Vol.16(2), pp. 64-79 April-June 2024
DOI: 10.5897/JAERD2023.1391
Articles Number: 12EF86B72153
ISSN: 2141-2170
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ACADEMIC JOURNALS
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Journal of Agricultural Extension and Rural Development

Full Length Research Paper

A proposal of rock dust and biological fixation of nitrogen based on cooperatives to reduce dependence on chemical fertilizers in Myanmar

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Received 22 August, 2023; Accepted 13 February, 2024

The defense mechanism against the Coup in Myanmar and the war in Ukraine hampered the functioning of most private and public activities and the relationships between distance and price dispersion have increased. Through a study of the rice cultivation in Myanmar, the article suggests the creation of an institutional environment that supports voluntary forms of cooperatives, developing a culture of independence, self-help and self-governance, the characteristics of the bio-dynamic agriculture. As the main contribution, this article presents two models: The Culture-Knowledge-Intelligence (CKI model) and the biodynamic agriculture model based on cultural change, agricultural cooperatives and the remineralizer rock dust to cope with climate change and the various barriers caused by armed conflicts in Myanmar and Ukraine, strongly supported by China and Russia, respectively. This model is based on Knowledge Management (KM, knowledge creation) and Organizational Intelligence (OI, knowledge application), in particular communities of practice (KM practice) and expert analysis (OI practice). The main conclusion is that Myanmar should strengthen ties with Germany and Australia in the area of agriculture, including research about rock dust, since Germany has the largest bio-dynamic area (34% of the world total) followed by Australia (20%).

Key words: Biodynamic agriculture, cooperatives, fixation of nitrogen, knowledge management, Myanmar, organizational intelligence, rice, rock dust.

INTRODUCTION

Boincean (2018) explains that the challenges facing agriculture show that it is in a systemic crisis. The industrial model of agricultural intensification, based on the concept of “green revolution”, did not guarantee sustainable economic, ecological and social development. The predominant orientation towards maximizing the level of production and income within the framework of high-performance crop cultivation

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technologies has completely neglected the restoration of soil fertility and the disintegration of rural communities.

This article could be of interest to soil scientists because it provides two modern advances in improving the soil’s nutrients, focusing on the culture of rice, in Myanmar.

When the state fails to assure its normal role in ensuring food security, the ONGs should provide training small farmers to avoid further suffering of vulnerable households.

The civil disobedience movement (CDM), as a defense mechanism against the Coup in Myanmar, hampered the functioning of most private and public activities and the relationships between distance and price dispersion have increased, in particular in more remote region due to the difficulties of transportation in the Myanmar’s roads and the agricultural trade with China. This seems to be the plan of China in Myanmar to provoke a very high level of brain drain, as in Taiwan (De Angelis, 2023).

According to Minten et al. (2023), China controls also the most important Special Economic Zones (SEZs). In fact, the three most notable ongoing SEZ projects are the Kyaukpyu, Dawei, and Thilawa.

Kyaukpyu SEZ is the backbone project of the China-Myanmar Economic Corridor (CMEC) established under the belt and road initiatives (BRI) (Dutta, 2018). It is China’s flagship BRI project in Myanmar Terminal Point of China’s USD 2.5 bio oil and gas pipelines, which provides an alternative energy transport route from the Middle East to China, thereby improving port facilities in the Bay of Bengal (Sternagel, 2018).

The International Commission of Jurists (2017) has reported that SEZs in Myanmar are linked to human rights violations and environmental abuses (Donateo, 2017).

The highest rate of deforestation is linked to the military regime due to increased fuelwood demand, commercial agriculture, urbanization, and illegal logging (Linn, 2015).

Springate-Baginski et al. (2014) analyzed the potential of the EU timber legality verification system to advance democratic reforms in Myanmar, and Dong and He (2018) analyzed the distributors of benefits from timber trade between Myanmar and China.

In 2015, Myanmar started negotiating a volunteering partnership agreement (VPA) with the EU in Bago region (EIA, 2016).

This short introduction of the attempts of EU to compensate the strategy of China in Myanmar only reinforce the necessity of ONGs to provide the high level of training for small farmers in order to reduce the impact of the Coup on the production and distribution of rice, the main agricultural commodity of Myanmar.

In order to help the ONGs in this possible initiative this article shares with the readers a model of biodynamic agriculture based on knowledge management and organizational practices.

Theoretical background

Rock dust applied and fixation of nitrogen in Myanmar's rice culture

Myanmar's military took control of the country in a coup on February 1, 2021, setting the country on a path toward widespread violence and major economic collapse, and the fallout increased due to protests against the coup, which became known as the Myanmar Movement Disobedience (MDL) and worker strikes that led to stoppages in the provision of services by public and private institutions, and then violence, which also leads to an increase in price dispersion.

Some researchers have discovered a link between rising food prices and the violence generated by eating disorders (Bellemare, 2015; Dube and Vargas, 2013; Hendrix and Haggard, 2015).

Obviously, the people most affected by rising retail prices are those who live in more isolated areas, further away from export opportunities and the country's main production zones.

Minten et al. (2023) found that in September 2021, almost 30% of food vendors indicated problems acquiring food, the highest figure in all surveys conducted in the previous 1.5 years. They also found that proximity and trade flow across borders are associated with less price dispersion, suggesting that ties to export markets can anchor rice prices.

In 2020, around 2.3 million tons of rice were exported through formal and informal channels (USDA, 2021) and most of the rice to China through the border town Muse (Proximity Design, 2016).

However, more recently we have seen an increasing diversification of export locations (Diao and Li, 2020; USDA, 2021).

According to the Observatory of Economic Complexity (OEC) in 2021, Myanmar exported $702M in rice. The main destinations of Myanmar exports on rice were China ($338M), Philippines ($67.3M), Belgium ($58.6M), Bangladesh ($44.2M), and Poland ($40.4M).

This work then demonstrates the importance of keeping borders open and increasingly strong, in particular with India, Laos and Thailand, given China's influence on the Myanmar conflict, including voting against a UN intervention in the region with the aim of attempting a return of democracy.

Due to many challenges in the rice value chain after the coup, most importantly linked to banking and transport, Minten et al. (2023) found increases in retail rice prices, by 11% on average.

Minten et al. (2023) examined the travel costs and border crossings and also explained that rice is the main staple in Myanmar, accounting for 51 and 62% of calories consumed in urban and rural areas, respectively, making it crucial for food security in the country, but unfortunately approximately 70% of rice that is consumed is purchased.

In 2021, OEC found that Myanmar imported $1.32M in rice, mainly from Thailand ($830k), India ($329k), China ($154k), Japan ($2.03k), and Bangladesh ($1.12k).

Mostafanezhad et al. (2022) the Thai-Myanmar border represents one of the most protracted displacement situations in the world, while the Myanmar-Bangladesh border is now home to nearly one million displaced Rohingya, making it the world's most populated refugee camp.

These refugees could work with the Thai farmers to send good agricultural products to Myanmar.

In term of infrastructure, there is a lot of progress being made on the Trilateral Highway, which will link India, Myanmar, and Thailand. The natural gas pipeline being built in the North East would benefit Manipur, a state in India's North Eastern region, which has 398 km of border with two Myanmar provinces: Sagaing region in the east and Chin State in the south (Minten et al.,2023).

Sen et al. (2004) state that India-ASEAN bilateral trade has increased from $2 billion in the early 1990s to $71.6 billion in 2016 to 2017 and since Myanmar is important as a link between South and Southeast Asia, it has played a large part in India's diplomatic horizon. Both countries have a long land border and a maritime border in the Bay of Bengal. Myanmar is also important for Indian national security where the two countries have agreed to share real-time intelligence in order to combat Indian insurgents operating along the border (Kundu, 2022).

Economically, Moreh is a major commercial center that is crucial to the India-Myanmar relationship, as well as a rapidly developing trade point in India on the Myanmar border, with the city of Tamu on the other side of the border. In the meantime, India has evolved into a transit country as well as a target market for drugs generated in the "Golden Triangle," which is situated between Thailand, Myanmar, and Laos. These are persistent issues, and, if not addressed, smuggling drugs into Manipur would then exacerbate the state's and India's internal drug problem (Sen et al., 2004)).

Internally, three regions (Bago, Yangon, and Ayeyarwady) collectively account for 45% of the monsoon rice produced in Myanmar (Goeb et al., 2022) and 69% of the summer rice production (Minten et al., 2023).

According to Silva et al. (2022), Bago, Myanmar, has two major growing seasons per year: the summer season or dry season (DS) from November to May and the monsoon season or wet season (WS) from June to January.

In Myanmar, rice productivity is significantly lower than in neighboring countries mostly due to low input use, limited training, and poor infrastructure. However, the government recently set targets to double agricultural productivity and farmers' incomes in a little over 10 years (Dubois et al., 2019).

In fact, the southwest of the country has the appropriate weather to produce rice since this culture depends on a great amount of water, but the farmers are still high dependent of chemical fertilizers. This is the reason that according to Thwe et al. (2019) over 55% of the rice area located in the Ayeyarwady delta, that fans out from the limit of tidal influence at Myan Aung to the Bay of Bengal and Andaman Sea, 290 km (180 mi) to the south at the mouth of the Ayeyarwady River.

Silva et al. (2022) found that the yield gap, in terms of efficiency, resources and technological components in rice production through better crop management, was greatest in Bago, Myanmar (75% of Yp), intermediate in Yogyakarta, Indonesia (57% of Yp) and in Nakhon Sawan, Thailand (47% of Yp), and lowest in Can Tho, Vietnam (44% of Yp). The yield gap in Myanmar was largely attributed to the resource yield gap, reflecting a large scope to sustainably intensify rice production through increases in fertilizer use and proper weed control (that is, more output with more inputs).

The aim is to mitigate dependence on the foreign market through the technique of soil remineralization with the use of minerals.

Farmers who are familiar with the rock-dusting technique are looking for lower costs and higher production, which is why it has greater potential in family farming, as it is an activity with less financial risk and reduces dependence on imported chemical fertilizers (Parikoglou et al., 2022).

Rock dust also reduces the environmental impacts caused by chemical fertilizers, such as soil and water pollution (Silva et al., 2022).

Besides that, according to Ramos et al. (2022) chemical fertilizers rely heavily on chemical pesticides, which cause damage to soil's microfauna (responsible for the decomposition of organic matter and nutrient cycling) and the loss of organic carbon (in the form of dioxide), which is quickly dispersed in the atmosphere.

Dobiszewska et al. (2023) state that rock dust is created, in the production process of crushed-stone aggregates. In the course of mechanical treatment and extraction process of rocks and the follow-up sorting, an appreciable amount of waste material, such as rock dust, is produced. This waste rock dust is also produced in the asphalt industry. The most abundant sedimentary carbonate rock generated from calcium carbonate is limestone. They are usually rocks made of cemented, clastic carbonate components or of directly precipitated carbonates, containing rock-forming carbonate minerals: calcite, aragonite, and dolomite. Contemporary limestone sediments consist of calcite and aragonite $CaCO_3$, while in older formations metastable aragonite has been converted into a permanent form of calcium carbonate, calcite, in earlier formations (Mindess and Diamond, 1980).

Kurdowski (2014) found that the negative effects of the reaction of some aggregate components with the solution in the pores of the slurry are, for example, the reaction of reactive silica (opal, tridymite, silica glass) and aggregates with sodium and potassium hydroxides contained in cement paste, which leads to expansion and cracking in concrete. Pyroxene and olivine, two magnesium-containing rock-forming minerals, produce unfavorable concrete swelling (Kurdowski, 2014).

On the other hand, there are several rocks that are excellent nutrients for the soil, depending on the type of rock, the type of soil and, above all, the crop to be grown.

However, the relationship between different rocks and crops has not yet been properly researched. Soil remineralizers can come from rocks of various origins and chemical compositions.

There are studies analyzing the use of rock dust to replace cement in concrete production. Dobiszewska et al. (2023) found that rock dust of different geological origin can be considered as potential alternative material that can be used in cement composites production. However, there are some conflicting findings concerning the effect of rock dusts as partial cement replacement on the physical and mechanical properties and durability of cement composites as reported in the literature. Thus, a comprehensive assessment and analysis are needed to evaluate the value of rock dust application as cement replacement in concrete production.

Rock dust releases nutrients more slowly, which offers advantages such as a longer residence time of nutrients in the soil compared to chemical fertilizers (Theodoro and Leonardos, 2006). In addition to increasing agricultural production and reducing production costs, it avoids environmental impacts caused by chemical fertilizers, such as the pollution of soils and water resources (Silva et al., 2022.

One of the techniques used by de Barros Viana et al. (2021) involves the association of intermediate doses of basalt powder with larger doses of bovine manure (Camargo et al., 2012). The techniques are varied but the most effective was the use of rock powder associated with another type of fertilizer.

de Barros Viana et al. (2021) emphasize that the use of rock dust in Brazilian agriculture has great potential but it is still not well explored and requires the development of further research and studies, especially evaluation of the agronomic effectiveness of rock dust associated with animal manure.

Theodoro and Leonards (2006) state that rock powders are rich in phosphorous, calcium, magnesium, potassium, and micronutrients.

Theodoro and Leonardos (2006) selected the MATA DA CORDA volcanic rocks as the best likely materials to be used as rock fertilizers in such settlements. Their tuffs, lavas, and pipes were richer in macro and micro nutrient elements than most rocks and besides they have ample distribution (450 km^2) in the Central Planteau of Brazil.

According to Theodoro and Leonardos (2006) in all the areas, farmers who conducted the experiments to the end were unanimous in recognizing the advantage of rock fertilizers in respect to conventional chemical fertilizers. In fact, one of the main reasons to use basaltic rock dust in agriculture is due to its potential reducing chemical fertilizers.

According to Conceição et al. (2022) the several benefits from basalt dust were due to its parent rock, which provides part of the macro and micro nutrients required for plant development and soil pH rebalancing. Studies have reported production cost savings of up to 50% by the use basaltic dust (Melo et al., 2012). Most Brazilian regions have basaltic rock reserves rich in P, Ca, and Mg (Ramos et al., 2015).

Soil with contrasting textures (sandy and medium) were incubated with basalt dust doses for 90 days and the results of the incubation test showed that basalt dust increased available phosphorus, potassium, calcium, and magnesium levels in up to twenty times higher than those without the basalt dust due to the maintenance of improved chemical properties in the soil. In particular, maize and bean plants grown in soils enriched with basalt dust up to five times higher than plants without the use of basalt dust (Conceição et al., 2022).

In the same direction, other studies have shown that applying Basal Rock Powder (BRP) significantly improve the chemical properties of the soil, particularly calcium, magnesium, phosphorus and potassium concentration (Curtis et al., 2022; Luchese et al., 2021).

Van Der Bauwhede et al. (2024) highlight that rock dust helps prevent the leaching of nutrients down the root as it provides for the slow release of these nutrients into the soil, but it depends on the mineralogy of the rock, the acidity of the soil and the test methodology.

Physicochemical properties that can be altered by soil disturbance, reducing fertility and revegetation potential, include pH, texture, moisture, temperature, electrical conductivity, nitrogen, phosphorus, potassium and soil organic matter (Ingole, 2015) .

Ongoing soil acidification poses a significant threat to the functioning of numerous ecosystems around the world. Rock powders are increasingly used for acidic soils to restore their pH, but the acid neutralizing capacity and dissolution rate of these products are highly variable and lack adequate assessment protocols (Van Der Bauwhede et al., 2024).

Therefore, global interest is now growing in treating acidic soils with silicate rock dust (RD), also called rock dust/flour (Beerling et al., 2018; Kelland et al., 2020; Lewis et al., 2021; Taylor et al., 2021). The exploitation of rock dust as an agricultural amendment has increased in the last decade, e.g. its share currently reaches 7% of annual agricultural inputs in Brazil (Manning and Theodoro, 2020; Ramos et al., 2022, 2015). Furthermore, RDs are proposed as a “no regret” measure in critically acidified forests to support nature restoration objectives, e.g. as described by the European Union's Natura 2000 framework (García-Gómez et al., 2014; Graveland et al., 1994; Jacobsen et al., 2019; Diggelen et al., 2019; Vicca et al., 2022). Commercially, silicate RDs are a broad and not formally classified group of mining (by-)products, but are generally ground igneous or metamorphic rocks (0.001-3 mm) that consist of aluminosilicates and may contain varying amounts of other classes of minerals. Among the aluminosilicate minerals commonly found in RDs are orthosilicates (e.g., olivine), inosilicates (e.g., pyroxenes such as diopside, amphiboles such as hornblende), tectosilicates (e.g., orthoclase, plagioclase, nepheline, and leucite), and phyllosilicates (e.g., mica such as biotite and muscovite) (Calabrese et al., 2022; Swoboda et al., 2022; van Straaten, 2006). RDs can be an alternative to conventional liming, but unlike liming, they have a lower ANC and release their alkalinity more gradually. Furthermore, they are a source of a set of nutrients such as calcium (Ca) and magnesium (Mg), but also potassium (K), phosphorus (P), and sulfur (S) (de Vries et al., 2021; Ramos et al., 2022; Swoboda et al., 2022).

In addition, Ramos et al. (2022) demonstrate the clear influence of enhanced weathering of rocks on the sequestration of CO_2 in the atmosphere and other greenhouse gases emitted by human activities. When CO_2 reacts with Ca and Mg cations, which are present in abundance of silicate minerals such as olivine, serpentine, wollastonite, and Ca-plagioclase, it configures itself in a favorable process to form carbonate minerals and therefore the possibility of CO_2 sequestration through accelerated weathering.

The sequestration of carbon dioxide in the atmosphere and its accumulation in the soil in the form of soil organic matter reduces global warming (Dent and Boincean, (2021).

Dobiszewska et al. (2022) found out that in the literature, there are relatively few study results on the effect of basalt dust on the cement hydration compared to the findings on other dusts, e.g., limestone, marble, or quartz. The chemical and physical effects of basalt powder on the hydration rate of cement are related. The crystallization of cement hydration products may be aided by the large specific surface area of basalt dust, which in turn raises the degree of hydration.

The overall conclusion is that the addition of stone powder can reduce the long-term mechanical properties of conventional cement composites and a slight improvement in strength can be observed at an early age. However, a different situation in the case of ultra-high-performance concrete (UHPC) was observed. The inclusion of quarry stone powder degrades the mechanical properties of UHPC in the short term, but it may considerably improve the long-term compressive strength development.

In Myanmar, the crop establishment method was set individually for each farmer (Silva et al., 2022); however, rock dust could be accepted by farmers collectively through agricultural cooperatives. For this culture, change is necessary in order to reduce the dependence of government's regulations, formation courses, and financial support.

Incentive to the production of organic compost within the same properties using rock powder, as mineral and organic fertilization methods should be jointly encouraged through practices of Knowledge Management and Organizational Intelligence.

Silva et al. (2022) found that N application rates in Bago were well below 60 kg N ha^{-1} in most fields. Improvements in pest, disease, and nutrient management are likely to be needed, in tandem with increases in N applied, for intensifying rice production in this site. The levels of fertilizer use and rice yield observed in Bago are comparable to those observed in the 1970s for rice crops in Central Luzon, the Philippines (Kajisa and Payongayong, 2011; Laborte et al., 2012).

Another well-accepted strategy in the literature to improve food production is biological nitrogen fixation in rhizobia, which occurs mainly in the root or stem and is induced by bacteria present in legumes (Lindström and Mousavi, 2020).

According to Boicean (2021), the lack of organic fertilizers and the predominant use of mineral fertilizers, especially nitrogen fertilizers, intensify the mineralization processes of soil organic matter.

In fact, Boincean et al. (2010) studied the influence of organic fertilizers in reducing the danger of nitrate leaching both in corn grain crops and, in particular, in sunflower crops.

The search for alternative ways to meet the nitrogen needs of plants continue to be a serious problem for all humanity and this increases due to the fact that the efficiency of use of mineral fertilizers by plants, based on nitrogen, is relatively small (Dent and Boincean, 2021).

According to the data reported by Mulvaney et al. (2009), coefficient of use of nitrogen mineral fertilizers by cereal crops constitutes 33 and 36%.

Approximately 95% of the N present in the soil is in organic form. Only about half of these compounds have been identified. In addition to organic nitrogen, there are inorganic mineral forms.

BNF decreases the use of mineral N fertilizers (Saxena et al., 2019), which require high levels of energy for synthesis and additionally they require energy for transport, and their use results in the emission of nitrogenous gases (Reis et al., 2017; Soumare et al., 2020). According to Telles et al. (2023) in one of the first studies on the economic benefits of BNF carried out in the USA, the estimated value from increased BNF efficiency was 1.067 billion USD with a reduction of 1,547 thousand tons of N fertilizers and corresponded to 4,484 billion USD with the total elimination of N fertilizers of major crops (Tauer, 1989). Approximately a decade later, the economic benefits of BNF for legumes were estimated at 90 billion USD globally and 8 billion USD in the USA (Pimentel et al., 1997).

Biological nitrogen fixation (BNF) is the process by which atmospheric nitrogen (N_2) is converted into forms that can be absorbed by the plant, such as nitrate (NO_3-) and ammonia (NH_4+). This fixation is carried out by nitrogen-fixing bacteria that have the nitrogenase enzyme responsible for catalyzing N_2. The more rhizobia there are in the soil, the better the biological nitrogen fixation will be. In addition to generating greater productive yield, nitrogen fixation helps to recover degraded areas and improve soil fertility (Embrapa, 2017).

Telles et al. (2023) estimate the value of ecosystem services provided by BNF in soybean crop in Brazil. Savings generated by BNF in the 2019-2020 crop seasons were estimated at 15.2 billion USD, and 183 million Mg CO_2-e were avoided.

Vieira (2017) explains that organic nitrogen mineralization (MNOr) is an enzymatic process resulting from the conversion of organic forms of N into inorganic forms available to plants. It is driven by heterotrophic, aerobic and anaerobic microorganisms, which use plant residues as sources of carbon (C), N and energy. To be absorbed by organisms, organic N (NO) is first decomposed into smaller units by extracellular enzymes (Moreira and Siqueira, 2006). The resulting compounds can be absorbed directly or mineralized in ammoniacal form [NH_3, ammonia (gaseous form); NH_{4+}, ammonium].

Lindström and Mousavi (2019) highlight that this symbiotic nitrogen fixation uses solar energy to reduce the inert gas N_2 to ammonia at normal temperature and pressure, and this is especially important today for sustainable food production.

Plant endophytes and bacteria inhabiting the rhizosphere have been reported to improve module formation and tolerance to biotic and abiotic under controlled conditions (Vijayabharathi et al., 2016). These plant growth-promoting rhizobacteria (PGPR) represent diverse taxa and have sometimes been used successfully as biofertilizers. Hydrogenation of N_2-fixing root modules can help fuel plant growth promoters (Schuler and Conrad, 1991).

More knowledge and experience is obviously needed in these two techniques: soil remineralization using rock dust and biological nitrogen fixation in rhizobia.

Best practices and lessons learned from bio-dynamic agriculture

According to World Wild Life (WWF), agriculture is the world's largest industry, employing more than one billion people worldwide and generating more than $1.3 trillion worth of food annually.

Morseletto (2019) argues that the so-called "green revolution" has been characterized by intensive agricultural practices in developed countries, where abuse of chemical fertilizers and pesticide use, monoculture production, intensive irrigation and deforestation have been common practices.

The green revolution has failed to catch on because it has greatly reduced production and productivity, without a balance with job creation and food subsistence, even within the household. This was due to excessive focus on the environment, without a balance with the community, livestock and marketing of part of the production.

An excellent alternative to industrial agriculture, also in decline due to excessive mechanisation, chemical manipulation and use of herbicides, as well as disregard for environmental conservation, is bio-dynamic agriculture.

Bio-dynamic agriculture is a step ahead of organic farming because it takes a holistic, ecological and ethical approach to farming, gardening, food and nutrition, and is a way of living, working and relating to nature and agricultural vocations based on common sense practices, awareness of the uniqueness of each landscape and the inner development of each person and, consequently, of all practitioners within the community.

Bio-dynamic agriculture has its roots in the work of the philosopher and scientist Dr Rudolf Steiner, whose 1924 lectures to farmers opened up a new way of integrating scientific understanding with an awareness of the spirit in nature.

Crops are used for a variety of purposes, including human food, animal feed, biofuels and other non-food products (Cassidy et al., 2013).

Cover crops also contribute to farm fertility by adding plant diversity and bringing life and sentence to the soil through oxygen and nitrogen.

Dent and Boincean (2021) explains that adherence to crop rotation helps to reduce the use of mineral fertilizers (in particular, nitrogen) and pesticides to combat diseases, pests and weeds.

Furthermore, Boincean et al. (2010) highlight that the nitrogen doses applied do not take into account the mineralization of nitrogen in the soil and its use in different crops within the rotation system.

Crop rotation helps balance the needs of each crop and allows for creative diversity of expression in the soil. Together, these practices reduce or eliminate the need for imported fertilizer and allow the farm to move toward balance and resilience (Zaller, 2004).

Common sense practices include: striving to be self-sufficient in energy, fertilizers, plants and animals; structuring activities based on working with the rhythms of nature; using diversity of plants, fertilizers and animals in a healthy way; approaching work with seriousness, neatness, tidiness, focus on observation and attention to detail; timeliness in doing work (Paull, 2011).

Campbell and Ortíz (2012) and Raupp (2001) found that soil improvement, within the bio-dynamic farming approach, is achieved through proper humus management, for example, by applying sufficient manure and organic compost in the best possible fermentation state; proper crop rotation; good soil functioning; protective measures such as wind protection; cover crops, green manures and diversified crops rather than monocultures; and mixed cropping so that plants can help and support each other.

Dent and Boincean (2020) determined the amount of mineralised organic matter to obtain the expected yield of different crops in isolation with and without perennial grasses. Soil organic matter balance was determined by comparing the amount of mineralised organic matter for yield formation and the amount of newly formed organic matter (humus) from crop residues and manure. The authors propose a model to evaluate the provision of dairy cattle with forages and, concomitantly, the capacity of soils to compensate, together with manure, the mineralization losses of soil organic matter for the formation of the expected level of production (Dent and Boincean, 2020).

The general rule is that soil-depleting crops, such as maize and potatoes in the field and cabbage, cauliflower, etc., in the garden, should alternate with soil-replenishing crops, such as those of the legume family (peas, beans, clover, etc). Also, deep-rooted crops should alternate with shallow-rooted crops, and crops that require fertiliser should alternate with those that can do without.

In this direction, a national policy and programme of technical assistance for family farming, with implementation through local administrations and institutions, will benefit smallholder farmers through subsidized inputs and technical assistance (Mazhar et al., 2021), will help encourage improved farming practices through crop diversification (Nyantakyi-Frimpong and Bezner-Kerr 2015), and new mechanisms for farmers to communicate with investment banks and traders, as well as social organizations (producer association) to facilitate participation in state-promoted programs and projects

In the direction of bio-dynamic agriculture, FAO (2021) found that sustainable agricultural practices can help reduce damage to ecosystems and help maintain food production despite climate change, extreme weather, drought and other disasters, as well as progressively improve land and soil quality.

With regard to irrigation, it should be noted that comparisons between irrigation infrastructures are scarce in the literature, but the clear advantage of drip irrigation is the uniform supply of water directly to each plant throughout the growing season, according to the water needs of each crop. The irrigation interval and frequency must be maintained as they vary from crop to crop.

Other advantages of drip irrigation in relation to sprinkler irrigation are: 1 savings in water and energy in pumping water and in the workload itself, (2) possibility of applying fertilizer, (3) reduces the risk of weeds, and (4) maintains the structure and texture of the soil.

The main disadvantage is the initial cost. It is also important to note that drip flooding can occur. In this sense, it is extremely important to be aware of trade-offs in the agrozootechnical areas of family farming.

For example, in the absence of measures to restore soil fertility, irrigation contributes to the intensification of the processes of mineralization of soil organic matter, with all the negative consequences.

Drip irrigation rather than sprinkler irrigation is, without a doubt, the best irrigation technique for Myanmar's soil type.

Integration of knowledge management and organizational intelligence practices

In general, scholars suggest that governments need to ensure that science is at the forefront of the strategy for economic recovery and economic growth. For them, science produces knowledge and therefore produces innovation, which improves quality of life, democracy, economic growth, and the ability to solve larger problems. However, Rothberg and Erickson (2004) hold that knowledge is static and ultimately, it only has value if people use it.

In 1989 Richard Ackoff established a simple taxonomy of environmental stimuli that has been widely adopted as concerns Knowledge Management (KM), holding that four classes of inputs exist for any system: data, information, knowledge, and intelligence (Ackoff, 1989).

Davenport and Pruzak (1998) made an important study about the differences among data, information and knowledge. Data is a set of discrete, objective facts about events. In an organizational context, data is most usefully described as structured records of transactions.

Like many researchers who have studied information, we will describe it as a message, usually in the form of a document or an audible or visible communication. As with any message, it has a sender and a receiver. Information is meant to change the way the receiver perceives something, to have an impact on his judgment and behavior. Most people have an intuitive sense that knowledge is broader, deeper, and richer than data or information.

Knowledge is a fluid mix of framed experience, values, contextual information, and expert insight that provides a framework for evaluating and incorporating new experiences and information. It originates and is applied in the minds of knowers. What this definition immediately makes clear is that knowledge is not neat or simple. It is a mixture of various elements; it is fluid as well as formally structured; it is intuitive and therefore hard to capture in words or understand completely in logical terms (Davenport and Prusak, 1998).

The transformation of knowledge into intelligence is an operation accomplished by the human capacity to interpret, analyze, integrate, predict, and act.

The information is analyzed in the context of the personal standards, criteria, and expectations of the decision-maker to become knowledge. Finally, the decision-maker applies this knowledge to a particular situation to create intelligence.

Rothberg and Erickson (2004) clarify that knowledge is socially constructed through collaborative activities, but access to this knowledge does not mean success in decision making, since knowledge without application is innocuous. In summary, knowledge is the foundation for intelligence, since intelligence is knowledge in action to solve problems.

Bali et al. (2009) define Knowledge Management as a set of tools, techniques, tactics, and technologies designed to leverage the intangible assets of the organization by extracting data, pertinent information, and relevant knowledge to facilitate decision making. KM is a set of practices aimed at the interaction between tacit and explicit knowledge to acquire and create new competencies (knowledge + skills + attitudes) to enable an organization to act intelligently (transform complexity into meaningful simplicity) in different environments (De Angelis, 2013).

Knowledge Management practices are grouped into three dimensions: people, processes, and technologies.

Regarding people, the best known practices are: forums (face-to-face or virtual)/discussion lists, corporate education, narratives, coaching, corporate university, mentoring, communities of practice or knowledge communities.

In regard to practices in the area of process management, the most commonly used practices are: Internal and external bench-marking, best practices and lessons learned, bank of organizational and individual competencies, mapping or KNOWLEDGE audit, lessons learned, competency-based management system, management of intellectual capital or intangible assets.

Regarding the practices in the technological area, we have the following practices: electronic document management (EDM), collaboration tools: portals, internet and extranet, workflow systems, data warehouse, data mining, content management, customer relationship management (CRM), balanced scorecard (BSC), decision support system (DSS), enterprise resource planning (ERP) and key performance indicators (KPI).

For this work, the suggested practices are the lessons learned both internally and externally, the best practices that involve the co-production of public policies and, in particular, to organize, create and apply collective knowledge, the communities of practice (CoPs). de Oliveira and Villardi (2014) explain that to stimulate the formation of CoPs it is necessary to take into account, as Nicolini et al. (2003) warn, that people, their emotions and desires directly influence social interactions and the way how they perceive themselves and their work groups. People, according to the author, are also motivated by the search for knowledge as an end in itself. However, Moura and Gianella (2016) points out that CoPs have rarely been studied from a critical perspective and Wenger (2000) recommended not understanding CoPs with a romantic vision, because "They are the cradle of the human spirit, but they can also be its prisons."

Three elements characterize a CoP: domain, community and practice.

(a) Domain, a CoP presents an identity defined by a set of shared interests, committed members who possess a shared competence, learn from each other, stand out and are valued by this collective competence, they are not just a club of friends;
(b) Community, being part of a CoP involves participating and discussing joint activities, helping each other and sharing information among members due to their interest in the domain they own. To maintain this, in CoPs relationships are built that allow them to learn from each other, even if they do not work together on a daily basis;
(c) Practice is the characteristic of a CoP because its members are practitioners and share experiences, stories, tools, ways of solving problems, that is, they carry out a shared practice (Wenger, 2002).

New members enter the community through their progressive commitment, becoming involved in collective practices through their "legitimate peripheral participation" (PPL) that perpetuates a CoP through which newcomers learn and socialize until they are gradually recognized as members of that community (Gherardi et al., 2000).

Adherence to the informal social interaction environment and collective commitment of CoPs are important to build, transmit knowledge and promote group learning situated (anchored) in practice (Nicolini et al., 2003).

The best thing about CoP is the involvement and understanding in joint activities, mutual help and mutual growth. Obviously, the exchange of information and knowledge (contextualized information) between members depends on the interest in the domain that they must have in the subject. To be part of a CoP, it is important to have access to an explanatory booklet about the public-private project that is being discussed and a questionnaire about the main points (agenda) to work on within the CoPs, separated by topics.

Permanence in CoPs depends on building relationships that allow members to learn from each other, even if they do not work together on a daily basis. Only then are the group's reflexivity, learning and social competence collectively expanded, and then it can be considered a CoP.

Choo (2002) defines Organizational Intelligence (OI) as a continuous cycle of activities that include sensing the environment, developing insights, and creating meaning through interpretation, using the memory of experience to act on the developed interpretations. OI refers to a process of turning data into knowledge and knowledge into action for organizational gain (Cronquist, 2014).

De Angelis (2016) considers OI as the ability of an organization to adapt and to learn and change in response to environmental conditions using relevant knowledge.

Staskeviciute and Ciutiene (2008) point out that in the scientific literature it is possible to find different concepts of OI, but they are all constrained by the same characteristic: the organization's ability to adapt to the environment and to KM.

It is only recently that organizational strategy scholars have begun to engage more substantially with the Organizational Intelligence literature (Munro, 2010; Kornberger, 2013; Mackay and Zundel, 2017; Kornberger and Engberg-Pedersen, 2019). For example, Ndiege and Backhouse (2023) highlight the role of knowledge management within local governments in developing countries; Cajková et al. (2023) investigate KM as a tool to increase efficiency in municipal governments. Therefore, the organizational intelligence literature has recently become a broad and multifaceted field of applied research.

Based on these perspectives, one can conclude that KM provides methods for identifying, storing, sharing, and creating knowledge, while OI integrates, analyzes, and interprets this knowledge for decision making and problem solving.

Despite such a shared intellectual and practical heritages, work in organizational intelligence and Organizational Intelligence have developed in separation, with surprisingly little interaction.

In other words, despite the intuitive appeal that the concepts of KM and OI are complementary and interdependent, this relationship has received relatively little attention in the literature. For Halal and Kull (1998), Organizational Intelligence is a function of five cognitive subsystems: organizational structure; organizational culture; stakeholder relationships; strategic processes; and KM. Liebowitz (2019) emphasizes that active knowledge management is critical to enable organizational performance improvement, problem solving, and decision making. The Organizational Intelligence practices are used to improve the interpretation and synthesis of the knowledge generated: expert analysis, intelligent systems, and advanced techniques, such as competitive hypothesis and modeling using structural equations. Organizational Intelligence tools combine a mix of sociology-technical elements from (a) subjective assessments of the online discussion led by facilitators and subject matter experts with (b) real-time feedback from data mining and semantic analysis of the online discussion. OI tools contribute to deep structural changes and transformations in the social climate, the collaborative culture, and the role of internal collective intelligence (Moreira da Silva et al., 2010). The idea behind OI tools is to transform crowdsourcing models that apply the "wisdom of crowds" to the "wisdom of experts" to solve complex problems.

The purpose of this article is to create communities of practices related to the themes of rice cultivation in Myanmar, in particular transport, fertilizer, irrigation, internal marketing, and relationships with India, Thailand and Laos to improve both import and export, and mainly the formation of agricultural cooperatives to improve the production and distribution of rice within the country. These communities of practice must be led by experts on each topic, in order to facilitate, motivate and, above all, deliver effective results to decision makers.

METHODOLOGY

This study uses the triangulation method to demonstrate the relationship between the constructs. Triangulation is a method used to increase credibility and validate research results (Cohen et al., 2000).

It also helps to refute when one set of data invalidates an assumption generated by another. You can help confirm a hypothesis that one set of hallazgos confirms another set (Noble and Heale, 2019). Finally, triangulation can help explain a studio's results (Carvalho and White, 1997).

A central element of triangulation is the notion that methods lead to erroneous results and greater reliance on research obstacles (Rothbauer, 2008).

For this reason, the studio uses the literature review methodology in an integrated way to better understand the impact of culture on knowledge and intelligence.

Snyder (2019) states that literature review as a research method is more relevant than ever. Traditional literature reviews present a careful menu of thoroughness and rigor and are carried out on an ad hoc basis rather than following a specific methodology.

In the article, it will be argued that the potential for theoretical and practical contributions using the literature review as a method will be advanced to clarify what a literature review is, how you can use it, and what criteria should be used to assess its quality.

This article carries out an integrated review of the literature on Inca culture, rock dust, biological nitrogen fixation, agricultural cooperatives, culture, knowledge and intelligence.

Integration occurs not only in the literature review itself, as the intersection between these concepts is demonstrated through different sources, but also through the research model in which the constructs are present.

RESULTS AND DISCUSSION

Model culture, knowledge and intelligence (CKI model)

Roland (2000) shared some practical explanations about the formation of cultures and the relationship of state to knowledge and intelligence.

The first definition of culture that was formulated from an anthropological point of view belongs to Edward Tylor, in the first paragraph of his book Primitive Culture (1871). Tylor also sought to demonstrate that culture can be the object of a systematic study, as it is a natural phenomenon that has causes and regularities, allowing for study and analysis with the aim of providing the formulation of laws on the cultural process and evolution.

Kroeber (1949), despite considering genetics, goes further and states that man only differs from animals thanks to culture. For him, man is a being that is above his organic limitations, culture is a cumulative process throughout a learning process, that is, man accumulates experiences and, therefore, culture. This is in line with Sen (2000) research on education as freedom since the elements of culture - beliefs, values, assumptions and traditions - are directly related to education and as a consequence of freedom, to participate, to collaborate, for example, with the creation and development of agricultural cooperatives. In other words, create a culture that motivates cooperative learning, collaboration to face bureaucratic difficulties, climate change, lack of water, soil quality, etc.

This can be seen in the way the Incas handled agriculture.

Umuteme and Adegbite (2023) define culture from the perspective of learned beliefs and values, which reinforce behavior both personally and as a group, or society, nation. For Schein, culture is beliefs, values, assumptions and traditions, and it also thrives in the presence of underlying assumptions (Schein, 2010).

Culture is always very difficult to change, due to the fact that beliefs, values and traditions are rooted in organizational culture, and that is why many organizations and governments focus on the organizational climate and the easiest part of influencing culture, assumptions.

Cultural assumptions, such as artifacts and symbols, can influence the work climate in an organization (Schein, 2010) and are expected to create an environment conducive to successful teamwork.

In this regard, Espinoza-Santeli and Jiménez (2019) conclude that organizational climate (OC) management is a commitment and co-responsibility to improve the quality of life of people who belong to an organization.

The Student's T test for the Pearson correlation coefficient allows us to determine whether there is a relationship between the variables, or whether it is the same, making inferences about the relationship or independence between the variables.

Umuteme and Adegbite (2023) found a correlation between Organizational Culture and Leadership. The values were 0.48 for the Person R and 7.93 for T Statistics.

Umuteme and Adegbite (2023) maintain that the strong control of organizational culture over team effectiveness creates an environment in which members enjoy a relationship of exchanging knowledge and experiences with leadership. This is corroborated in the literature (Alvesson, 2002) which highlights that by emphasizing organizational culture, projects can achieve several advantages. Firstly, a strong and well-defined culture can promote a sense of unity and shared purpose among team members. When employees are aligned with the organization's values, mission, vision and goals, they are more likely to work collaboratively and harmoniously towards the success of the project.

The main thing is to build a climate, and gradually a culture, in which instead of focusing only on individual gains, rewards, benefits and higher positions, employees are encouraged to prioritize the collective achievement of the project's objectives and purpose. This creates an environment that promotes cooperation and teamwork, allowing for a smoother and more effective design, execution and review of the project.

For Kroeber, culture is a cumulative process, resulting from all the historical experience of previous generations. This process limits or stimulates the individual's creative action.

Félix Keesing and Alfred Kroeber agree that there is no correlation between genetics and culture, for example, anyone born, regardless of where they were born, absorbed the culture of the place where they grew up. Kroeber goes further and states that man only differs from animals thanks to culture. Because man is a being that is above his organic limitations, culture is an accumulative process, it is said, man accumulates experiences and, therefore, culture.

(1) Culture, more than genetics, determines behavior and determines your actions.
(2) Man ages according to his cultural standards. His instincts were partially nullified due to the long "evolutionary process" that took place.
(3) A culture is a cumulative process, resulting from all the historical experience of previous generations. This process limits or stimulates the individual's creative or non-creative action.

As noted by Hofstede (2011), culture has the power to shape the minds of individuals, establishing shared values that are specific to the members of a given group. Empirical evidence consistently supports the notion that culture has a beneficial impact on psychological reasoning processes (Shiraev and Levy, 2010). Cultural influences contribute positively to the way individuals think and make rational decisions, highlighting the important role that culture plays in shaping cognitive processes.

Based on the previous theoretical foundations, the

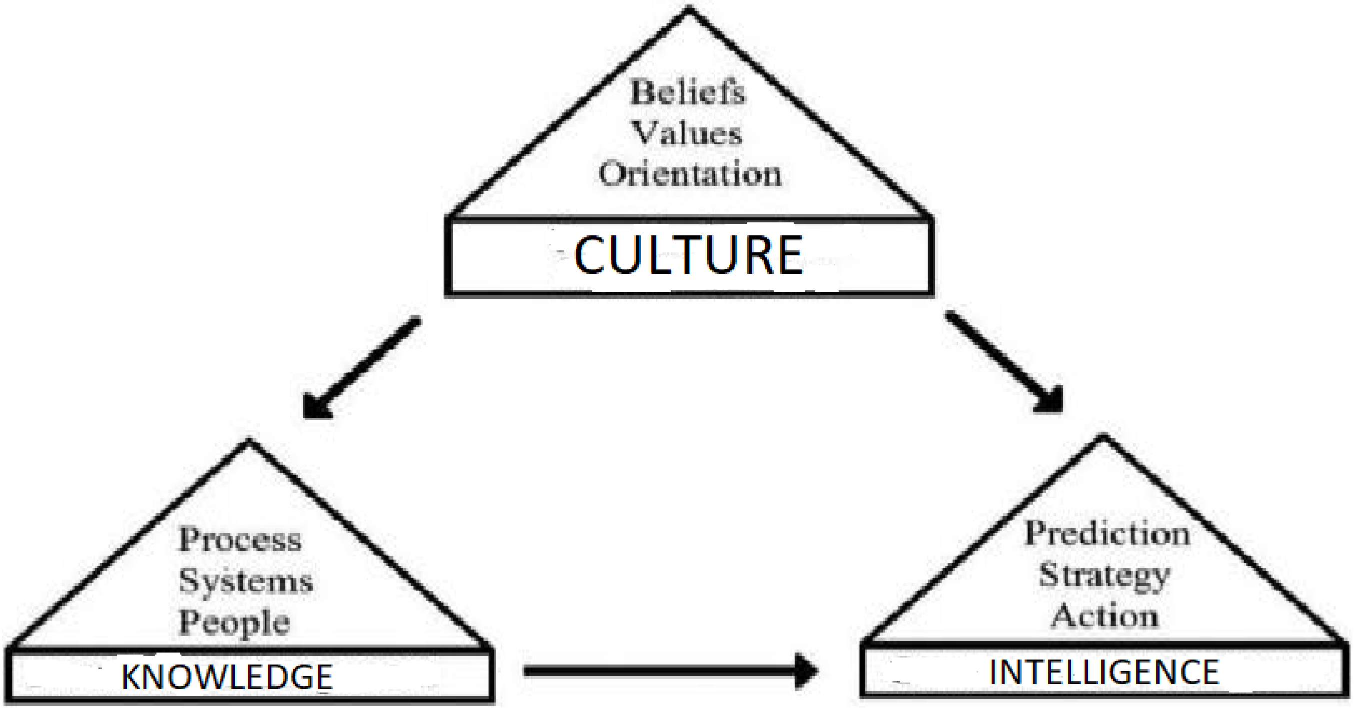

Figure 1. The culture-knowledge-intelligence model.
Source: Adapted from Choo (1998).

Culture-Knowledge-Intelligence (CCI) model is constructed, as shown in Figure 1.

The premises of the CCI model are:

(i) Culture is formed by beliefs, values, assumptions and traditions of a society (Shein, 1985)
(ii) The central argument is that, for education to be successful in its tasks, the curriculum as its core must be restructured or reformulated around the four pillars of learning: learning to know, learning to do, learning to live together and learning to be (Smith, 2018)
(iii) The three pillars of intelligence are: prediction, strategy and action (Rothberg and Erickson, 2004).

The CCI model is based on three hypotheses (Table 1).

Bio-dynamic model

This study uses the literature review methodology in an integrated manner to better understand the impact of culture on knowledge and intelligence.

The integration occurs not only in the literature review itself, in which the intersection between these concepts is demonstrated through different sources, but also through the research model in which all constructs are present.

Snyder (2019) asserts that the literature review as a research method is more relevant than ever. Traditional literature reviews often lack thoroughness and rigor and are conducted ad hoc, rather than following a specific methodology.

In the article, it will be argued that the potential for theoretical and practical contributions using the literature review as a method will be advanced to clarify what a literature review is, how you can use it, and what criteria should be used to assess its quality.

This article carries out an integrated review of the literature on biodynamic agriculture, rock dust, agricultural cooperatives, Knowledge Management and Organizational Intelligence. Figure 2 shows the biodynamic family farming model.

This biodynamic agriculture model shows that the basis for this type of agriculture is agricultural cooperatives. However, for farmers to be willing to come together to solve their problems, there is a need for an appropriate culture that accepts training courses, particularly on the topics of fertilizers and irrigation, two topics covered previously. Therefore, both training courses, particularly on rock powder, and Inca history and culture are also good foundations for the development and maintenance of biodynamic agriculture.

Besides that, the biodynamic model demonstrates that the culture change of small family farmers has a positive impact on the knowledge management practices applied

Table 1. Assumptions of the CCI model.

Hypotheses	Sources	Results
Cultural has a positive impact on Knowledge	Alaviy Leidner (2001), Deal and Kennedy (2002) and Tweed Ledman (2002) suggest that the way in which individuals perceive, organize and process information and the way in which they communicate with others and the way in which they understand, organize and generate knowledge and solve problems, is related to culture.	Supported
Cultural has a positive impact on intelligence	Culture, more than genetics, determines behavior and its actions (Kroeber, 1949). Umuteme and Adegbite (2023) posit that factors such as values, norms, beliefs and practices embedded in organizational culture significantly shape the overall project environment and affect team dynamics.	Supported
Knowledge has a positive impact on intelligence	Rothberg and Erickson (2004) maintain that knowledge is static and, ultimately, only has value if people use it (intelligence)	Supported

Source: Author (2023).

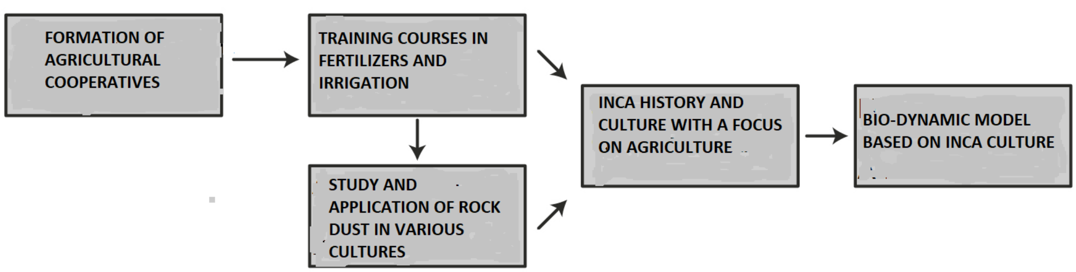

Figure 2. Biodynamic family farming model.
Source: Author (2023).

within cooperatives and also on the development and implementation of the Farmers' Technical and Financial Assistance Plan (intelligence).

Consistent with previous literature, the results of this study suggest that the development of an organizational culture (macro-level national culture) supports the application of KM practices (Davenport and Prusak, 2001; Nonaka and Takeuchi, 1995; Gold et al., 2001; Janz and Prasarnphanic, 2003; Lee and Choi, 2003; Donate and Guadamillas, 2010).

Some authors point out that organisational culture is not only a critical success factor for KM, but also the most difficult and important factor to address, especially if an adequate culture does not already exist (Davenport and Prusak, 1998).

However, changing a culture in an organisation or community is a formidable challenge.

The process of culture change encompasses the

Table 2. Hypothesis in the biodynamic model

Hypothesis	Source	Results
Cultural change has a positive impact on Knowledge Management (KM)	Many authors point out that organisational culture is not only a critical success factor for KM, but also the most difficult and important factor to address, especially if an adequate culture does not already exist (Davenport and Prusak, 1998).	Supported
Cultural change has a positive impact on intelligence	Culture affects organizational and societal behaviors, how people will act in a given situation, such as thinking and decision making (Schein, 1985).	Supported
Knowledge management (KM) has a positive impact on intelligence	Active knowledge management is essential to enable improved organizational performance, problem solving and decision making (Liebowitz, 2019).	Supported

Source: Author (2023).

following requirements:

(1) people must be willing to cooperate (there must be appropriate incentives and rewards);
(2) basic understanding of how CM can improve communication between farmers, academia, the private sector and government.
(3) networking to promote cultural change.

Culture also plays an important role in creating the conditions for learning with the internal and external environment. This research empirically tests three hypotheses (Table 2).

The biodynamic model shows the importance of the recognition of the essential role of diverse social contacts, local knowledge exchange and application, and cooperation in promoting the resilience of rural areas to global changes, by organizing on-farm events, creating spaces for spontaneous meetings or supporting various associations in rural areas (Junquera et al., 2022).

The European Union has developed a territorial cohesion strategy through a set of structural funds to reduce regional inequalities:

(i) a balanced urban system through multiple centers (polycentrism) and new forms of city-rural relations;
(ii) equal accessibility to infrastructure and knowledge.
(iii) multi-level and participatory governance system between federal and municipal governments

Among other benefits, the cooperatives should promote the creation of training courses, employment generation, induction of investments and implementation of social programs and projects, taking into account economic, social and environmental dimensions.

Conclusion

The article clearly demonstrated through interviews and literature review that a cultural change among smallholder farmers would lead to the use of good knowledge management practices, especially mentoring, best practices and lessons learned. In addition, this cultural change would support the development and implementation of a technical and financial assistance plan. All of this is very clear in the bio dynamic model.

Small farms do not have communication with medium-sized farms because there is no place to exchange knowledge and experience, as well as machinery such as tractors, ploughs, harrows, spreaders and harvesters. One solution could be to set up cooperatives to help medium-sized farmers with fuel and running costs if they help small farmers with soil preparation.

Cooperatives would also be responsible for transferring relevant knowledge and opening credit lines for farmers.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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