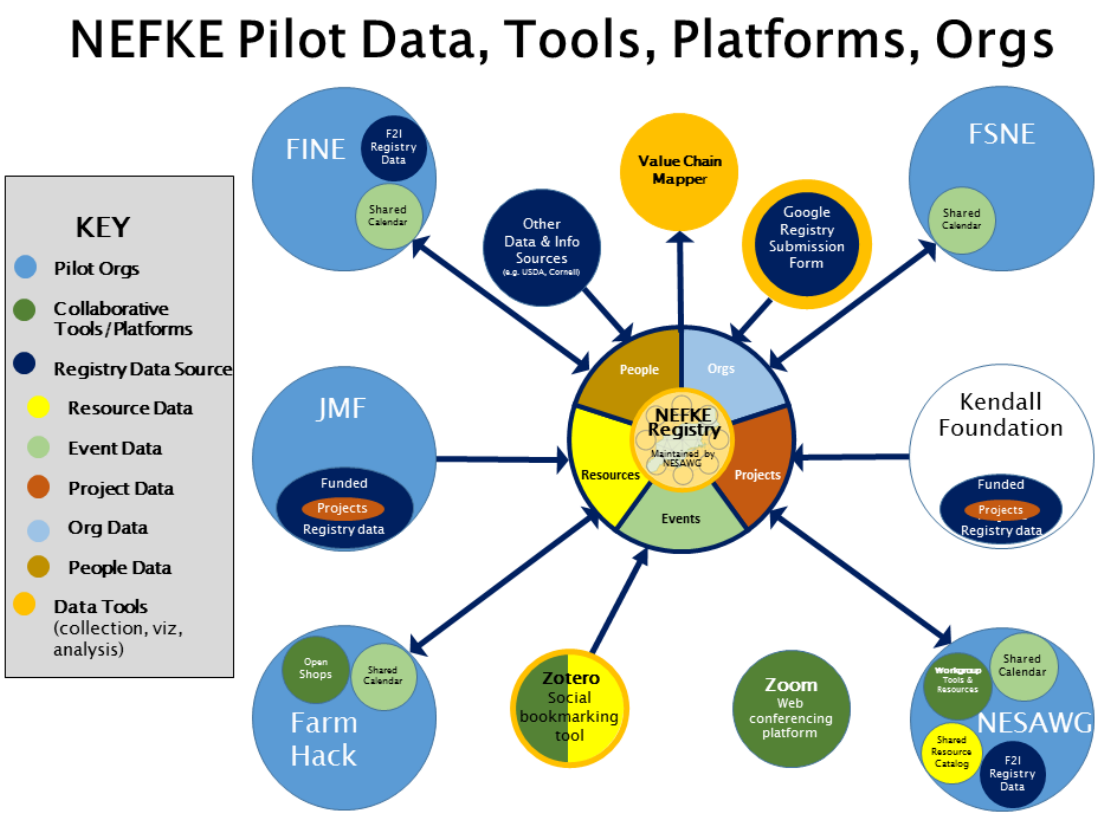
Several new projects are now underway at Cornell representing initial steps in providing such services there. That includes a monthly newsletter and development of a new website. Both are intended to serve as a communications "hub", highlighting faculty and staff food system projects, "stories" and findings from those, as well as upcoming events and other resources of possible interest. Ideally these efforts will lead to greater collaboration in the development of shared tools and platforms, potentially including a next generation version of the Agricultural and Food System Data tool described above, have utility for a broad range of users.

Northeast Sustainable Agriculture Working Group (NESAWG)

Founded in 1992, NESAWG was one of the first multi-sector food system networks in the U.S. It continues its mission today, working to "unite farm and food system practitioners and allies to build a sustainable, just and economically vibrant region in the Northeastern United States". NESAWG provides leadership in the Northeast by fostering peer learning, advocacy, leadership development, resource development[182], training, and collaboration. NESAWG has been a particularly strong advocate of regional approaches in realizing a more sustainable and just food system, articulated in the publication *It Takes a Region: Exploring Regional Approaches to Food System Development* (Ruhf & Clancy, 2010).

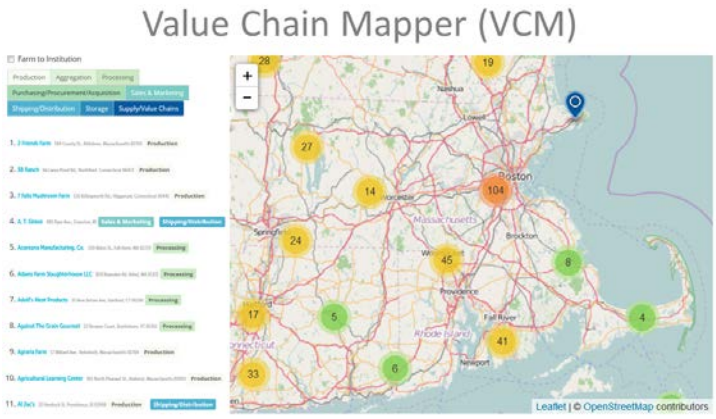
A "Northeast Food Knowledge Ecosystem" (NEFKE) pilot project[183] was recently undertaken in support of NESAWG's interest in promoting greater regional collaboration which I helped initiate and lead. The impetus for that emerged over the course of several years, surfaced in part through conversations hosted by NESAWG's Research & Assessment Working Group (NESAWG fosters discussion and action around specific topics/sectors through such groups). It became clear through those discussions that many were struggling to find and leverage data and information resources in support of their work. They also found it difficult to know and track who was doing what across the region, to avoid competition or duplication of effort, or identify potential collaborators. Many of these themes were confirmed through a widely distributed regional survey.

[181] Including the Appalachian Foodshed Project and OSU Initiative for Food and AgriCultural Transformation
[182] Including a report on Land Grant stakeholder accountability –see Ruhf & Johnson (2006)
[183] http://nesawg.org/our-work/nefke



One pilot activity was the creation of a regional food systems "registry". This was designed to aggregate and share back out information related to people, projects, organizations and events, from and with partner orgs. Each used a shared taxonomy of 74 terms to tag entities within their own databases in a consistent manner. Data was also imported into the registry from other organizations, including the USDA.

The registry itself and each of the partner org websites (NESAWG, Farm to Institution New England, Farm Hack and Food Solutions New England) run on the free and open source CMS Drupal, leveraging its built in capabilities for dynamic data exchange via its Feeds function, as a well as common exchange formats like iCalendar. The DKAN data platform, used by USDA's Ag Data Commons, mentioned earlier, was initially considered for the registry but ultimately rejected due to issues with implementation and maintenance costs.



A proof of concept interactive "Value Chain Mapper" was developed to illustrate one use of registry data. The VCM displayed organizational and project entities previously identified (using the shared taxonomy) as directly engaged in some aspect of the food value chain, from production to consumption. It was designed as a web application, drawing data from the NEFKE registry via API, which could be embedded within partner web sites for a variety of visualization and analysis purposes, including mapping Farm to Institution value chains (a focus of the pilot).

Though many of the technical goals of the pilot were achieved, a combination of conditions made adequate socialization (and adoption) of the tools and approaches difficult. That included geographic distance amongst project collaborators (making in person meetings difficult), varying technical background/competencies, and resource constraints (typical of non-profits like those involved with the project) limiting ongoing commitment in maintaining the registry and the technical infrastructure. Such knowledge ecosystem[184] efforts would likely be much more sustainable if participating organizations had some of the underlying storage and management layers like described above in place, enabling them to build lighter weight, easier to maintain applications rather than attempting to develop and maintain the entire sociotechnical stack themselves.

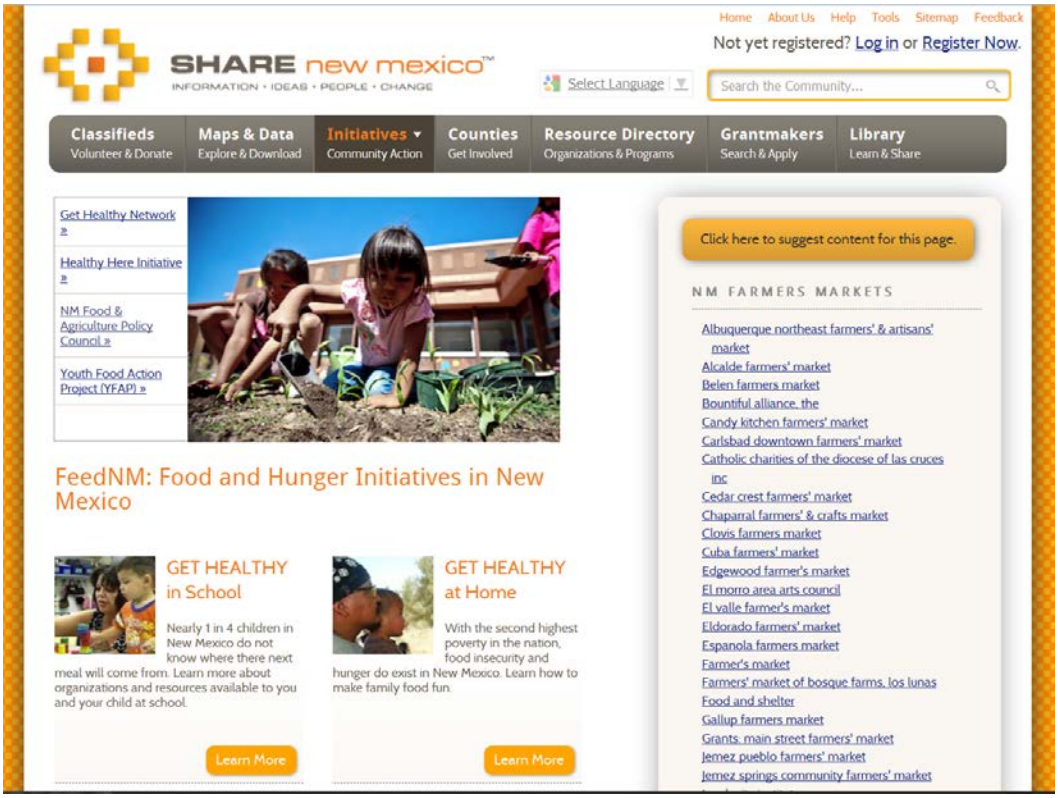
[184] https://en.wikipedia.org/wiki/Knowledge_ecosystem

Tompkins County Childhood Nutrition Collaborative

The Tompkins County Childhood Nutrition Collaborative is a Collective Impact initiative in Tompkins County New York involving multiple organizations and projects (including Cornell Cooperative Extension of Tompkins County) interested in working together on issues related to childhood hunger. Initially spurred by a Stanford Social Innovation Review paper of the same name (Kania & Kramer, 2011), Collective Impact represents a commitment by a group of actors from different organizations and sectors to work together through a structured form of collaboration on a common agenda for solving a specific social problem. Though its implementation varies, Collective Impact proponents generally believe five basic conditions are required:

- **Common Agenda**: A shared vision for social change that includes a common understanding of the problem and a joint approach to solving it through agreed upon actions.
- **Shared Measurement System**: Agreement on how success will be measured and reported, with a short list of indicators shared across all participating organizations.
- **Mutually Reinforcing Activities**: Coordinating complementary activities engaging a diverse set of stakeholders, typically across sectors.
- **Continuous Communication**: Frequent communications over long periods of time within and across organizations, building trust and supporting ongoing learning and adaptation.
- **Backbone Organization**: Dedicated staff providing resources, services and infrastructure supporting each of the above.

Within the CI community of practice, the ideal form and function of a Backbone Organization has continued to evolve. Some now believe focusing on "Backbone Function" is more appropriate, with backbone support services potentially provided by a combination of organizations and shared tools/platforms. That includes those supporting greater access and exchange of data and information, vital to all of the conditions of CI.



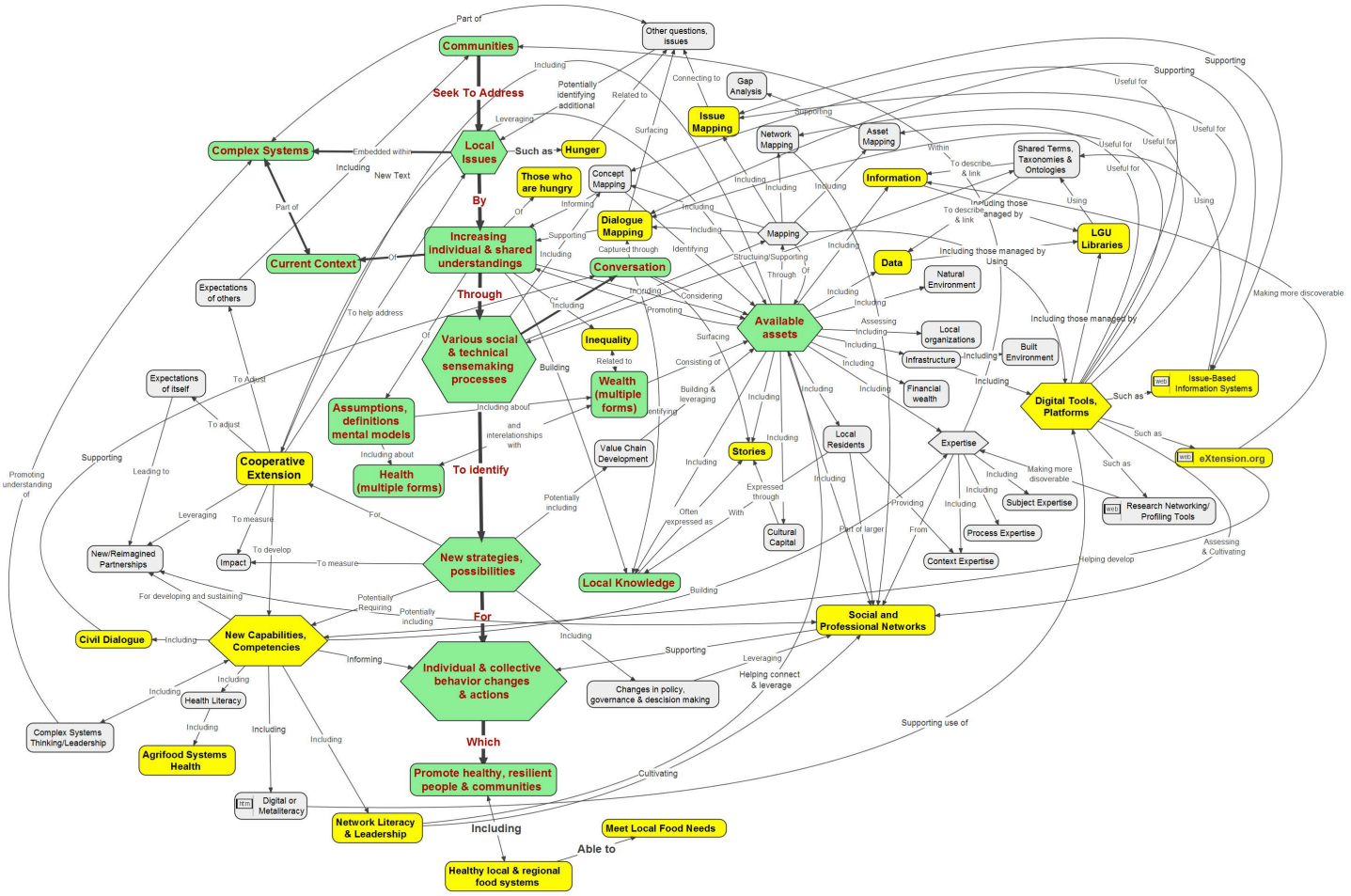
The Childhood Nutrition Collaborative is currently working with other Collective Impact initiatives in Tompkins County to identifying a suitable "Digital Backbone" tool. The Community Platform, originally developed as a project of the Urban Institute, is one being assessed. It provides a variety of tools for aggregating, sharing and visualizing national and local data (including 211 data). The example here, from New Mexico, illustrates how it might support food and hunger related initiatives.

With trustworthy and FAIR compliant data and information stores more available as sociotechnical scaffolding, efforts like these could emerge and scale much more rapidly, aided by complementary efforts like Open Referral, making locally curated data more machine readable, reusable and combinable.

Appendix C – Implementation Concept Map

Ideas for implementing tools, concepts and processes surfaced by this fellowship (including Issue-Based Information Systems and asset-based community development) were workshopped with several other Community, Local and Regional Food Systems (CLRFS) CoP members at an eXtension hosted Diversity & Inclusion Issue Corps "designathon" on February 14-15, 2017[185]. Led by Paul Pangaro[186] and a support team of key informants assembled by eXtension, we developed a concept map outlining a potential collaborative/social learning process which might specifically respond to the issue of hunger, while drawing on a larger sociotechnical support system.

Using the free and open source software tool VUE[187], a more detailed concept map was developed from the original one, shown below. There are now ongoing discussions on how this might be implemented/tested on a pilot level. Those efforts could in turn provide a template for other eXtension Issue Corps teams, and others interested in exploring similar approaches[188] and any tools/platforms developed.



185 https://extension.org/2017/01/05/diversity-inclusion-issue-corps-designathon-planned-for-february/

186 Much of Pangaro's work is centered around "designing for conversation", a key thread running through this report

187 One of the reasons the VUE tool was chosen for this concept mapping exercise is its ability to link nodes to digital assets and work with ontologies, potentially important elements in future implementation work. A new "branch" of this software called designVUE has been developed to specifically support Issue-Based Information System (IBIS) notation and bi-directional hyperlinking. Though not easy to install/use at the moment, with further development this may prove helpful in the future.

188 Perhaps adapting or building on Community Café and Appreciative Inquiry initiatives.