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Domain framework for agriculture sales pricing: a case study in horticulture

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Abstract

Cost management techniques allow rural administrators access to information that can assist them in decision-making about the marketing of their products. The pricing of sales is responsible for the management of the production costs and the price definition of the product. There are few automated solutions in the agricultural context for cost management in the literature. This work created a domain framework that allows helping farmers in sales pricing. For the implementation of the tool, a framework development methodology was used and its validation was done through data collected from the literature. Using the developed framework, farmers can manage production costs as well as set a marketing price for their crops according to the desired profit margin. This facilitates decision-making that is part of the process of managing your property.

Keywords: Costs. Domain framework. Horticulture. Sale price.

Resumo

As técnicas de gestão de custos permitem aos administradores rurais o acesso a informações que podem auxiliá-los na tomada de decisão sobre a comercialização de seu produto. A precificação de vendas é responsável pela gestão dos custos de produção e pela definição do preço do produto. Existem poucas soluções automatizadas no contexto agrícola para gestão de custos na literatura. Este trabalho criou um framework de domínio que permite auxiliar os agricultores na precificação de vendas. Para a implementação da ferramenta, foi utilizada uma metodologia de desenvolvimento de framework e sua validação foi feita por meio de dados coletados na literatura. Usando a estrutura desenvolvida, os agricultores podem gerenciar os custos de produção, bem como definir um preço de comercialização para suas culturas de acordo com a margem de lucro desejada. Isso facilita a tomada de decisões que faz parte do processo de gestão do seu imóvel.

Palavras-Chave: Custos. Estrutura de domínio. Horticultura. Preço de venda.

1 Introduction

The definition and calculation of the costs of agricultural products are influenced by factors resulting from the features of agricultural production. Among the most relevant are: natural factors, which include soil conditions, climatic conditions, and the location of the agricultural area. These factors determine the quality of the land and the yield of the crops (Stašová and Bajus, 2017).

When there is no planning or control of agricultural activities and costs, the different types of farmers –

business or family – may have difficulties staying in the market (Moreira et al., 2016). Concerning agricultural production, there are few forms of negotiation between the producer and the consumer, which shows the importance of cost management in rural areas, because through this the farmer can increase economic gains (Gura et al., 2018).

The use of cost management practices allows the rural administrator to obtain accurate information for decision making, making it possible to know how much to produce, how to produce, which inputs to buy, and from which suppliers, among other data. The development of

technologies related to pricing in horticulture, becomes important, considering that the majority of small farmers do not use any type of cost management practice, generally, they only use annotations (Crepaldi, 2012), that is, they use a deductive method to form the sale price of the product.

One of the cost management practices is related to sales pricing since it is possible to manage the production costs and define the price of the product for sale. Sales pricing methods emerged to ensure that buyers pay a fair price for a certain product, as well as, entrepreneurs receive the right value (Crepaldi, 2012).

There are sales pricing software that already exist in the agricultural area, they are used to price agricultural equipment, as is the case of PRAPAG (Mercante et al., 2010), AGMACH (Mapemba et al., 2008), MACHSEL (Mapemba et al., 2008), and MAQCONTROL (Piacentini et al., 2012). These systems control the types of possible costs for a given production, considering only agricultural machinery.

Still, on the sales pricing, some methodologies that carry out the pricing of agricultural products using accounting methods. An example is a study by Sampaio et al. (2011), who implemented the activity-based costing method (ABC method) in agricultural grain production. Another application was given in the work by Backes et al. (2006), Carmo et al. (2013) and Maia et al. (2015). The first is related to the application of full cost techniques in an agricultural cooperative; the second refers to the application of the uniform annual cost equivalent method (CAUE), in the logistics sector of an agricultural cooperative in Ponta Grossa; and the latter uses multiple linear regression analysis to define the price of peach palm in the Vale da Ribeira region.

There are also works, on sales pricing in the agricultural area, that use only specific software or a costing methodology, that is, there are no studies that relate more than one form of price definition for a crop. In addition, it is observed that there is little research relating horticulture to cost management.

This work developed a domain framework that assists the farmer in pricing their products. The methodology for building the tool was that of Braga (2002), and its validation used data obtained from a literature review. Data were obtained from the National Supply Company (Conab), Embrapa Hortaliças, and the Technical Assistance and Rural Extension Company (Emater) (Conab, 2022); (Embrapa, 2022); (Emater, 2022).

With the framework created, the farmer can manage the production costs of his property, as well as set the marketing price of his crop according to the defined profit margin. These features facilitate decision-making by the rural administrator.

2 Pricing in Agriculture

The price can be considered as a monetary conception of the value of a product or a service. For companies, the term refers to the amount of money that can be accepted in exchange for a product, while for consumers it is something for which they are willing to pay in exchange

for a product (Monteiro and Coelho, 2015).

The responsibility for pricing products is called pricing. Its formation is related to the emergence of cost theories, because before it was not possible to calculate the cost of a service or product (Machado and de Souza, 2006); (Bertó and Beulke, 2017).

In the agricultural sector, farmers need to face some challenges related to the sales pricing, such as the diversification of production, climatic conditions, and depreciation, which must be considered for efficient management, since the fact of knowing the costs involved in the production, allows the producer to remain in the market and make a profit (Lopes et al., 2015).

Few are the producers who systematically make accounting notes and really know how the business is doing. Most are concerned with monitoring the productivity indexes Crepaldi (2012). In the study carried out by Gura et al. (2018), it was found that the small producer controls their spending through notebook annotations, that is, they do not have an automated tool for this purpose, which causes low adherence to cost practices and the lack of a history of their expenses. For this reason, new tools can be suggested for cost management.

2.1 Cost Management in Agriculture

Cost management is a relevant factor due to economic globalization, growing competition, and decreased profit margins. There is a need for organizations to seek efficiency in their results, insertion in new markets, development of new products, expansion or just to remain active (Crepaldi, 2012). According to Crepaldi (1998) "agriculture represents all the activity of exploring the land, whether is the cultivation of crops and forests or the raising of animals, intending to obtain products that will meet human needs".

Farmers use cost knowledge to economically evaluate their activities and verify production factors, such as soil quality, labor, and capital, in an efficient, complete and economical way (Lopes et al., 2004) apud (Lopes et al., 2015).

In the process of raising the costs of a given production, it is necessary to carry out the planning and define the strategies (Lopes et al., 2015). This is possible through the costing methods that are used to perform the pricing of a given production (da Costa Schier, 2011). The Activity-Based Costing (ABC), Absorption Costing, and Variable Costing methods are examples of practices used by small farmers for cost management (SENAR, 2019).

Activity-Based Costing (ABC) is a cost control and allocation technique; that allows the identification of existing processes and activities; the analysis and control of costs involved in a process or activity; the allocation of costs to products, using cost generators as a parameter (da Costa Schier, 2011).

The Absorption Costing method considers the appropriation of all production costs for a given product, as well as other expenses related to the effort applied to production (Martins, 2003).

The Variable Costing method divides the production costs of a product into fixed and variable costs. Fixed costs are not appropriated to products, as they are related

to the organization's structure and not to production, while variable costs are those resulting from production (Megliorini, 2012); (Leone, 2000).

After surveying the costs, it is necessary to apply a sales pricing method so that the marketing price is defined. This subject is covered in the next section.

2.2 Sales Pricing in Agriculture

For sales pricing to be possible, it is necessary to identify the costs and expenses involved in a production process, that is, when there is an efficient costing system, its results can be taken into account to assist in decision making (Domingues et al., 2017). According to Nascimento et al. (2016), the sales pricing must have the collaboration of all participants involved in the production, because wrong decisions can bring economic imbalances and financial losses.

One of the existing methods for pricing is the contribution margin. It represents the remaining value of the price of a product and or service, after deducting variable costs and expenses (Felippi et al., 2017).

Martins et al. (2003) states that this method ends up becoming a useful tool because it contributes to the verification of information regarding the survey of expenses and to avoid possible errors in the financial statements. Wernke (2017) says that the margin helps to understand the relationship between costs, volume, prices, and profits; it identifies which products generate negative results, and demonstrates which productive segments should be expanded, restricted, or even abandoned.

3 Proposed Framework

The proposed domain framework aims to assist the farmer in the pricing of products. In order to use the tool, it is necessary to have as a prerequisite the information related to the production costs of a given crop. The functioning of the framework is outlined in Fig. 1.

To register the modality and the divisions related to the productive process of the farmer's property, the functions of Category and Subcategory are used. An example of entries for these features is Horticulture as a category and Fruit harvesting, Olericulture, Floriculture, among others, as subcategories.

Costing groups (crop costing expenses, financial expenses, post-harvest expenses, etc.) must be reported in Costs. The product or culture related to the reported data is stored in Product.

After inserting this information in the framework, it is possible to input the data that quantify the cost groups. It is necessary to inform the units of measure regarding the entries that will be made in the system. Each cost component is recorded in the Component function; in addition, another data necessary for sales pricing is the productivity (Productivity function) of the crop in question.

To form the sales price using the ABC Costing method, you must first register the activities and their respective drivers. After this information is stored, it is possible to

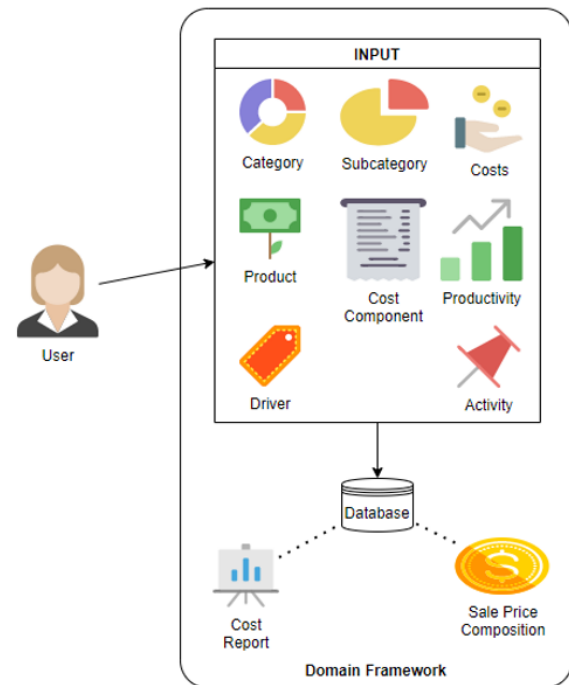


Figure 1: Proposed Framework

conduct the simulation, selecting the type, productivity, and defining the desired contribution margin. In the same way, it is possible to carry out the other simulations present in Sales Pricing, which are Absorption Costing and Variable Costing.

The framework presents the group of functionalities: Reports; in which the farmer can access the information extracted from the reported data. This group includes the following reports: Production Costs, Unit Cost, Totals by Cost, and ABC Costing.

The Production Costs report shows all costs related to a given crop. The Unit Cost report shows the value of one unit of the cultivated product, while the Totals by Cost report shows the cost values for each informed costing group. The ABC Costing report is specific to the ABC Costing methodology, containing activities and values by drivers.

The modeling of the framework has followed the methodology of Braga (2002), in its three steps: development of the language of standards, construction of the white box framework, and instantiation of the framework.

3.1 Development of the Languages of Patterns

Initially, information was collected regarding the three costing methods that make up the framework structure (ABC Costing, Absorption Costing, and Variable Costing) in order to perform the domain analysis. The information was extracted from technical documentation and literature. As a result of this step, a use case diagram and

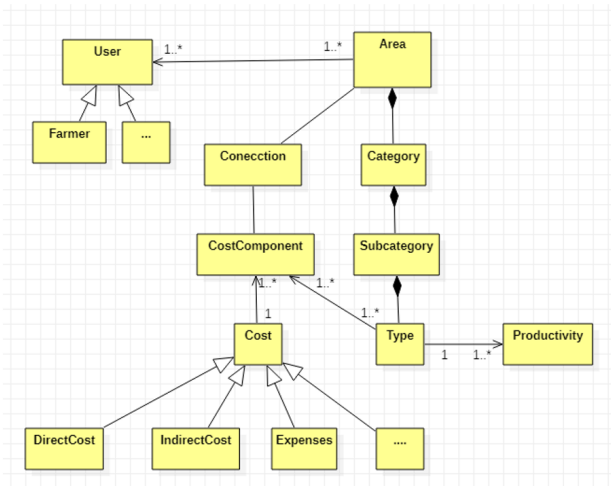


Figure 2: Frozen spots

a class diagram were created for each of the methods, because the models for these methods are not available in the literature.

Through the analysis of the use case and class diagrams developed, a class diagram was constructed with the stability points, that is, the aspects common to the three costing methods illustrated in Fig. 2. With these stability points, one can generate the language of patterns belonging to the domain of cost management in agriculture.

With the language of patterns defined for the domain of sales pricing in agricultural products an applications of the patterns flow diagram was constructed with the objective of determining the stability and flexibility points – they are specific to each application-example, that is, of each costing method –, as shown in the chart in Fig. 3.

The groups that are part of the language of patterns created are Group 1 – “Business Domain”, Group 2 – “Product Information”, Group 3 – “Costs and Expenses”, and Group 4 – “Costing”. Group 1 has as pattern names: Identify the area (1), Identify the category (2), Identify the subcategory (3).

For Group 2, the following pattern names: Identify the type (4), Quantify the productivity (5), and Identify the cost (6). Group 3 consists of the following patterns: Classify the cost (7), Quantify the cost (8), Store the cost (9). Finally, Group 4 consists of the Calculate the sales price pattern (10).

In the developed language of patterns, it is possible to visualize the dependency relationship between the patterns through the arrows’ directions. An example of this relationship is the patterns (1) – (2) – (3) – (6) – (7) – (8) – (9) – (10), that is, it is only possible to identify, classify, quantify, store the cost, and calculate the sales price after identifying the area, category, and subcategory.

After analyzing the graph of pattern application, a table was elaborated with the points that may suffer variation in the domain. The list of points of flexibility is presented in Table 1. The other points present in Fig. 3 that are not included in Table 1, were considered the points of stability,

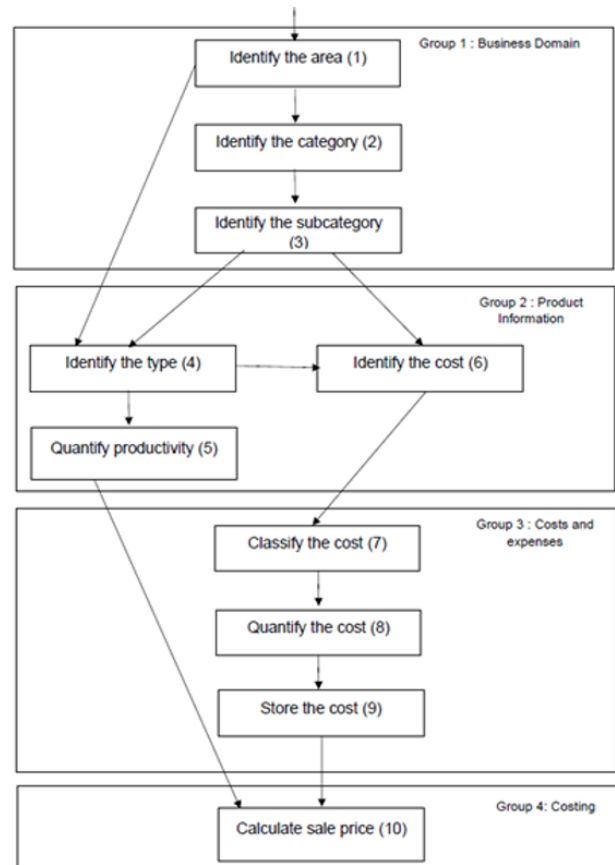


Figure 3: Developed graph based on patterns language of research domain

that is, those that do not vary between the costing methods analyzed, they are (1) – (2) – (3) – (4), and (5).

Based on the graph analysis, the following points of flexibility were identified: Identify the cost (6), Classify the cost (7), Quantify the cost (8), Store the cost (9), and Calculate the sales price (10).

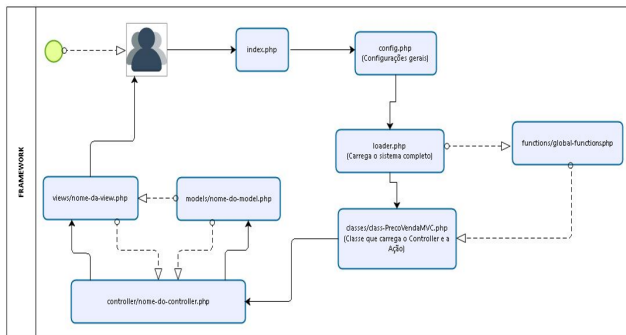
For example, the Classify cost pattern was considered a point of flexibility, because depending on the domain method used in pricing; this classification may have the following denominations: direct cost, indirect cost, unit cost, variable cost, expenses, among others. Similarly, it happens with the Calculate the sales price pattern, because according to the chosen costing method (ABC Curve, Absorption Cost, and Variable Cost), its operation is different. After identifying the points of flexibility and stability, the implementation of the domain framework project for agricultural sale pricing was carried out.

3.2 Construction of the White Box Framework

Regarding the framework design, the application development started based on the architectural standard MVC (Model ViewControl), in this way, the project structure was organized in the MVC layers as illustrated in Fig. 4.

Table 1: Flexibility points list

Pattern Name	Description	Type	Pattern N°
Identify the cost	A cost can or can't have a type related to it. It's possible having multiple or lined up types.	PARTIC CHOICE	6
Classify the cost	A cost may have several classifications depending on the method used.	PARTIC CHOICE	7
Quantify the cost	A cost may be the one or may have multiple Instances and may be managed in different unities.	PARTIC CHOICE	8
Store the cost	The application could not need to manage cost storage.	PATTERN OPTIONAL	9
Calculate sale price	There are different ways of a production costing, each one of them has its specific methodology.	PARTIC CHOICE	10

**Figure 4:** Framework Operation

The framework architecture works as follows:

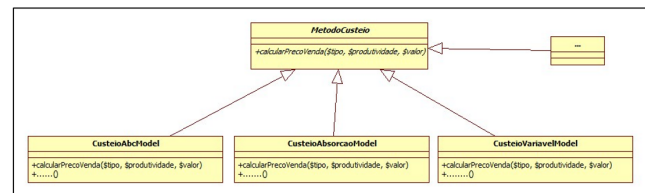
- The user accesses the website;
- The index.php file only includes the config.php file;
- The config.php file is responsible for registering the tool's settings and loading the loader.php file;
- The loader.php file loads the global-functions.php file which is responsible for maintaining all global functions, such as autoload to load the classes automatically and is responsible for instantiating the "PrecoVendaMVC" class that will control the entire initiation of the application;
- The "PrecoVendaMVC" class will check if a controller is requested by the URL and include it. In addition, it will check if any controller action has been requested (still via the URL). Otherwise, the "index" action of the controller will be performed. Therefore, every controller will have an action called "index";
- The controller file (controller) is responsible for having all the actions of the session. Each action will differentiate the Models and/or Views that are requested;
- The model file (model) contains all the methods necessary to execute the View's actions;
- The view file (view) shows the user who requested the action in the corresponding interface.

Subsequently, the classes referring to the three costing methods were added to the class model. The class diagram was refined through the application of patterns and metapatterns. Regarding the metapatterns available in the literature, the framework class model called Unification was applied. It was used in classes where there is a method

for calculating the sales price, as represented in Fig. 5.

It is noted that in Figure 5 the hook (hot spots) and template (frozen spots) classes are united in the same class (Costing Method) and there is an overlap of the hook method, responsible for calculating the sales price.

With regard to design patterns, the following patterns were applied: Singleton, Observer, and Strategy. The Singleton pattern was implemented in the data persistence class PrecoVendaDB as illustrated in Fig. 6.

**Figure 5:** Unification

The main purpose of the Singleton design pattern is to ensure that a class will only have one instance and provide an access point to it (Gamma et al., 1995). For this to happen it is necessary to have a static (pdo) attribute that will be responsible for storing the class instance, in addition, a static (connect()) method is needed and will check, through a conditional structure, if it has already been instantiated an object of the class in question.

Another applied pattern was the Strategy for visualization and control classes. The purpose of the pattern is to allow algorithms to vary independently among the customers who use them (Gamma et al., 1995). The application of Strategy in the class model of the framework can be seen in Fig. 7.

The PrecoVendaMVC class defines an interface that allows the control classes to access their data, that is, to access which functionality was requested to load the respective view class. The MainController class declares a common interface for the supported algorithms and the PrecoVendaMVC class uses this interface to call the algorithms defined in the control classes. The control classes have the implementation of the (index ()) method that defines which view class should be loaded.

Model classes use the Observer pattern to keep the view and control classes up to date on the most recent state changes. The goal is to define a one-to-many dependency among objects so that if an object changes its state, all its

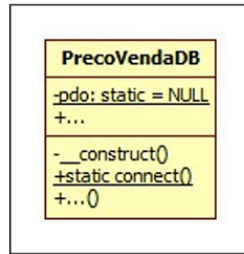


Figure 6: Singleton

dependents are automatically notified and updated. The class diagram in Fig. 8. shows the structure of the pattern applied for the developed tool.

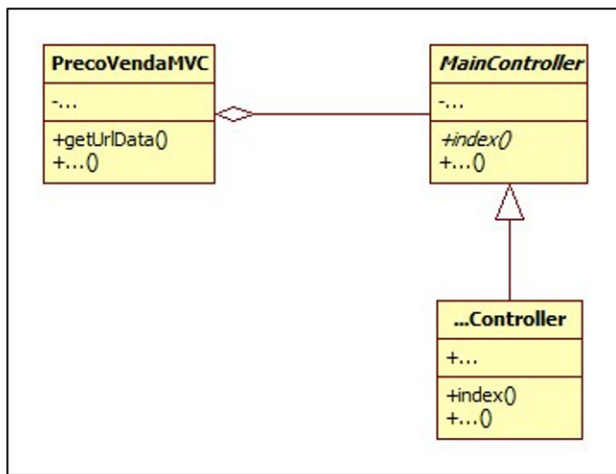


Figure 7: Strategy

The Subject class provides an interface for attaching and separating objects from the SplObjectStorage class, this class is an implementation of the Observer standard

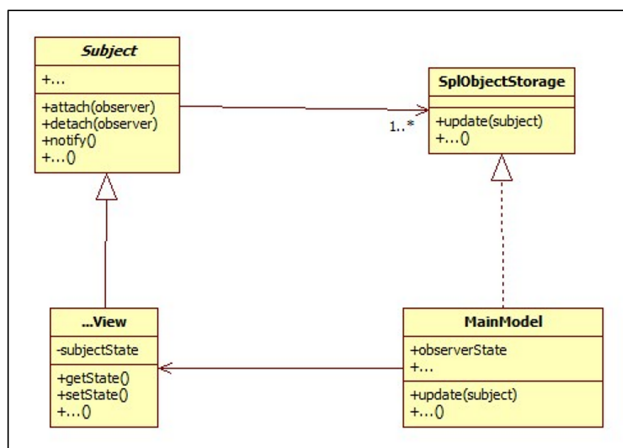


Figure 8: Observer

available in the language. The visualization classes send a notification when their states change, that is, when the view class changes, this operation is notified to the model classes. Finally, MainModel notifies the visualization and control classes that the model has been loaded.

After the refinement of the general class model of the framework with the application of design patterns and metapatterns, the implementation phase of the framework began, in it the view, control, and model classes were coded in PHP.

3.3 Framework Instantiation

The framework is reused through inheritance, as it is a white box framework. The requirements of the application to be extended must be checked to define its classes and which classes of the framework should be specialized. According to Braga (2002), this process has four phases: system analysis, mapping between the analysis model and the framework, implementation of specific classes, and testing of the resulting system.

The analysis of the system must be carried out according to the language of patterns. The steps for using the developed language of patterns are:

- Study the language of pattern to find out what your domain is, what patterns are available, and when and how to apply them.
- Produce a document of requirements, this file must describe all the desired features to be developed.
- Generate a use case diagram and a class diagram according to the document of requirements produced earlier.
- Check which language patterns can be applied to the system to be implemented.
- Create a list of the classes that are to be implemented and that have not been identified by the language patterns.

The document of requirements for a specific system and the language of patterns can serve as inputs for this step. As a result of this step, a system analysis model is generated, the patterns to be used, and a list of decisions made when the language of patterns does not meet all system requirements.

With the analysis model of the developed system and the patterns that will be applied, the second step of the instantiation begins: the mapping between the analysis model and the framework. In this step, it is possible to identify which classes will be used in the framework, as well as which should be stanchied. The result of this step is a list of the application's classes and corresponding methods to be implemented.

The class diagram illustrated in Fig. 9, shows the possibilities of instantiation from the framework classes. The term “incomplete” indicates where new classes can be added and from which classes these new ones should inherit.

It is noteworthy that the classes that are not identified in the language patterns or the methods that do not have correspondents in the framework's class model must be implemented together with the classes already generated.

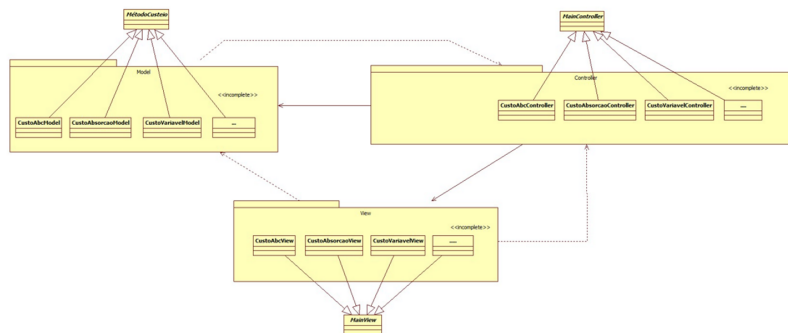


Figure 9: Class Model of Proposed Framework

To add a new costing methodology to the structure of the proposed framework, it is necessary to create the corresponding class (name of the methodology + Model) and extend it from the “Costing Method” class, in this way, the method responsible for calculating the sales price is implemented. In addition, it is necessary to create a controlling class and a viewing class.

After defining the classes and methods to be implemented in the previous step, the implementation phase for the specific system begins. It is recommended to code in the language in which the framework was developed, in this case, PHP. The result is the source code of the new application classes, which must be used in conjunction with the framework classes to compose the new application.

The system obtained must be tested so that all application requirements are met and to verify its functioning in the end user’s environment. The desired result is a properly tested application, which can be delivered to the end-user.

4 Results

The proposed framework was instantiated to form the sales price in horticulture. Horticulture is the science that studies the different types of plants in different forms of cultivation such as in gardens, orchards, vegetable gardens, or greenhouses, in order to meet the nourishment and aesthetic needs of human beings (Sebrae, 2022). Filgueira (2000) say that “Horticulture in its current concept is the science and art of growing fruits, vegetables, flowers and ornamental plants, medicinal plants, aromatic and condiment plants and mushrooms.”

Horticulture can be divided into olericulture (cultivation of vegetables), fruit culture (cultivation of fruit species), floriculture (cultivation of flowering species), gardening (cultivation of ornamental plants), viviculture [U1] (cultivation of seedlings in general), condiment plants, medicinal plants and edible mushroom culture Filgueira (2000).

After the development of the framework, it was necessary to apply it with data belonging to horticultural crops, to meet this demand it was only necessary to insert the data and activities. The costing methods were validated with data from the agricultural segments:

ID	Type	Month	Year	Sale Price	Contribution Margin (%)
16	Rose	August	2019	0.25	60

Figure 10: “ABC Costing” screen

roses, irrigated garlic, and strawberries, which are part of horticulture. The input values for validation of the framework were extracted from Emater, Conab, and the work of Badejo (2000).

In pricing rose culture, it was necessary to input the category, subcategory, cost, cost component, and productivity information. Table 2 presents some of the data provided for the sales pricing.

The methodology used for pricing this crop was ABC. Thus, the framework was fed with the activities and their respective drivers. The activities reported were Irrigation / Fertigation, Harvesting and Pruning, Pesticide Application, Greenhouse Aeration and Transport, and their respective drivers: hours/pump, number of buttons, system functioning hours, hours of aeration, and kilometers traveled.

The sales price of the rose was set at a contribution margin of 60 (demonstrative amount). The sales value returned by it was R\$ 0.25 for each rosebud, as shown in Fig. 10.

In the functionalities belonging to the Reports group, the user can view the information inputted through groupings according to the chosen costing methodology; in this case, it is possible to check the total expenses per

Table 2: Input data for testing in the framework

Category	Subcategory	Cost	Component	Productivity	Value
Horticulture	Floriculture	Harvesting and Pruning	Labor	5500 buttons	R\$ 31.20
		Pesticides	Spraying System		R\$ 27.76
		Greenhouse	Fan Consumption		R\$ 9.00
		Transportation	Fuel		R\$ 52.27

Table 3: Data for simulation of the irrigated garlic culture

Category	Subcategory	Cost	Component	Productivity	Value
Horticulture	Floriculture	Crop Costing	Fertilizers	9000 kg/ha	R\$ 5741.13
		Post Harvest	Agricultural insurance		R\$ 600.00
		Depreciation	Machines		R\$ 554.79
		Income from Factors	Land		R\$ 562.50

Table 4: Strawberry culture data

Category	Subcategory	Cost	Component	Productivity	Value
Horticulture	Floriculture	Inputs	Green adubation [U2]	2800 boxes.	R\$ 1200.00
		Inputs	Strawberry seedlings	1.2 kg	R\$ 12500.00
		Services	Planting		R\$ 2400.00
		Services	Grating		R\$ 330.00

Activity	Activity Cost	Driver	Quantify	Driver Cost
Irrigation/Fertirrigation	99.23	Pump hours	10	9.92
Defense Application	128.18	Working system hours	5	25.64
Greenhouse Aeration	50.17	Aeration hours	30	1.67
Harvest/Pruning	54.37	Number of buttons	5500	0.01
Buttons Transport	202.64	Run km	420	0.48

Figure 11: “ABC Costing Report” screen

ID	Type	Month	Year	Sale Price	Contribution Margin (%)
14	Washed Garlic	February	2019	14.425	60

Figure 12: “Absorption Costing” screen

activity in the production of rosebuds, as shown in Fig. 11.

The Absorption costing method was validated using the costing information of the irrigated garlic culture. Some of the data used for the simulations are shown in Table 3.

After inputting the information, the simulation of the irrigated garlic crop returned the value of R\$ 14.42 per unit, as shown in Fig. 12.

The variable costing methodology was applied to the strawberry crop, this crop belongs to the fruit culture category and some of its production costs are shown in Table 4.

The selling price for the strawberry crop is 60 contribution margin and can be seen in Fig. 13.

The suggested price for marketing the strawberry unit is R\$ 8.25, with this value the farmer will be able to

reach the desired contribution margin. Thus, it is noted that the quoted values change as the days go by, which means that the farmer has to monitor prices and adjust his contribution margin according to their production.

4.1 Discussions

The results obtained by this research can be analyzed from two perspectives: the first is related to the gains that the proposed framework model can bring and the second to the reuse of the already instantiated framework that represents a software product in the field of horticulture.

The framework model can be extended, as presented in this article for horticulture. The developer who wants to instantiate the framework for another agricultural

ID	Type	Month	Year	Sale Price	Contribution Margin (%)
71	Strawberry	January	2019	8.25	60

Figure 13: “Variable Costing” screen

area can create specific abstractions to its area without changing the framework structure. The developer’s job is to study the pattern of languages and create the list of classes that need to be inserted into the model. In addition, the developer can add new costing methods to the framework structure and for this it is necessary to create the corresponding class (name of the methodology + Model) and extend it from the “Costing Method” class, thus implementing the method responsible for calculating the sales price. In addition, it is necessary to create a controlling class and a viewing class.

The framework model is different from the published researches because it uses only a single costing methodology for management, as is the case of the work of [Di Domenico and Lima \(1995\)](#) who used the ABC methodology for cost management in a citrus farm, [Silva et al. \(2016\)](#) who applied the Absorption Costing method to corn production on a farm located in the state of Mato Grosso and [Becker et al. \(2020\)](#) who used the Variable Costing methodology to survey costs in tobacco production. In the research by [Moutinho et al. \(2012\)](#), two forms of costing were used: Variable costing and ABC applied to soybean and corn production. Thus, the framework model contains several cost survey methodologies, covering three costing methods: ABC costing, Absorption costing and Variable costing, in addition to offering the possibility of being extensible.

Other works found in the literature, use the Variable Costing methodology as the case of [Rauber et al. \(2005\)](#) in soybean and corn crops; [de Andrade et al. \(2011\)](#) in soybean culture; [Barbosa et al. \(2012\)](#) in the livestock and dairy areas and [Bonfanti and Cittadin \(2019\)](#) in the irrigated rice culture. It is observed that these surveys use manual models for cost management and do not implement techniques for the formation of sales prices. The contribution margin was not considered in any of the studies analyzed, which demonstrates a differential of the proposed framework model.

Another perspective is related to the reuse of the framework instantiated for horticulture that facilitates the process of inputting costing information by the rural

property manager, bringing agility to the process and reducing any errors in costing calculations.

By using the framework in the domain of horticulture, farmers can store data related to the production costs of a given crop, facilitating planning and controlling expenses of their property. In addition, it is possible to calculate the unit cost of a given crop using one of the three options of costing methods: ABC Costing, Absorption Costing and/or Variable Costing, which highlights the difference between the framework in relation to other existing applications.

Another positive aspect is related to the contribution margin, in which users can define the margin that best suits their production. It is possible to generate different types of reports that assist farmers in managing their property and making decisions.

With the price returned by the framework, rural managers can use it to define the marketing value of their crop. When selling their products at the established price, farmers will have a greater chance of reaching the goals established in the decision-making process, in addition to facilitating the achievement of the desired profitability.

5 Conclusion

This work developed a domain framework for product pricing applied to agriculture and instantiated to horticulture. As for the identification of sample applications, the methods of ABC Costing, Absorption Costing and Variable Costing were chosen. In addition, data from the test cases are from horticulture and were extracted from the literature: Companhia Nacional de Abastecimento (Conab), Embrapa Hortaliças and Company of Technical Assistance and Rural Extension (Emater).

The framework has three features that make the approach an alternative for farmers. The first refers to the free availability of the framework, facilitating the adherence of the farmer. Secondly, the developed model can be used by other researchers for future improvements or use in other works in the area. Third, the template provides for the use of existing methods and classes, as well as the possibility of adding new features.

Based on the analysis of the proposed framework with the related work, it is possible to state that HortiPrice has some advantages, among which the following stand out: the availability of an automated tool, considering that most studies suggest manual execution solutions; the use of more than one costing method to calculate the sales price formation, as the articles published in the area use only one costing method; and the applicability of the tool in several crops belonging to horticulture, making it a differential due to the fact that the results found in the systematic mapping, had as their theme only one modality of this area, as an example, the work of [Emerole et al. \(2013\)](#) with application exclusively in fruit growing.

It is worth noting that the HortiPrice framework will be made available to farmers free of charge, as its development used non-proprietary and open-source technologies. The model can be used by another researcher in order to make improvements or use it for other work in the area.

With regard to the proposed framework model, it is possible to add new classes and methods or reuse existing methods for calculating the sale price. With the use of technologies related to cost management, cost control, and also, with the information generated by the tool that can help in decision making, the farmer will be able to face less difficulties to remain in the market and, consequently, will be able to increase your profits.

As future works, the research suggests the inclusion of more costing methods so that the user has more simulation options in the tool; insertion of other forms of pricing, not just restricted to the contribution margin; creation of a functionality that provides information on product quotations, using computational intelligence mechanisms, without the need for the farmer to leave the platform to obtain data on sales and use of the tool by farmers in the region, thus allowing the collection of data related to costs of its properties.

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