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Establishing the initial benchmark for the sustainability of Arabica coffee-growing householders in a highland region, Brazil

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***Abstract* —** *The production of specialty coffees is an important activity for farm incomes and should be encouraged. However, it is necessary that this process may respect the principles based on the economic, environmental, and social axes of sustainability. This research was carried out aiming to generate the initial benchmark of the sustainability of four farms in the municipality of Afonso Cláudio, State of Espírito Santo, Brazil. The System for Assessing Sustainability Standards for Coffee Growing in Espírito Santo, a tool in the format of an electronic spreadsheet, was used in order to quantify the scores of the different standards. The results showed a gap in the three axes with intervention needs mainly related to economical standards, followed by environmental, and social ones. The main interferences have been related to the quality of coffee beans management, costs and incomes of the farms, improvement in harvest and post-harvest processes, training in the use of manual machines, and the correct use of pesticides. Different intervention techniques will be offered to coffee-growers for*

intervention in the farms aiming to improve the level of their adequacy regarding the sustainability standards. However, the owner's family values, as well as their cultural and economic restrictions, must be respected. Thus, the results of farm adjustments must be achieved in different ways and at different times.

I. INTRODUCTION

Brazil is worldwide the largest coffee exporter and has the second position among countries that consume coffee. The State of Espírito Santo is the second largest Brazilian coffee producing, cultivating Arabica and Robusta (Conilon) coffee species. The total coffee crop of these two coffee species reached a total production of 837,480 tons, being 285,900 tons of Arabica coffee (CONAB, 2020; SOUZA et al., 2021).

Arabica coffee is one of the main agricultural activities in the State of Espírito Santo, where it is cultivated in sloping areas with altitudes ranging from 500 to 1,200 m. Approximately 170,000 ha have been cultivated, and more than 26,000 farms and 53,000 householders are directly involved in the cultivation of this coffee species in this Brazilian State (INCAPER, 2020; SEAG, 2021). Most of these farms fit the definition of family-based agriculture (Law 11,326, of July 24, 2006), responsible for a large part of the Brazilian economy. Despite its great representation, familyfarming still needs technological investments to increase crop productivity and to provide more significant economic returns for producers (SULZBACHER; DAVID, 2009).

The main characteristic of the Arabica coffee cultivation system in the highland region of the geographical indication (GI) "Café Montanhas do Espírito Santo" is the manual labor. This happens mainly due to the conditions of sloping areas where the use of agricultural machinery becomes quite difficult. However, in this region, great unavailability of labor for work in agriculture has been related. So, different types of partnerships among owners have been adopted, such as agricultural partnership, sharecropping, and temporary hiring of employees. But all such partnerships need to be properly registered in accordance with Brazilian labor law. On the other hand, different technologies have been adopted by householders in order to maximize the use of available labor, as well as trying to replace it in crop management, harvesting, and post-harvesting of coffee berries (DIAS et al., 2021; KROHLING et al., 2021).

Soils of this sloping region are, for the most part, chemically poor, acidic, and with low levels of nutrients. Thus, many producers still practice the traditional cultivation system, which is highly dependent on external inputs, such as chemical fertilizers and pesticides. In addition, when these inputs are used inappropriately, they can cause environmental impacts, contamination of soils, water, and air, and may cause pest/disease resistance and increasing greenhouse gas emissions; besides it could increase coffee production costs (ROSSET et al 2014; KROHLING et al. al., 2021; DIAS et al., 2021).

During important events such as the United Nations Conference on Development and the Human Environment (1972), the World Commission on Environment and Development (1987), and the United Nations Conference on Environment and Development (ECO-92, 1992), the concept of sustainability was being adapted. It is currently defined as a set of actions or use of natural resources that must meet the needs of the present generation, without affecting the possibility of future generations to meet theirs. Sustainability, therefore, includes actions in several areas, known as axes, mainly in the Economic, Environmental, and Social. Thus, for an activity to be considered sustainable, it needs to guarantee a financial return without neglecting the importance of environmental preservation, and respect for human dignity (MARTINUZZO et al. 2021).

Agricultural technologies for coffee production are available and can allow high levels of productivity. Despite this, these technologies have been used inappropriately aiming to obtain overproductions, making this process unsustainable (DEPONTI, 2001; VERDIN FILHO et al., 2019).Although there are appropriate and adapted technologies for householders to produce specialty coffees, these technologies have not been widespread for them (GREENBERG, 1997; DE MUNER et al., 2019).

Sustainability assessment and monitoring standards have been important tools for identifying problems, as well as defining strategies that promote necessary changes to improve the sustainability performance of farms (DE MUNER et al. 2019).

Despite its extreme importance, the assessment of sustainability in coffee farming is still a major challenge due to the complexity of environmental, socioeconomic, and cultural aspects.It is a dynamic and complex process that cannot be measured by parameters or universal criteria that cover all this complexity. In this way, the assessment of sustainability standards is considered as a system under construction, which evolves and stabilizes at increasing levels and adapted to each regional socioeconomic and cultural reality. One of the advantages of carrying out a sustainability assessment is that it is able to provide an

analytical framework for studying and comparing different systems and farms. In addition, it also allows prioritizing and selecting a set of standards for monitoring, guiding planning, and decision-making processes (ASTIER et al. 2008; DE MUNER et al., 2019).

The System for Assessing Sustainability Standards for Coffee Growing in Espírito Santo is a methodology instrument developed by Incaper to assist in measuring the levels of socioeconomic and environmental adequacy. It uses standards selected based on the sustainability protocols followed by the main international certification organizations.This evaluation criteria have the format of a spreadsheet, is an accessible and cost-free way, and is designed to assist the user in assessing the level of adequacy of the farms to the standards used in the economic, environmental, and social axes. Its use facilitates the identification of the standards that need more attention, often representing a bottleneck in the axes; on the other hand, its use facilitates the planning intervention needs to adapt farms to the pre-established standards. (MARTINUZZO et al. 2021).

This research was carried out due to characterize the economic, environmental, and social reality of different farms in the municipality of Afonso Cláudio, State ofEspírito Santo, Brazil, aiming to generate the initial benchmark for sustainability of Arabica coffee farms. Based on the data of this research, technical assistance interventions will be offered to the farmers aiming at improving the level of adequacy of the farms in terms of the sustainability standards.

II. MATERIAL AND METHODS

2.1 Location of the sampled farms

Data collection was carried out on four sampled farms in the municipality of Afonso Cláudio, State of Espírito Santo, Brazil, from February to October 2021. These farms were located in the communities of Serra do Boi (704m asl), São Luiz da Boa Sorte (680m asl), Piracema (973m asl), and Alto Santa Joana (1045m asl).

2.2 Criteria for selecting the studied farms

The municipality of Afonso Cláudio was initially selected because this is the largest municipality in territorial extension in the highlands of the State of Espírito Santo, one of the main producers of Arabica coffee, particularly specialty coffees. Coffee cultivation has been part of the history of this municipality, and this is its main economic activity, the main responsible for employment in rural areas (DUMER et al., 2012; IBGE, 2017).

The main criterion for the selection of the four farms was to prioritize coffee growers who do not adoptthe production of specialty coffees. Therefore, it is expected to know the current situation of cultivation, encourage the production of specialty coffees, as well as introduce the principles of sustainability in these farms.

The different altitudes may be justified by the peculiarity of these regions to produce different types of specialty coffees (terroir). Coffee flavors are influenced by several factors, such as sensory characteristics, natural and human factors, in addition to local customs and culture (DIAS et al., 2021; SOUZA et al., 2021).

2.3 Standards for sustainability assessment

The adopted methodology for characterizing the initial benchmark of the farms followed the recommendations of the ‘System for the Assessment of Sustainability Standards for Coffee Growing in Espírito Santo’ (MARTINUZZO et al. 2021).The standards used on the economic axis were crop productivity efficiency, coffee marketing efficiency, coffee quality management, production cost and income management, good agricultural practices (GAP) - soil analysis, GAP - foliar analysis, GAP - soil conservation, GAP - integrated pest and disease management, GAP – irrigation, good harvest, and post-harvest practices, traceability of production, and coffee bean storage.

On the environmental axis the standards used were the acquisition of pesticides, use of personal protective equipment (PPE); return of empty pesticide packaging bag; pesticide storage; adoption of practices to protect water source areas; waste disposal; licensing of agricultural activities required by law; management of solid and liquid waste generated by agricultural process on the farm; regularization of the legal reserve and permanent protection areas in accordance with the environmental law (CAR); the presence of domestic sewage system in all relevant houses and structures on the farm; no illegal hunting, fishing or trafficking of wild animals and plants; no use of fire without authorization from the competent public bureau.

Standards used in the social axiswere the agricultural pesticide applicator training; training for weed cutting machine and coffee bean picker operator; chainsaw training; training for agricultural implements and machine operator (farm tractor); all agricultural partnership and employee contracts are registered under Brazilian labor law; no children labor; no forced labor; no hazardous conditions of labor; freedom of employees organization, and partners; employee payment are according to the law; access to education; access to the health service.

The four selected farmers were interviewed according to the items in the spreadsheet, and the obtained information was certified through documents. Also, visual observationswere carried out through visiting standard-

specific items of the crop, the post-harvest processing system, the coffee bean, and the pesticide storehouses.

III. RESULTS

A gap in the three evaluated axes in all the farms sampled was noted. The average of the standards of the economic axis was 37, with scores ranging from 32 to 47. For the environmental axis, the average was 68, ranging from 56 to 79, and in the social axis the average found was 73, ranging from 67 to 81.Thegeneralaveragesustainability score of the four sampledfarms was 59,ranging from 57 to 61 (figure 2).

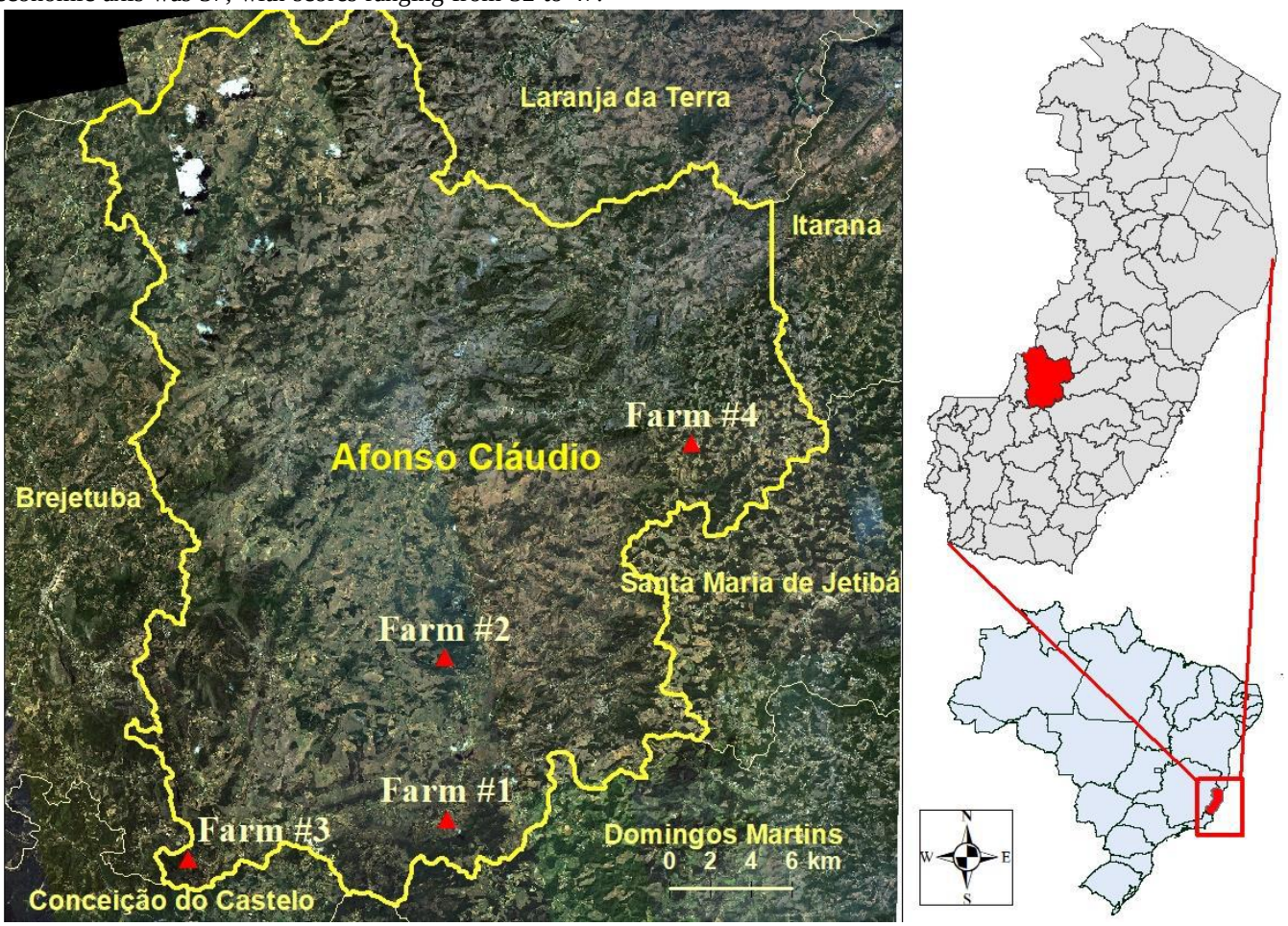

Fig.1 - Map of farm locations according to altitude and community, municipality of Afonso Cláudio, State of Espírito Santo, Brazil. Source: Elaborated by Cecília U. Zandonadi (2022).

3.1 Farm #1

The score 47 was assigned to farm #1 related to the economic axis (figure 2), and the maximum scores (100) were found in the standards productivity, irrigation, and soil conservation efficiency. For integrated pest and disease management, and soil analysis, scores were 75. Marketing, harvest, post-harvest, and coffee bean storage as well as cost and income management, score 50 was assigned. Traceability, coffee quality, and foliar analysis were assigned with 0 (zero) (figure 3A).

The average score obtained by farm #1 in the environmental axis (figure 2) was 56. Maximum scores were obtained in the standards of solid and liquid waste management, the presence of sewage systems in all houses, and relevant structures on this farm. There was no practice or authorization for hunting, fishing, or illegal trafficking of wild animals and plants, as well as non-practice of burning without authorization from an official bureau, adoption of practices for the protection of water resource areas, and correct disposal of waste. Regularization of the legal reserve and permanent protection areas, in accordance with the environmental law (CAR), proved to be partially adequate, and a score of 75 was attributed to these standards. Scores 0 (zero) were assigned to the standards acquisition of pesticides, use of PPE, return of empty pesticide packaging bag, storage of pesticides, and licensing of agricultural activities required by law (figure 3B).

This farm showed the best scores in the social axis (figure 2), obtaining maximum scores in the standards access to health, education, and training for operators of machinery/agricultural implements; also, the criterion of employee and partners organization showed be regularized, as well as the term of commitment to change service or temporary service were in accordance with Brazilian current labor law. Child labor, forced labor, work in hazardous conditions were not found on this farm. The freedom of employees and partners organization have been respected, and employee payment was compatible with the law. These standards had received maximum scores. On the other hand, the standards training of pesticide applicator, training for weed cutting machine, coffee bean picker, and chainsaw operator, the scores assigned were 0 (zero) (figure 3C).

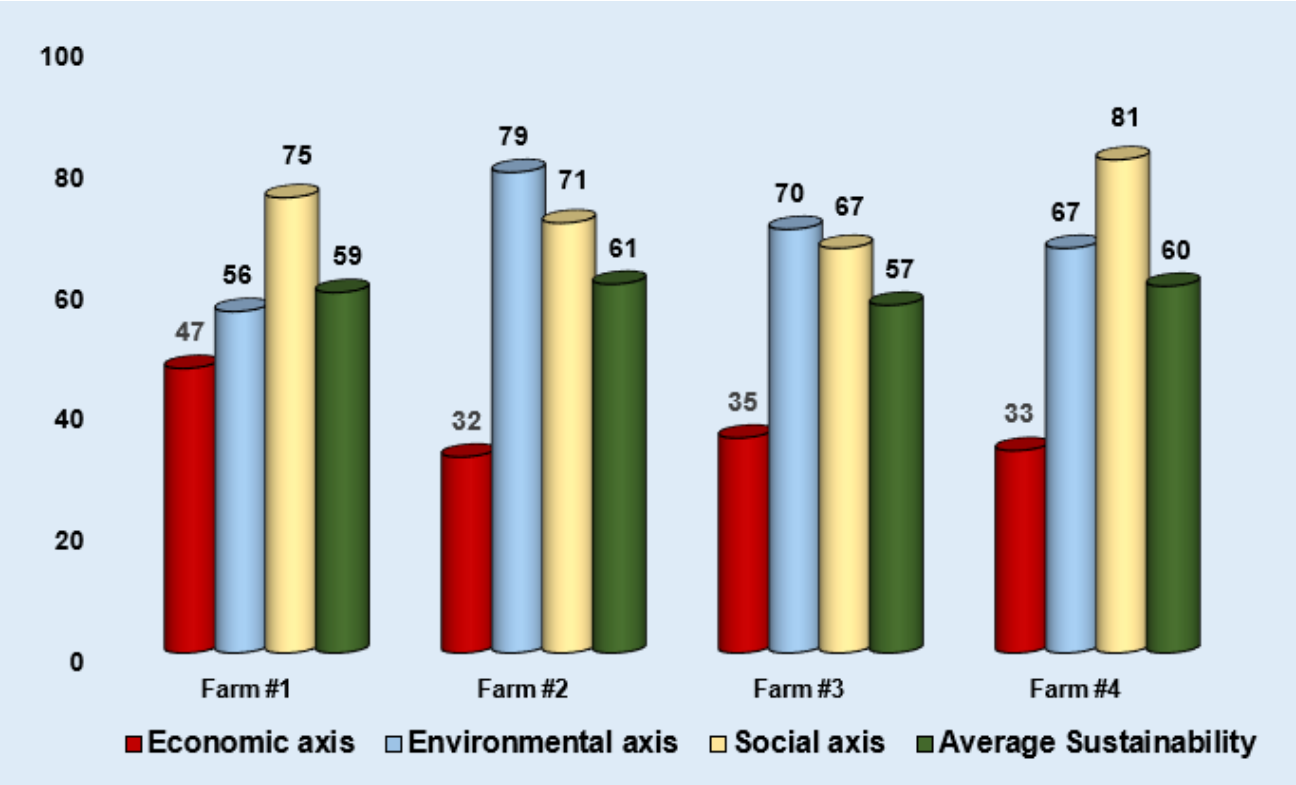

Fig.2 – Scores attributed to the general sustainability standards of the four farms sampled, and the average for the economic, environmental, and social axes. Afonso Cláudio, State of Espírito Santo, Brazil. 2021.

3.2 Farm #2

The lowest score offarm #2 was pointed out on the economic axis (32) (figure 2), and it was the lowest score among all farms evaluated. Zero was assigned to the standards irrigation, coffee quality management, foliar analysis, marketing management, and cost and income management. The productivity efficiency, soil conservation, and integrated pest and disease management reached maximum scores. These were the standards that most contributed to the final score of this farm. The score for the soil analysis was 75. In the traceability, harvest, post-harvest, and coffee bean storage the score was 50 (figure 3D).

The environmental axis had the highest score (79) on farm #2 (figure 2). The standards that most contributed positively to this were the documentation for acquisition of pesticides, return of empty packaging, licensing of agricultural activities, legal reserve and areas of permanent protection, management of solid and liquid waste generated by production, practices to protect water source areas, sewage system, non-practice or permission of hunting, fishing or illegal trafficking of wild animals and plants, and non-practice of burning without authorization from the competent bureau, achieved the maximum score. The appropriate waste disposal obtained a score 50. The score 0 (zero) was assigned to the pesticide storage, and use of PPE, due to their total inadequacy to the used criteria (figure 3E).

In the social axis (figure 2) a score of 71 was assigned, reaching the maximum score in the access to health, education, training for machinery and agricultural implements operator, no occurrence of child labor, forced labor and work in risky conditions, freedom of employee and partners organization, and employee payment compatible with the law. Training of pesticide applicator, weed cutting machine, coffee bean picker, and chainsaw

operator, and the term of commitment for exchange of service or temporary service was found as totally inadequate, and the scores assigned were 0 (zero) (figure 3F).

3.3 Farm #3

Farm #3 pointed out the lowest score in the economic axis (35) among the others evaluated (figure 2). Scores 0 (zero) were assigned to the standards quality management, foliar analysis, marketing management, cost and income management, harvest, post-harvest, and coffee bean storage. The irrigation was the only standard that proved to be adequate in this axis, being assigned with the maximum score. Productivity efficiency, soil conservation, and traceability were partially adequate, and the score assigned was 50. Integrated pest and disease management, and soil analysis, a score of 75 was assigned (figure 3G).

The environmental axis (figure 2) was relatively well suited on this farm, reaching a score of 70, the highest score among the axes of farm #3. The negative points found in environmental sustainability were in the standards of pesticide storage, and use of PPE, with a score 0 (zero). In the proper disposal of waste, the score was 50. The standards documentation of the acquisition of pesticides, return of empty pesticide packaging bags, licensing of agricultural activities, legal reserve, and permanent protection areas, management of solid and liquid waste, practices of protection of water source areas, sewage system, non-practice or permission of hunting, fishing or illegal trafficking of wild animals and plants, non-practice of burning without authorization from the competent bureau reached maximum score (figure 3H).

The social axis of this farm reached an average score of 67 (figure 2), and maximum scores were assigned in the following social standards: access to health, and to education, training for the operator of machinery, term of commitment for exchange of service or temporary service, child labor, forced labor, work in hazardous conditions, freedom of employee and partners organization, employee payment compatible with the law. However, scores assigned to the training of pesticide applicator, weed cutting machine, coffee bean picker, and chainsaw operator were 0 (zero) (figure 3I).

3.4 Farm #4

Farm #4 showed the lowest score on the economic axis (33) among the other evaluated farms (figure 2). The maximum score was obtained only in the productivity efficiency followed by the soil analysis standard (75). In decreasing scores, we observed the standards soil conservation, irrigation, integrated pest, and disease management, harvest, post-harvest, coffee bean storage and marketing management (50), cost and income management (25). Quality management, leaf analysis, and production traceability had the lowest scores (0) (figure 3J).

The environmental axis of this farm #4 received an average score of 67 (figure 2) with the main deficiencies observed being related to waste disposal, pesticide storage, and use of PPE (0) followed by proper disposal of solid and liquid waste (50). The documentation of the acquisition of pesticides and return of empty pesticide packaging bags, licensing of agricultural activities, legal reserve and permanent protection areas, practices to protect water source areas, sewage system, non-practice or permission of illegal hunting, fishing, or animal trafficking, and wild plants, non-practice of burning without authorization from the competent bureau reached maximum scores (figure 3K).

The best evaluation (81) of this farm was found in the social axis (figure 2). The maximum score was observed in the standards access to health, education, training for machinery and agricultural implements operator (tractor), child labor, forced labor, work in hazardous conditions, freedom of employee and partners organization, employee payment are compatible with the law. The standards training for pesticide applicator, weed cutting machine, coffee bean picker, and chainsaw operator were found to be totally non-compliant, and score 0 (zero) was assigned (figure 3L).

IV. DISCUSSION

Based on the individual evaluation of each farm, a result was generated that allows the identification of the level of its adequacy. Thus, it is possible to apply some actions related to the good agricultural practices in coffee production and post-harvest processes in order to improve the performance of each deficient standard, and so, in the general sustainability of each one of the farms.

4.1 Economic axis

The economic axis provided the lowest scores in all the four farms sampled. Thus, this axis was the one that most needed changes.

The maximum score for the average productivity of arabica coffee was just reached if it was over 30% above the average productivity of the State of Espírito Santo (1,5 ton/ha). The score is gradually reduced as productivity decreases. Three farms obtained the maximum score, and only one of them reached a score of 50. Thus, just one farm needs more severe interventions in order to increase productivity. The use of GAP must be implemented. However, these results do not dispense interventions in the

other farms because they can increase their income through the use of techniques that allow new gains in productivity.

Productivity is directly related to the profit and profitability of the rural enterprise, supporting the production structure. Techniques that increase product quality, as well as the productivity, should be encouraged, implemented, and used in coffee crops (REZENDE et al., 2010). A tool that may increase productivity with no additional costs is the development of arabica coffee cultivars. These cultivars must present greater production, tolerance/resistance to pests and diseases, and adaptation to the climatic conditions of the different coffee growing regions. Using new cultivars, it is still possible to increase the stand of plants/ha, providing significant increases in productivity (KROHLING et al., 2021; EMBRAPA, 2022a).

Another factor worth mentioning is the use of GAP. Satisfactory levels of adequacy to the soil analysis were observed. This practice has been carried out every two years and follows technical recommendations made by a qualified professional. Soil recovery and conservation practices should deserve more attention with appropriated technologies being used. The maintenance of vegetation covering the soil and/or the use of leguminous plants or grasses to protect the soil should be more used in the farm, as well as the increasing use of periodic mowing with the sporadic use of herbicides to manage natural vegetation. Because this is a sloped and highland region, the technologies recommended should be adapted or developed specifically to this situation (ALIXANDRE et al., 2020). Thus, direct benefits will be obtained for the farm costs, such as savings fertilizer use, increased productivity, and longevity of production of coffee crops (ROCHA et al., 2000; MARTINUZZO et al. 2021), with direct effects on increasing sustainability.

Annual foliar analysis, as well as the technical recommendation for corrections in the appropriate nutrient levels, is another standard that needs to be better worked in order to increase coffee yields. This standard was extremely important to reduce the scores of the farms, as none of them carry out this agricultural practice. Monitoring soil and leaf fertility is another practice that may be used as a routine in the coffee industry. Soil sampling requires criteria to better show its characteristics, avoiding incorrect fertilization and liming. Leaf analysis is important in complementing soil analysis, identifying the need for adjustments and dosage in macro and micronutrients (REZENDE, 2022).

Several management strategies can still be adopted to increase the sustainability of the standard production, such as the use of renewable natural resources, recycling oforganic waste, organic fertilization, use of natural pesticides, biological and mechanical control of pests and weeds, crop diversification, intercropping and crop rotation. Thestrategiescan still beapplied together, in

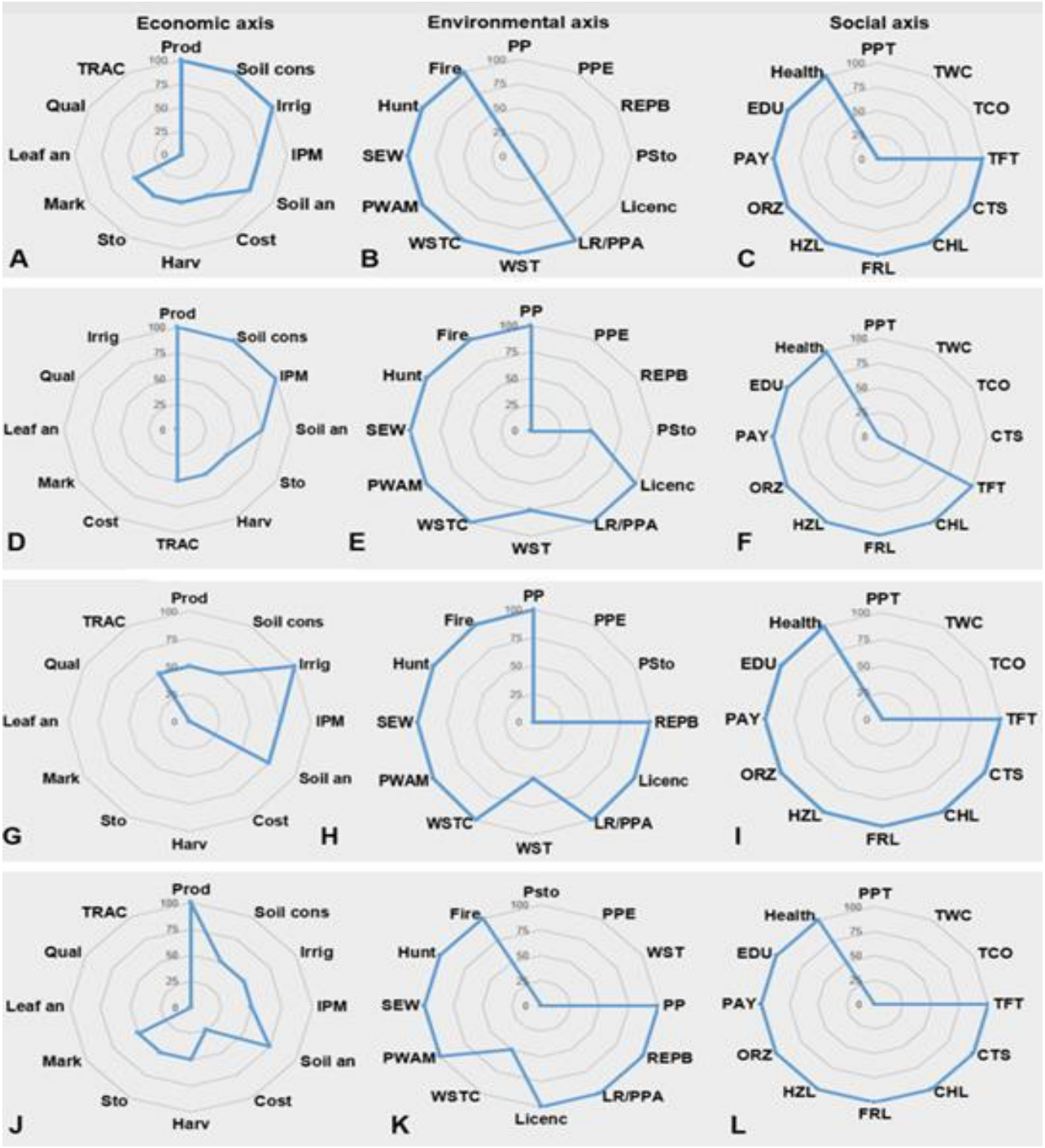

Fig.3 – Evaluation of the standards of the economic, environmental, and social axes of the evaluated farms 1 (A, B, C), 2 (D, E, F), 3 (G, H, I), and 4 (J, K, L). Afonso Cláudio, State of Espírito Santo, Brazil, 2021. Prod-crop productivity efficiency; Mark-marketing efficiency; Qual-grain quality management; Cost – costs and incomes management; Soil an-Good Agricultural Practices (GAP) of soil analysis; Leaf an.-GAP leaf analysis; Soil cons-GAP soil conservation; IPM-GAP integrated pest and disease management; Irrig-GAP irrigation; Harv-GAP harvest and post-harvest; TRAC-production traceability; Sto-coffee beans storage; PP-purchase of pesticides; PPE-use of personal protective equipment; REPB-return of empty pesticide packaging bag; PSto-pesticide storage; PWAM-protection of water source áreas management; WST-correct disposal of waste; Licenc-licensing of agricultural activities as required by the law; WSTC-management of solid and liquid waste from coffee production; LR/PPA-regularization of the legal reserve and permanent protection areas; SEW-sewer system in all relevant houses and structures on the farm; Hunt-prohibition of hunting, fishing or trafficking of wild animals and plants; Fire-no use of burning without authorization from the competent bureau; PPT-pesticide applicator

training; TWC-training for weed cutting machine and coffee bean picker operator; TCO-training for chainsaw operator; TFT - training for agricultural implements and machine operator (farm tractor); CTS - employees and partners have contract, term of commitment for exchange of service or temporary service in accordance with current labor law; CHL - no child labor; FRL-no forced labor; HZL-no labor in hazardous conditions; ORZ- freedom of organization of employees and partners; PAY-employees payment are suitable for the market; EDU-access to education system; Health-access to health system.

order to form an adequate and viable production system for each farm and more suited to the cultural values of each coffee grower (DE MUNER et al., 2019; VERDIN FILHO, et al 2019; TRISTÃO et al., 2019; ALIXANDRE et al. al., 2020).

The IPM is another standard that needs to be better adapted to coffee growers with the use of the systematic monitoring of the pest population. Furthermore, biological control can be stimulated, aiming at reducing and/or replacing the use of chemical pesticides. It should be noted that the GAP recommends that only pesticides registered in Brazil for coffee cultivation should be used, respecting the time limit for use from application to berry harvest. The coffee IPM contributes to the maintenance of high yields and fruit quality, reducing the cost of production and the potential of negative impacts of chemicals (FORNAZIER et al., 2017; GUERRA et al. 2021).

Pests and diseases can cause significant damage to arabica coffee crops if not properly managed. Several diseases and pests occur associated with coffee in the State of Espírito Santo. The rust and the coffee berry borer are the two main limitations to productivity and must be properly managed due to the big damage caused directly and indirectly to coffee productivity and quality. Biological control should be encouraged, but the use of chemicals is also an important tool for reducing pest infestation, particularly when observing and using the concepts of ecological and physiological selectivity to natural enemies, and the management of pest resistance to pesticides (FORNAZIER et al, 2017; MESQUITA, 2016; ALIXANDRE et al. 2020).

Irrigation, when necessary, requires a project and a management plan to achieve maximum efficiency with water savings. This standard needs to be better worked on in two sampled farms. The adoption of irrigation significantly increases the productivity of coffee plantations, and this practice has been increasingly widespread. In addition, irrigation it makes possible to produce Arabica coffee in areas not suitable for this coffee species due to water restriction (GUERRA et al. 2021). On the other hand, it is worth noting that the farms sampled were located in a region with satisfactory rainfall, with no need to use the irrigation technique.

The farm must have at least 50% of its production of special Arabica coffee to obtain the maximum score in the quality management standard. All the sampled farms received a score 0 (zero). However, this was already an expected result due to poor coffee quality being the main standard for selecting the farms to participate in the government project to adjust coffee beverage quality indices. Specialty coffees are beans free of impurities and defects and that have differentiated sensory attributes, such as a clean and sweet drink, balanced body, and acidity, which add value to the drink. In addition to intrinsic quality, specialty coffees must have proven traceability, environmental respect, economic and social sustainability criteria at all stages of production, Thus, they enable the aggregation of value in the commercialization and conquest of new and differentiated consumer markets (BSCA, 2022).

Management of costs and income of farm activities was the main challenge for coffee growers in the four sampled farms. Some factors directly interfered in the final result, such as the low control of production costs, farm costs and incomes. This deficiency may be explained by the low level of regular education and by the deficient qualification/training of coffee growers in administrative and management of farm activities. Making notes of the basic items that make up the cost of coffee production, such as noting the dates and services performed, the inputs purchased and places where they were applied, may improve the organization and management of the farms (DINIZ et al., 2016).

All farms showed low performance in the harvest and post-harvest processes due to the traditional practices used, which do not allow obtaining superior quality coffees. In order to obtain the maximum grade, it is essential that the farm adopt the ten essential commandments for the production, preparation, coffee bean storage, and commercialization of specialty coffees (INCAPER, 2013). Several adjustments are necessary for these harvest and post-harvest processes, such as the coffee berry need to be harvested when ripe and quickly transported to the post-harvest processing site (ALIXANDRE et al 2020; EMBRAPA, 2022b).

Another major challenge for the coffee growers was in managing the marketing of coffee beans. The scores obtained regarding the coffee beverage qualities of the four farms sampled were very low and associated with the Rio beverage - type 7. This level of quality does not allow the valuation of the coffee beans and does not allow value aggregation as a result, value-added to coffee beans does not occur and farm incomes remain low. Marketing management helps the farmers to plan their sales, may control the farm expenses, may reduce the production cost, and is a protection from market price fluctuations. Furthermore, the use of appropriate marketing tools makes it possible to increase the average value of coffee sales increasing farm incomes (DINIZ et al., 2016). Specific formal courses for the use of these tools should be carried out for these coffee growers in order to improve marketing management. Also, courses that allow them to previously know the quality of the different coffees produced on the farm must be given.

For production traceability, it is essential that the farmers have the map/sketch of the farms with identification of the individualized coffee plots, as well as the records of the different batches of coffee beans produced (ALIXANDRE et al., 2020). This is a process that allows traceability from the yield to the coffee bean storage within the farm. All farms did not achieve satisfactory scores in this standard because the traceability process is not yet implemented.

None of the four sampled farms met all the necessary criteria for the proper coffee bean storage, and this affected the final scores. In order to adjust them, it is necessary homogeneous coffee batches according to the coffee beverage and type, the coffee bean bags must be placed on wooden pallets, and away from the wall. The coffee bean storage must be very clean, free of pests, airy, closed, and must have controlled lighting. Jute bags or plastic eco-bags should be used. The grains can be stored in the form of coconut or parchment, and the internal humidity of the coffee beans must be kept around 11 - 12% (DINIZ et al., 2016; ALIXANDRE et al 2020).

4.2 Environmental axis

The farms sampled showed variations in the final scores, ranging from 56 to 79 in the environmental axis. However, the same deficiencies were repeated in several of the standards used. These standards were related to the pesticide's storehouse, acquisition and return of empty pesticide packaging bags, use of PPE, and proper disposal of the farm's waste.

Pesticide acquisition standard showed that coffee growers do not always purchase these chemicals with the prescriptions required by the Brazilian law, and under technical support; this was the cause of all sampled farms receiving the score 0 (zero). Article 84 of Law 7,802 (literature) obliges the pesticide user to follow this standardization described as a standard, as well as coffee growers must follow the technical specifications of the chemical for coffee cultivation (ALENCAR, 2010).

Another standard that had not been observed in the sampled farms was the storage of pesticides according to specific Brazilian law. One of the farms had partial adequacy. The specifications for this standard are based on the NR 31 of the Brazilian Association of Technical Standards - ABNT (literature): the storehouse construction must be located in a place distant at least 30 m from homes and water sources, must have an impermeable floor, a pesticide leakage containment system, a ventilation system, natural lighting, cannot allow access to animals, and must be signed with danger symbols. Pesticides cannot be kept together with human and animal feed, seeds, or medicament, and must be stored by type (e.g., fungicides, herbicides, insecticides) (COSTA, 2019).

Evidence of the return of empty pesticide packaging bags was also not a reason for attention on the farms, and this was the reason why the average score of this standard on the environmental axis be reduced. Empty pesticide packaging bags must be sent to specific collection points, together with their respective purchase receipts, within a period of up to one year after purchase. Before, however, they must receive the triple washing, and be perforated to make their reuse unfeasible. Furthermore, the proof of this process must remain kept by the farmers. The use of empty pesticides packaging bags is expressly prohibited for any purpose (DINIZ, 2016).

The use of PPE was one of the standards with the lowest score due to the non-use of complete equipment. The use of this PPE is individual, and each farm must have at least one complete PPE for each pesticide applicator. PPE aims to protect workers' health and reduce the risk of intoxication resulting from exposure to pesticides. Brazilian labor legislation (literature citation) determines the mandatory use of this PPE, as well as its correct conservation (DINIZ et al.,2016; COSTA, 2019). The challenge in this standard is to encourage applicators to participate in training courses for the correct use of PPE, keep their PPE in good condition, and replace any damaged part.

Three of the four farms reached maximum scores in the management of solid and liquid waste generated on the farm. This standard establishes that waste collection must be selective and recyclable materials must be separated from those that are not recyclable (DINIZ, 2016;

MARTINUZZO et al., 2021). The main challenge found was related to the public structure of waste collection in rural areas of the municipality, with a great irregularity in service in regions within the municipalities. Thus, the farms have difficulties in guaranteeing the correct destination of the waste. However, it was found that farmers were aware of this need and, to solve that situation, they periodically took solid waste for previously defined collection points in the urban area of the municipality. There is the possibility of adapting the destination of some residues within the farms such as food remains, water from the post-harvesting process, as well as the coffee husk. So, organic waste has been transformed into fertilizer, through a composting process, and reused on the farms. The proper disposal of waste consists of minimizing its impacts on the environment and for the people. Agricultural activities are subject to licensing, as regulated by Law 6,938/1981 and Complementary Law 140/2011. The domestic sewage system must receive adequate disposal, using septic tanks, biodigesters, or other appropriate treatment ((DINIZ, 2016; IDAF, 2022).

All the farms sampled were regularized for the standard legal reserve and permanent preservation area in accordance with the environmental law, through Rural Environmental Registry (CAR). Furthermore, all of them were visually evaluated, and supported by adequate documentation; thus, they received the maximum score. This demonstrated the environmental awareness of the farmers regarding the preservation of the native flora of the Atlantic Forest biome in which the farms are inserted. According to Law No. 12,651, of May 25, 2012, the farm must present the regularization of the legal reserve and permanent protection areas in accordance with CAR, electronic registration of national scope with the competent environmental agency. Registration is mandatory for all farms, in order to integrate environmental information from farm, with monitoring, environmental and economic planning, and combating deforestation (IDAF, 2022). Permanent Preservation Areas (APP) are areas protected by Law 12,651/2012, whether or not covered by native vegetation; they have the environmental function of preserving water resources, landscape, geological stability, biodiversity, the gene flow of fauna and flora, protecting the soil and ensure the well-being of human populations. The suppression of vegetation in these APP can only be authorized in cases of public utility or social interest (SNIF, 2019).

The standard water source areas protection also received the highest score in all sampled farms because the non-presence of water source areas was found in any of them. Adoption of preservation and recovery practices, such as soil protection, vegetation enrichment, fencing of the water source areas with soil and water contamination control, and the restriction of access to protection this area is necessary to be adopted if there are any water source areas on the farm. (CARVALHO, 2004).

Espírito Santo State Law No. 6,613, of February 6, 2001, and Law No. 5,197, of January 3, 1967, determine the prohibition of hunting, fishing, or illegal trafficking of wild animals and plants in addition to illegal fire, restricting the use of burned without authorization from a competent bureau (IDAF, 2022). All farms achieved maximum scores because none of them use these practices such as illegal activities, and demonstrated a very high degree of awareness regarding the preservation of native fauna.

4.3 Social axis

The social axis presented the highest score in all farms, ranging from 67 to 81 points. The main standard that contributed to this highest score was the adjustments found in relation to the current labor law. Employees and partners were regularized under labor law, child labor or forced labor was not found, and no labor was found in hazardous conditions. Three of the four coffee growers reached 100 points, since they are the owners, work with their own family, and do not use external labor, a characteristic that raised the scores in this standard. Just one of them did not show the required documentation of the partnership agreement, partially reducing the grade. Employees' freedom of organization was respected, and their payments were compatible with the labor market. Access to education and health services also received maximum scores because these two standards were fully regularized in all sampled farms.

The employer, whether an individual or a legal company, must legally hire its employees through a contract and a work record booklet for permanent and temporary employees, in accordance with Laws nº 5.889/1973, 9.300/1996. The farmer must give equal treatment to any worker, including family members, regardless of race, sex, religion, and political affiliation, whether at the time of hiring, during the period of service provision, or on dismissal (DINIZ et al., 2016).

Access to public education is offered by the municipality government, and schools and transport are available for different age groups of the rural population. Access to health is provided by the Brazilian Unified Health System (SUS, 2022), and family care is carried out by public health agents in specific programs.

In the training standards (application of pesticides, cutting machine, coffee bean picker, and chainsawoperator), the farms did not show satisfactory scores because it is necessary to prove the training through

the presentation of certificates, which is not the reality of these farms. Therefore, most farmers use this equipment without the necessary training, based on their own experience and need just within their farms. The National Rural Apprenticeship Service (SENAR, 2022) has continuously offered courses for the education and training of workers in rural areas. Among these training is the application of pesticides, in which it is possible to learn about all the technology for the safe use of these chemical or biological products. In addition, it is possible to understand the importance of using PPE in pesticide manipulation, as well as the need for the professionalization of this activity. The certificate of the course operators of agricultural machinery is required to comply with the standard if there is an agricultural tractor on the farm; if not, the maximum score is assigned. For these cases, it has been recommended that training be carried out (SENAR, 2022).

The real need for intervention in the four farms sampled, in order to increase the level of their sustainability, was pointed out from the evaluation of the three axes. Mainly the standards related to the economic axis were the ones that most affect the final grade of adequacy in sustainability in the four farms sampled, followed by the standards of the environmental and social axis, which also showed a lack, although in smaller proportions. In order to understand the sustainability process of the farms, it is necessary to interrelate the component aspects of the three axes evaluated in a dynamic and holistic way. It is necessary clearly comprehend that sustainability is a dynamic process, in constant change and that it can undergo changes that interfere with the relative degree of farm sustainability. Thus, it is necessary to outline clear goals, choose the path and strategies to achieve them, as well as adjust the time to reach these goals, respecting the elements that make up the culture and the desire of the farmers involved in the process. This comprehension is mainly for the maintenance and development of sustainability levels on farms (ASTIERet al. 2008).

V. CONCLUSIONS

- The proposed methodology proved to be efficient for diagnosing the levels of economic, environmental, and social adequacy of farms;
- The main intervention needs to improve sustainability levels of the four farms were related to the economic standards, followed by the environment and social;
- In general, the main needs were related to the quality management of coffee beans, production costs and incomes, improvement in the harvest and post-harvest processes, training in manual machines, and the correct use and application of pesticides;
- There is a need for individualized interventions in the farms; however, the ownerfamily's values and their limitations, particularly the cultural, must be respected;
- Different intervention techniques must be used on each farm in order to reach the maximum levels of adequacy, according to sustainability standards criteria. However, the results of farm adjustments must be achieved in different ways and at different times;
- Finally, interventions that need to be improved may enable to increase the production of specialty coffees on the studied farms and adjust them to the requirements of several international coffee certifiers. Thus, these farms will be able to export specialty coffees to new international markets, add value to coffee beans, increase incomes on the farms, and develop the level of the economic sustainability axis,as well as the quality of life for these householder's families.

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