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Bridging the engineering gap: integrated systems thinking

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Abstract. On visits to rural Indonesia it is apparent that the advances made possible by technical engineered solutions, are rarely at the same pace as the human captivation of technical development. This uneven pace has limited the application of labour-saving equipment and efficiency. It is suggested to be of primary importance to advance technical application skills among communities as part of the continuous advancement cycle in our human environment. A creative approach to inclusive technology and internal transfer of equipment knowledge in society, reduces barriers and could diminish structural or societal undesired situations. Earlier theoretical concepts provide us a lens for describing the practices of habitus, conceptualization of social capital and integrated systems thinking. The interrelationship and complexities in technical and social systems requires to be investigated. This paper aims to describe those, combined with technological applications in an empirical ethnographic approach. The study analyses the negotiations of community members with the available technology. It intends to foster a better understanding of the various cultural-economic values by exploring the systems thinking theory, with a focus on rice cultivation in Indonesia, Japan and Australia. This research suggests that cultural, economic and technical advances vary considerably and human expectations are strongly influenced by local culture.

1. Introduction

Education is focused on the development of technical and engineering skills, whereas the required application skills have been lagging in communities. Without, a direct link to communities, the engineered accomplishments remain below the optimum utilisation. The general prominence is upon change and adaptability, of which the rate of new inventions appears to be at an increasing speed. We have in fact passed beyond the stage of human organisations in which effective communication and collaboration are secured by the well-established traditional routines of wisdom transfer through relationship in society alone.

For this change, it is suggested that a focus on physio-technical engineering development is useful [1]. It is no longer conceivable for an industrial society to assume that only the technical processes of agriculture will remain unchanged. The challenge is how local cultural elements are incorporated.

The technical skill transfer could both incorporate the technical aspects and elements to enhancethe social connectivity. The skills required in contemporary society have developed in two directions. On the one hand, a higher type of skills is required, based upon adequate scientific and engineering knowledge, and secondly the visions of asocio-culturallydynamic society. This paper is to foster a qualitative analysis of the social and technical advances which show; use of information technology (IT), technical advancement and the social environmental dimensions, including community’s affinities. Those elements require multiple

attention at the same time. The field work was limited to the artisan rice agriculture which incorporates a strong social and emotional or spiritual motivation, traditional commercial and the technologically advanced agiculture with a strongerhigher yield motivation.
These variables are discussed in the light of the tension between technical advancement and procedural human action. Agriculture as well as manufacturing are complicated by the interaction of environmental, economic and social factors. This fosters an exploratory of the Integrated Systems Thinking theory and visit the current human adoption in a reality setting of open engineered social and closed sciences systems [2].

2.Integrated Systems Thinking

It flows from a growing awareness that multi disiplenary collaborative approaches are obligatory as a result from the increased complexity in technical and human resource diversity. As well because ofthe positive evidence of enhancement when the participation of engineers, staff, corporate and individual farmer or stakeholders are incorporated. In those cases, the quality of participatory processes or synergy was suggested to become a key feature for success to reach adesired wholenessor optimumyield, subject to technical and cultural elements of limitation [3]. The cognitive basis demonstrates how knowledge supports the monitoring process of equipment employed. This movement relates to what Cook and Brown [4] have named an “epistemology of possession” of knowledge, when knowledge in its stabilised form is measured to be able to circulate from one place to another and stimulatesinnovation.

In the field of engineering and society are facing often issues in which realities are uncertain; values might be disputed, the stakes might be high, and making decisions urgent [5]. In that context, social scientists and engineers like others may have some fear of taking sides on value-laden issues. It is claimed by many; this stalemate position is not defensible. Once scientists and technical experts are asked to define what reality is, this distinction becomes problematic because knowledge carries implicit values and local worldviews: What they say and know, cannot be distinguished from what they perceive reality ought to be with the input of equipment or technical process implied. It is considered, social learning is needed to engage various stakeholders in a problem formulation allowing stabilised agreements and purposeful action. These processes occur through interactions with others, involve social, cognitive, as well as emotional dimensions and could take account of Habermas’s proposition: “...the paradigm of knowledge of objects has to be replaced by the paradigm of mutual understanding between subjects capable of speech and action” [6]. In the field of management in which engineers, staff and agriculturalists require joint communication in understanding the process and spheres of thought that can be brought together. A joint vision of what problems were perceived and to be solved, provide an obvious picture of what could be done. Checkland [7] stated that hard systems are goal seeking, with given or assumed goals, whereas in soft systems the goals themselves are the bone of contention, this perspective raises the question of the role of traditional knowledge before engineered processing options are implemented, in setting certain goals in the output [8]. Is it used to force interacting stakeholders to conform in their thinking and doing, to problems defined by others in others place. Perhaps we could say it is used to help engineered farm equipment in the bio-socio-physical environmentto be complementary in a process, and stakeholders adapt their thought to take the most appropriate decision and apply the “goodness of fit” [9].

In mechanised agriculture, it offers a holistic approach that can help to understand the influences of processing (use of equipment), elements of sustainability by focusing on problems as the result of root causes and not the symptoms, while mediating it as a composition of interconnected events [8]. A process in agriculture is a transformation of materials and energy by labour and equipment in a social environment. In complex management situations of interacting of labour and equipment “the components and their interactions are changing and can never be quite pinned down” according to Snowden [10]. It is considered that social learning is needed to engage various stakeholders in problem formulation allowing purposeful action. A framework of the systems thinking approach fosters an analysis of the complexity of economic environmental and social benefit conflicts encountered in the agricultural ormanufacturing systems in terms of costs and benefits.

Indeed, once a system or policy is implemented and becomes part of the culture, it suggests the vision of the world, it conveys that interacts with local perception and interests leading to a translation of the cultural or system’s goals [10]. The translation results in and results from social economic learning processes, a focus in adaptive management [11 bordieu] and which could be defined as knowledge co-production among stakeholders brought together [12]. As Mayo suggested in 1945, team work and spontaneous cooperation among all employees are possible if thoroughly planned or made possible in industry and society to meet and grow on a on a level more commensurate with the development and utilisation of technical skills. The suggested growth equation in the mixed open and closed systems environmentin the mathematical model by von Bertalanffy $L(t) - L_{\infty} - (L_{\infty} - L_0)e^{-kt}$, the founding father of Integrated Systems Thinking concept[2], The multi-disciplinary approach by von Bertalanffy is touched on in this paper, although the mathematical model itself is outside the material of this paper.

3. Research Focus

Researchers acknowledging the integrated systems thinking concept can identify not only the relations of certain human behaviour, but the dynamics of sustainable performance measures in manufacturingor agrarian economic-social systems. The economic motivations often hesitate to invest in environmental, safety, cultural-social and health efforts, as the long lead-time outcome is not clear and provides uncertainty to the returns on investment. The cause lies in the challenge of related environmental and social practices of the physical engineered project to meet the potential economic benefits envisaged by the stakeholders. Managers in agriculture want to measure human behaviour and other inputs on a cost basis, the usual yardstick in business. Key questions should be asked to provide clarity on the decisions to be made. For example, how much attention should be incorporated for cultural or religious dedicated activities or can be gained by having members in a skill upgrade? How much can be saved to appeal to staff or community members to contribute with ideas on process setting, such as making modification in the process, energy consumption of equipment and safety aspects? What are the economic performances contributing of these efforts over time? With a current focus on the sustainable practices in any environment, these variables can vary from location or country. This paper will include the artisan farmers, and commercial agriculturalists. This second group has greater access to capital, skills and have commercial visions reaching out into the future. From an engineering perspective, it will range from basic traditional tools to sophisticated cutting edge equipment, encountered in countries where labour costs are high and labour-saving devices are very important for survival of the farm.

4. Data and Methodology

The framework of data collection was developed in two stages. The first stage comprised of long separated investigations of communities with minimalistic technological interventions and agriculturalists with access to technological equipment. Empirical field notes were collected through direct observation of the activities and conversations with stakeholders in different locations. The data were gathered over an approximate period from February 2012 till April 2017 and spread over a geographical area from Australia to Japan and the tropical environments of Malaysia and Indonesia.

Rice cultivation in different social and economic environments

Knowledge skills and cooperation varies enormously, like the cost structure and cultural factors or the availability of seeds, soil fertilisers, infrastructure and capital means. Also, the marketability of rice as a commodity has a cultural and religious significance. For instance, in the Dayak groups surveyed in Borneo, an informant explained that till relatively recently rice was not available for sale in the market. From this recognition can be deducted that rice has values, hardto measure such as nutritional food value, human exertion, or in economic terms of money.

The images below are from four locations; two in Indonesia, one in Japan and one in Australia. The first two can perhaps be best described as artisan agriculture as tradition and religious aspects are finely interwoven in the rice cultivation. In Japan, because of its large number of smallnear hobby size rice farms, tradition is interwoven with the highly developed equipment for those rice plots.The Australian rice growing model is a commercial agro-operation led by a manager, who are up to date with the latest technology and news.

The purpose of the country comparison is to illustrate how local socio-cultural and economic driven aspects have created different settings of the agriculturalist’s interaction in their environment. Figure one to four below provides notions of human and equipment involvement in the planting stage, five to eight are impressions at the harvesting stageof the rice cultivar.

4.1. Various planting techniques to establish rice fields

Dayak shifting cultivators in Borneo, Indonesia, apply the traditional technique of community rice seed broadcasting in unirrigated fields. Shallow holes are poked into the soil with a stick or tugal, by a group of community planters. A second group, as seen in the image, follow and broadcast the rice seeds in the holes. The“nugal” planting technique is being performed by Dayak groups. This cultivation pattern yields one crop a year, without the input of industrial fertilisers.

Figure 1. Nugal tradition, photo by rmolsumsel.com.

Traditional aquatic rice planting in Central Java, Indonesia. This seedlingplanting technique is carried out in a small group or by a singular planter. With improved rice varieties and irrigation, crops are harvested five times every two years in Central Java. In some parts of West Sumatra, it is not unusual to grow up to three crops a year with special cultivated rice seeds and input of industrial fertilisers.

Figure 2. Manual aquatic planting, photo by Gunawan Kartapranata

Agriculturalists in Japan grow rice for commercial and personal purposes. With limited space for cultivation due to the many mountains the average farm size is under one hectare. Rice is perceived as a culturally precious commodity. Because of the many part time farmers,it is the norm to apply a mechanised seedling planting technique.

Figure 3. Mechanised planting, photo by Jerry Anderson

Aerial sowing of rice seeds by hi-tech equipped crop planes is one of the options in cost effective farming in Australia. Engineered facilities guided by satellite navigation systems for accurate broadcasting of the seeds. In this image, a plane swoops low over a recently irrigated rice field that will be drained at the precise moment to conserve water and maximised crop quality and yield atharvest time.Usual two crops are produced per year.

Figure 4. Aerial seed broadcasting (Photo by V Bucello)

4.2. Various techniques in crop harvesting

Figure 5. Traditional panicle harvesting, photo upperkapuas.blogspot.com.au

The ladang or field are harvested by the Dayak groups about four to six monthsafter planting, depending on weather andseed variety.Individual growersusually sow three to six different varieties each year.The genetic rice pool might be forty to sixty species in any given village. According to Dayak magico-religious tradition the rice goddess, in the Iban Dayak culture Pulang Gana, is honoured by harvesting only the rice panicles. It means that each rice stalk is harvested individually by hand.Yields vary from 200 kg up to 800 kg a hectare (kg/h) in recordings taken in the period from 1985 and 1997 [14].The variation are mainly caused by soil fertility, drought, floods, pests, fungal attacts and animal intrustion (birds and rats).

Figure 6. Manual harvesting, photo by author

In West Sumatera, Java Bali and many other locations in Indonesia or for that matter in Asia, the rice crop is harvested by cutting the whole plant. The padi or whole rice grain with husk is mechanical or manual released by a firm bashing movement. The padi, is transported in bags from the field to storage places. When the farmer or trader sells the rice, the padi is taken to a mechanical rice huller to remove the husk and polish the grain.Yield on the main islands of Indonesia varies between 4.8 – 5.6 tonnes a hectare (t/h) in 2009 [15]
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Figure 7. Mechanised harvesting,photofactsanddetails.com

Harvesting in Japan is being carried out on small rice fields with compact mechanised equipment. This is to meet the local conditions of the mainly part-time or "Sunday" farmers who derive their main income external from rice farming. Although food consumption patterns have shifted to include bread, cereals and pasta, the historical cultural significance of rice growing and consumption remains strong in Japan. To encourage the continuation the government is subsidising rice cultivation. Because of the staple food control act (1942) the government oversees distribution and sales. Average yearly crop yield is 5t/h [16].

Figure 8. Commercial harvester, photo by V Bucello

Harvesting in Australia is by means of special satellite navigated harvesters, to reduce damage and maximise rice yields. Monitoring equipment in the harvester records the precise rice yield in every section of the field. This data collection allows precise future application of fertilisers for optimal dosage. Agriculturalists are professional managers and work together with specialised technical rice production equipped contractors.The average 5 year yieldwas 10 tonnes a hectare in 2016[17].

5. Results and Discussion

Technological development supported by advanced engineering and IT has touched the agricultural sector in an uneven pattern. It is noted that agriculture is significantly influenced by local culture and the connecting worldviews in the community, as well as resources, education, infrastructure, financial capital and a whole range of interlocked variables, including government support. Farmers could be assisted in their rice cultivation by long established tradition and new modern sign posts. From traditional experience, to rice production needing high technically skills with the aid of electronic guided devices and software. Those advancements firstly enable farmers to be part of the participatory dynamics and suggest fostering skill ownership in the community which provides meaningfulness and self-confidence. Secondly, applied technology support the development of technological literacy in communities of non- or semi-skilled members. These utilisations provided engagements of opportunities on local and commercial matters of concern. Thirdly, they enabled teamwork and support the development of champions' in the community, able to orchestrate complex collaborations.

6. Conclusion

Locations have their emotional and commercial connectivity inrice cultivation, thus not a simple equation of people, growing, enhancements by engineering and capital investment. Von Bertalanffy allowed to foster a relative relationship of engineering, culture, commercial behaviour and human interaction. In Australia highly engineered assisted rice yields are 10 t/h while in higly cultural traditional Dayak cultivation, field yields between 200 to 800 kg/h. It is merely from the advantaged position in global rice cultivation that differences have come to our attention. The main findings in this paper suggest that an understanding of the different perspectives of the stakeholders in agriculture and open discussion could lead to better cooperation in engineering and understanding of cultural expectations. Future research in engineered solusions and cultural affinity could alleviate tension in crop procrument and food security.

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