Knowledge Building in Participative Projects

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Abstract--The collaborative elaboration of a development project is an opportunity not only to pursue conventional objectives such as equipment and infrastructure construction but also for collaborative learning and knowledge building and more sustainable development.

In this context this paper aims to present an analysis of the process of building knowledge during a project development. The research questions are: What was the knowledge inside the group before the project? What is the knowledge inside the group after the project? What knowledge gaps remain and how might a participatory, collaborative approach to research and development help address these gaps? Who has the necessary knowledge? How is this knowledge acquired? And does this knowledge help create development that is more sustainable?

The methodology includes the development of a conceptual model based on participatory action research, knowledge management, and sustainable community and regional development literature; followed by a participatory research case study from which conclusions and recommendations are drawn.

The paper describes and analyzes the participative construction of knowledge during the development of a project for new algae products, aquaculture and processing, with the participation of four algae associations and support of Pluspetrol and the Defensoria del Proyecto Camisea. This algae aquaculture and processing project has been developed in Pisco, Peru, where there is a community of 800 algae harvesting people.

I. INTRODUCTION

The success of development projects is often judged only by criteria such as efficiency, effectiveness or productivity, cost and timing. However development projects, and in particular participatory community and regional development projects, also have the opportunity to become vehicles of knowledge building and dissemination. The importance placed on knowledge and innovation in today's economies and societies challenges researchers to further examine the opportunities participatory development projects provide for knowledge generation and sharing.

Projects may be analyzed from a Fordist perspective based on "tangible", primarily economic, results or alternatively following a more integrated approach linked to outcomes such as learning and improved knowledge management as well as economic but also environmental, social and cultural sustainability criteria. This research employs the latter approach.

The hypotheses of this research are:

1) Peruvian research and development organizations are engaged in generating knowledge about algae;
2) This knowledge is dispersed, not integrated and unarticulated,
3) Benefits of this dispersed knowledge could be enhanced through the construction of a knowledge network, and
4) This knowledge (and social) network could be localized and applied in a specific region, like Pisco, and generate sustainable development outcomes.

Researchers from Pontificia Universidad Católica del Perú, including the lead author, have played an active role since early 2007 in the Pisco algae culture knowledge network, participating in approximately ten meetings and site visits. Within an overall participatory action research framework research methods have included participation observation, document review and fifteen semi-structured interviews conducted with a range of stakeholders. This research will continue throughout the project implementation phase. Gibson *et al.*'s [17] ideal model of knowledge flow, coupled with Vodden et al's three forms of collaborative knowledge management, provide an analytical framework while the learning histories tool [21] is used to organize data and assist in characterization and analysis of the knowledge building process.

II. KNOWLEDGE SYSTEMS AND REGIONAL DEVELOPMENT

Knowledge is defined here as "the application of critical faculties to information/data to gain an understanding, as distinct from opinion" [25]. It may include understanding that is theoretical or practical, often gained through experience [13]. Much more than simple information, "it can be regarded as a complex system of learning and understanding, with many different facets and components", includes "experiences, skills and techniques … perceptions, observations, actions, analyses, conceptual constructs, attitudes, and worldviews" [38].

Porter [33] suggests that knowledge is a source of regional competitiveness and that different regions of the same country may have a different economic dynamic because of their varied accumulated knowledge. Subsequent literature has emphasized concepts such as the "learning region" [43], [29], creating an environment that stimulates and facilitates the flow of ideas, knowledge and learning [12], and "regional innovation systems" [10], [4]. Knowledge and innovation rival traditional assets such as natural resources and labour (also critical to knowledge generation, flow and application) as key sources of economic growth [16].

Knowledge or innovation systems incorporate a range of knowledge types and sources, often brought together through personal interaction and collaboration among various knowledge holders and users. Vodden *et al*. [42] present examples of three forms of collaborative knowledge generation and transfer in fisheries and coastal resource governance: hierarchical, network and community-based research activities.

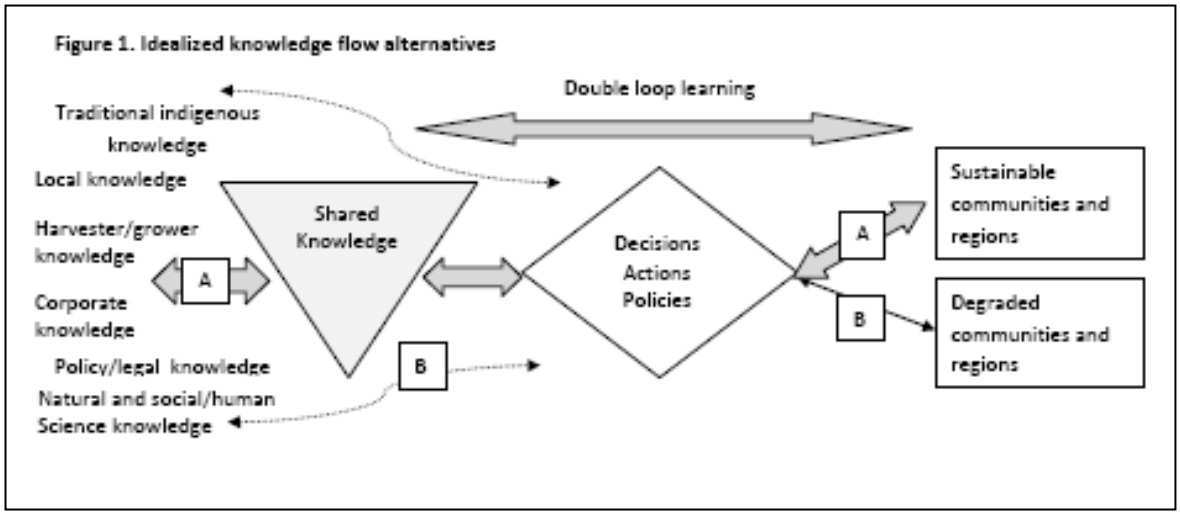
The example of hierarchical space-time modeling, for example, integrates both fisherperson's and community knowledge, which is spatially specific but temporally broad, with statistical data generated by fisheries scientists that covers an extensive geographic area but over a limited timeframe. Both are combined in computational form in a model estimating mortality rates and generating other types of knowledge. Results may then be discussed with other participants but the process is largely controlled by fisheries scientists.

In contrast, the more comprehensive network approach considers whole ecosystems, current and future generations, cultural and ecosystem as well as economic/harvest values. The "Back to the Future" project example included multi-level dialogue on ecosystem model development, results and strategies. Third, a community-based fisheries and watershed management example illustrates a knowledge network that is driven from the bottom-up. In contrast to the hierarchical model, local resource users and citizens lead this initiative. Despite their differences, each of these models is employed in the pursuit of more sustainable approaches to species and, in some cases, ecosystem management.

III. CONTRIBUTIONS OF COLLABORATIVE KNOWLEDGE SYSTEMS TO REGIONAL SUSTAINABILITY

Gibson *et al*. [17] suggest an ideal model of knowledge flow (shown in Figure 1), beginning with a specific research question and a careful, comprehensive study design that addresses demands such as reliability and validity. The model acknowledges a role for multiple forms and sources of knowledge and that local and traditional knowledge, like academic science, are based on repeated testing and observation. Further, no knowledge is value-free or without limitations and context.

Linking this knowledge model with regional economic development aims, Coe [7] points out that collaboration and partnerships with a variety of stakeholders, in some cases across territorial boundaries, is increasingly viewed as critical to enhancing regional economic performance. Extending beyond purely economic objectives, M'Gonigle [28] explains that experiential local and traditional knowledge forms are increasingly recognized for the sophisticated understandings they contain and for the benefits to sustainability that can be attained by operationalizing these understandings.



Source: adapted from Gibson [17]

Gibson *et al*. [17] emphasize the importance of applying knowledge to policy and decision-making and ultimately to development practices. Implementation and application of shared knowledge is a critical component of the learning process. Ongoing knowledge flow also calls for monitoring and evaluation ("reflection-in-action") throughout the process [35], learning about not only appropriate strategies and actions but also goals, values and norms in what is referred to as double loop learning [37], [3].

Local actors may contribute to knowledge systems by bringing discussion of values to the table. Their viewpoints are often (although not always) more holistic than actors that come from the culture of disciplinarily that accompanies academic partners or the departmental silos associated with government departments. Examining several Canadian case studies Vodden and Bannister [41] provide examples of regional knowledge systems that share "an integrated focus on social, cultural, economic, and environmental values, demonstrating local awareness of complex interconnections within social-ecological systems".

Traditional ecological knowledge (TEK) is formed primarily from tacit components and is transmitted for generation in generation. It is a form of community capital that can be combined with academic and more formal knowledge. Agreeing with Nonaka and Takeuchi [31] the case study project reflects hope that tacit knowledge can, at least in part, be converted into articulated knowledge, creating new learning and development opportunities.

Clearly Figure 1 is a simplistic representation of complex and dynamic processes of knowledge generation, sharing and application. Many factors can cause "knowledge traps" and inhibit information flow [25], including macro-level structures and processes such as dominant economic motives and other narrow agendas, layers of power and power differences [5]. Gaventa and Cornwall [15] point out that *"power and knowledge are inextricably intertwined"*. Knowledge systems are shaped not only by structure but by individual actors and their emotions, values, histories and personal relationships. Knowledge is constructed through social interactions among individuals [24] but also through interactions with particular natural environments [25]. Nor are the relationships between decisions, policies and actions and outcomes a simple one of cause and effect in complex social-ecological systems [32].

The model does, however, provide an idealized process (A in Figure 1) that more closely represents participation, collaboration and sustainable development goals and approaches than traditional linear, isolated, extractive knowledge flows and can be used a heuristic framework to enable analysis and understanding of the Pisco, Peru algae culture case study.

IV. REGIONAL KNOWLEDGE NETWORKS

Development literature makes an important distinction between the scale of "community" and "region" (multi-community micro-region). Rural Policy Research Institute [34], Markey *et al*. [26], Young and Charland [44] and others suggest, for example, that economic issues extend beyond community boundaries and that economic development is most effectively undertaken on a regional basis to provide political power, capitalize on regional assets, competitive advantages and economies of scale to provide infrastructure and services. Senior governments often prefer to deal with regional entities, viewing individual municipalities as financially or politically ill-equipped to deal with today's complex problems [11]. Vodden *et al.* [42], Yorque *et al*. [45] and others add that ecosystem-based regions such as watersheds are appropriate for ecosystem management initiatives.

Nauwelaers and Reid [30] define a regional innovation system as a set of relationships (economic, political and institutional) that occur in a given geographic area and generate a collective learning process that in turns leads to rapid diffusion of knowledge and best practice. Cooke [9] suggests that the notion of a regional innovation system is based on the assumption that location and spatial proximity matter for innovation activities. Key actors include private firms, particularly those participating in research and development activities, research institutions, support services, the regional workforce and all levels of government, including the policy framework, infrastructure, financial support and services they provide.

Literature in multiple disciplines has documented the importance of networks of actors and their interactions to the development of a regional knowledge base and also to economic outcomes [18], [19]. Marsden [27] suggests that local development outcomes are differentiated by a community's internal (local, regional) and external (national and international) connections. Coe *et al*. [8] add that networks and interconnections are expanding and thickening to their point where the utility of dichotomies such as "internal" and external" or "local" and 'global" should be questioned.

There are difficulties in determining borders of a community or region due to the dynamic characteristic and continuous construction and deconstruction of these spaces. Yet there are long-lived attachments to, and knowledge of, place that can be drawn upon in regional knowledge networks and development projects. Ideally, aided by community inclusion, sense of community is enhanced rather than degraded in the creation of new regional development spaces.

Levin [22] analyze the example of three communities in Norway: Froya, Snillfjord and Hitra, applying action research in a five-year development project. This project was developed in three phases with the methodology of the research including development, evaluation and learning. The first phase looked to encourage entrepreneurship and communal actions inside of each community. The second phase looked to generate links between the three communities through the extending of the networks from community to regional scale. The third phase included support to the networks through government and enterprises.

According to Levin and Knustad [23] network formation with the aim of regional development support in learning and knowledge construction can be spontaneous or planned. Levin [22] observes that action research facilitates the emergence of networks according to the needs of participants and makes adjustments over time based on the learning from research process. This learning occurs during meetings, ongoing dialogue, reflection on the outcomes and writing about these experiences.

V. CASE STUDY: ALGAE HARVESTING AND PROCESSING IN PISCO-PERU

A. Current and previous projects

1) In Pisco, there was a previous project for the aquaculture of algae with the participation of an expert in the area that involved the cultivation of two hectares of the algae *Chondracanthus chamissoi* using meshes in form of sleeves filled with small stones. These sleeves were made by the

algae harvester participants in the project. In total 50 sleeves were made and put in the sea working during three days. According to the expert that guided the project there were some problems with poor sitting of the sleeves and also with the algae product.

In that project, which began in 2004, *Chondrocanthus chammisoi* had been cultivated in Mendieta, inside the Reserva Nacional de Paracas, with the participation of the associations Alto Puno and Beatita de Humay. Because the project was developed inside the Reserva Nacional de Paracas it was necessary to have an authorization that was for one year, interfering with the progress and continuity of the project. Inclusion of reserve managers within the project network may have helped to address this issue.

The expert, of Peruvian Seaweeds, indicates (G. Villena, personal communication, 15 of February, 2008):

> *"The project that began in 2004 with the funding of Pluspetrol was considering paying 70% of the funding for the technical personal and experts. The algae harvesters' representatives did not agree with this point because they wanted to buy a bus with part of the funding of Pluspetrol. The consulting enterprise Peruvian Seaweeds did not accept. The result of this was lost time and money that the consultant invested in the getting authorizations for culture inside of the Nacional de Paracas reserve. Although two phases of project were concluded we requested the cancellation of the agreement."*

About the knowledge generation through the project the consultant adds:

> *"Though the agreement was transferring technology for the culture of Chondrocanthus chamissoi by means of fixation of spores in the sea middle, the patent for this technology belongs to the consulting enterprise. The installation was made with the algae harvester participation, so they learned the technology. However they will not be able to use it because in 2006 the agreement was annulled and the patent belongs to us. Also the technology was transferred by means of training courses."*

About the project advances the consulting also said:

> *"Until now there is the facilities pilot and there has been made several harvests. The participation of Alto Puno association was more than the Beatita de Humay association during the Project. I suggest any future work will be made with small groups and after that to integrate them."*

2) Two other projects provide additional insights into the prospects and approaches for partnerships between universities and technical experts, harvesters and other partners in algae culture. A research group of the Universidad del Pacífico has developed a similar study for Sechura - Vichayo beach north of Peru. That project is expected to generate a return of US$ 667,000 the first year and US$ 3,000,000 after ten years. Organic certification of the algae is planned at the third year along with increases in the red color of algae through a biochemical process.

The Alganor SAC project was developed for a study group of the Universidad del Pacífico. This project looked for export *Chondrocanthus chamissoi* algae to China.

3) In Lambayeque - Cherrepe in the north of Peru, with the participation of the Fondepes, an experimental project was undertaken for aquaculture of *Gracilariosis lemanaiformis*. That project was developed in a marine authorized area of ten hectares and included: culture systems using plastic sleeves or "chululos" of bottom and cords suspended in an eight hectare area; systems of handling of natural prairies of seaweeds; installations for drying, packaging and storing algae; administrative infrastructure; and use of the solar energy.

B. The project, project region and actors

In the project examined it is possible to identify two actors groups: "inside" or local actors that include the four algae associations of Pisco - Perú (Señor del Mar, Alto Puno, Beatita de Humay, and San Andres) and "outside" actors that include researchers from PUC-Peru, San Luis Gonzaga and Federico Villareal Peruvian universities. Project funding was provided by the Ministerio de Energia y Minas through the Defensoria del Proyecto Camisea, with implementation funding from the Pluspetrol enterprise.

The project was initiated in response to problems of decreasing algae resources and pollution of marine areas, implying decreasing economic outcomes for algae harvesters in Pisco. The project include: situational diagnostics including "problems tree" analysis; a market study for the product including a balance between supply and demand for USA and Japanese markets; technical study of the culture and processing of algae *Chondrocanthus chammisoi*; and costs-economic analysis.

According to UCN [39] this red algae is used like raw material for the elaboration of phycocolloid carrageenan and for human consumption. They suggest that this algae is currently only harvested in an uncultivated form, although there is research underway to develop technology for the production of small plants in a hatchery before undertaking aquaculture at an experimental level in the sea.

Pisco, the project region, shown in Figure 2, at south of Lima the Peruvian capital, is one of the five Ica provinces. The Pisco province was founded on October 13, 1900. The population of Pisco is 107,000 inhabitants, living in eight districts.

The Pisco port has a locational advantage in relation to Lima, only 250 km away from the capital city. It also has a pleasant climate and an airport that facilitates the transportation of the regional products. Pisco is also the site of the Camisea gas project, which has a strong impact on the regional economy through the Pluspetrol enterprise.

Pisco has tourist attractions such as the Reserva Nacional de Paracas, Ballestas Islands, the ancient city of Tambo Colorado, in addition to a pleasant climate that are likely to facilitate the formation of technological agglomeration. However, Pisco's development is limited by its few telecommunications services.

In Pisco there are some important industries like the Aceros Arequipa iron and steel industry, the gas transformation plant of Pluspetrol, artisanal and industrial fisheries, and agro-industry. The fishing activity that has characterized Pisco has resulted in a community of fishermen with an accumulation of social capital that is important for local employment generation. Pisco also has a fisheries faculty that is the Facultad de Pesqueria of the Universidad San Luis Gonzaga de Ica.

The total algae harvest registered in Pisco according Produce (2007) was 630 ton in 2004; 657 ton in 2005; and 2,960 ton in 2006, illustrating recent growth despite problems with the 2004 project mentioned above.

Source: Google.

Fig. 2 Algae aquaculture area in Pisco

C. Who holds the knowledge about algae and algae cultivation in Peru?

Different actors in the project network contributed different kinds of knowledge. For example, outside consultants contributed information about geographical aspects of the Pisco bahia that included Reserva Nacional de Paracas and other nearby areas, types of algae and their volumes in Pisco, and regulations and procedures about the assignment of sea areas for aquaculture. The local harvesters also contributed knowledge about previous experiences, characteristics of sea bottom habitats and types of algae in Pisco.

A taxonomic table (Table 1) identifies the dispersed centers of knowledge in Peru about algae culture and product development. This identification was through interviews and site visits.

The aim is to design a mechanism for transfer and use of this knowledge in the Pisco region and to combine this knowledge with that of local harvesters, government representatives and others who can contribute to the knowledge network according to the model presented in Figure 1 above.

In the Laboratorio Costero de Pisco of the IMARPE studies are being developed about algae with commercial importance like *macrociste, lessonia* and *chondracanthus chamissoi*. These studies consist of biomass determination, densities of algae on the sea, sizes, weight, and growth parameters.

TABLE 1: KNOWLEDGE TAXONOMY ABOUT ALGAE IN PERÚ

Theme	Group and /or laboratory	Project
Culture of *Gracilariosis lemanaiformis.*	Direcciòn de Acuicultura - Fondepes	Aquiculture of *Gracilariosis lemanaiformis* in Cherrepe (1995-1998)
Register of algae, Absorption of nutrients for algae in laboratory, Determination of vitamin C in algae	Facultad de Pesqueria – UNFV	Determination of vitamin C in algae, parts I and II (1990)
Histological morphology, Algae identification in Arequipa	Laboratorio de Biologìa – UNSA	Bioecological study of *Lessonia nigrescens* Bori algae
Algae register	Herbario Museo de Historia Natural Javier Prado – UNMSM	Algae register
Chondracanthus chamissoi algae exportation to China	Universidad del Pacífico	Alganor SAC project for algae exportation to China
Types of algae in Pisco, times of its growth and harvesting, culture of *Chondracanthus chamissoi* in sleeves	Pisco algae harvesting association.	Culture of *Chondracanthus chamissoi* in Mendieta
Production of alginates and carragenes	UNALM - Dpto. de Acuicultura y Tecnología Pesquera.	Refinement of carragenes
Densities of algae on the sea and growth parameters.	Laboratorio Costero de Pisco - IMARPE.	Estimation of algae populations in Pisco area.

Source: interviews and site visits

The chief of Laboratorio Costero de Pisco of IMARPE, describes the knowledge transfer and potential for activities in the future (J. Zevallos, personal communication, 26 of February, 2008):

"The knowledge generated during the project is used for Produce to administrate the resource seaweeds and as information. As Produce is a supervise organism they define norms for the sector.

The increase of use of the knowledge generated could be promoted through conferences and presentations for fishermen."

D. Observing gradual knowledge building in the project.

We use the learning histories tool [21] to examine the knowledge building process, where in a continuous process objectives are shown in the left side paper and the continuous advances of the project through participative meetings on the right side.

For example:

Process definition for getting use of harvesting areas and aquaculture sea areas	On November 8, 2007 there was a meeting with Engineer Lourdes Hermoza of the Dirección de Acuicultura of Produce, who presented us with the Resolución Ministerial No 326 of october 2007 that formed a multisectoral commission including government representatives, artisanal fishers and aquaculture representatives. It was observed that algae harvesters were not directly included in that commission. She also informed us about the procedures for get authorization for use of sea areas that are able in the Produce web. Also participating in this meeting were consultants of the PUC-Peru and San Luis Gonzaga universities and representatives of each algae association.
Asking for assignment of harvesting areas and aquaculture sea areas and need for a more sustainable conduct of the harvesting activity	On January 29, 2008 there was a meeting with an Acuicultura director of Produce and one engineer also from Produce and with two consultants of the PUC-Peru university. The consultants spoke about the advances in the project and expressed the need for authorization of 600 hectares for aquaculture development activity in the area near the Reserva Nacional de Paracas. The Acuicultura director said that algae quantity had decreased due to the inadequate harvesting practices. She considers a study of the natural prairies of seaweeds asking Imarpe - Pisco. Also she expressed that Algas Multiexport and Crossland enterprises dry the algae and sell the algae for human consumption. In addition she said getting authorization of sea areas for aquaculture requires the previous to qualify for use for the Capitanía de Puerto for detailed delimitation. They suggest that consultants consider the zone characteristics, like calm water, that could be affect the culture. They can only give areas not overlapping in the north direction of Santo Domingo and these areas must be smaller than 600 hectares. Finally, they suggest research before beginning with large scale culture.

By using this technique we can see advances being made in the ongoing knowledge building process. Several actors are brought together and missing actors identified. In particular knowledge is shared about government resolutions and procedures. The absence of algae harvesters, organization of second the meeting by the Dirección de Acuicultura of Produce and dominance of the agency as a source of the knowledge shared (one way vs. two-way) suggests that the project began as the hierarchical form of collaborative knowledge management.

However, there is an openness to including new actors, creating new paths and possibilities for learning. This suggests a willingness to move toward a more network-based approach. While it is too soon to fully describe the outcomes of this project observations to date suggest that knowledge generation outcomes are taking place. However, converting knowledge into decisions, actions, policies and innovations

that create sustainable development outcomes has yet to occur. Collaborative, participative development and observation and reflection on this process requires an ongoing and medium to long-term approach by actors in the knowledge network. The authors of this paper are themselves network actors and will continue to participate in this process.

Interaction in knowledge networks requires an investment of often-scarce financial and human resources. Further, poor interaction experiences may impact future willingness to engage in collaborative research and development activities. Effective knowledge systems must, therefore, apply knowledge to important problems and learn from that application. Determining if the loop will be closed, and if a collaborative, participatory approach will be fully applied and result in additional sustainable regional development outcomes, will require ongoing observation and participation.

VI. CONCLUSIONS

Referring back to the hypotheses of this research, the case study demonstrates that Peruvian research and development organizations are engaged in generating knowledge about algae and that this knowledge can be localized and applied in a specific region such as Pisco. A review of the experiences to date in algae culture in Pisco, Peru suggest that there has been research and knowledge sharing but development and innovation to date has been limited. In its initial phase, for example, the project has not yet resulted in the culture of algae *Chondracanthus chamissoi.*

The benefits of this knowledge generation, like sharing of the biochemical process for intensification of algae color, getting alginates and carragenes, harvesting techniques, drying technology, markets for algae and products, could be enhanced through the construction of a knowledge network that better integrates algae harvesters, government representatives and researchers through a more participatory, collaborative approach to research and development, helping to address remaining knowledge gaps.

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