

Resource Allocation Process for
Capital Expenses at Hawthorne Valley Farm
Using Analytical Hierarchy Process,
Expert Choice and Excel Solver

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Abstract

Hawthorne Valley Farm (HVF) is a diversified biodynamic farm that is part of a larger not-for-profit organization. The farm consists of five major departments. Three of the five departments, dairy, garden and farm were involved in this project. All departments draw from a single capital expense budget. In order to equitably distribute scarce resources – capital budget funds – to those projects that will have the most significant effect, a model was created using the Analytical Hierarchy Process (AHP), Expert Choice and Excel's Solver function.

Initially, department managers were interviewed in order to establish a list of possible expenses to be funded during the upcoming fiscal year. A list of approximately twelve projects was created from the three departments. In discussions with managers, it was determined that the mission statement would form the basis for the objectives to be used in prioritizing the alternative projects. The derived objectives included values such as quality of life, which represents the environmental and educational mission of the organization. Objectives also included more practical aspects such as savings, revenue, product quality, urgency and risk. Individually, and then as a group, the managers prioritized the objectives.

Managers were individually asked to rate all the possible projects against the objectives. The ratings were based on the degree of contribution with six possible responses: extreme, significant, moderate, some, tad or none. These ratings were also prioritized in a group meeting. Finally, the individual answers were aggregated and imported to Excel's Solver for analysis. The results were then presented to the management group and iterations will occur as more hard data is gathered about the possible projects.

Introduction

Hawthorne Valley Farm is a diversified biodynamic farm in Upstate, NY. Although the farm is primarily a commercial enterprise, it is part of a larger not for profit organization, the Rudolf Steiner Educational and Farming Association (RSEFA). The mission of RSEFA is to build bridges between agriculture, education and the arts. Within the RSEFA organization, each branch has a distinct area of focus, but some of the work intertwines, particularly the education and agriculture. Hence, Hawthorne Valley Farm, as part of this larger organization and in its own work, tends to combine commercial and educational purposes.

Hawthorne Valley Farm is comprised of five major departments: farm, garden, dairy, bakery and store. The farm has 400 acres and is comprised of a 60+ dairy herd, other livestock and hayfields. The garden is a 10-acre vegetable garden selling produce to the store and directly to consumers through a farmer's market in Manhattan and a 200-member Community Supported Agriculture (CSA) program. The dairy adds value to the milk by processing it into yogurt, milk and cheese for sale in the store and larger distribution throughout the East Coast. The bakery produces bread and other baked goods for sale in the store and at the green markets. It is a full-scale natural foods store that serves the local community.

The educational work of the organization is integrated into the farm in three ways. First, there are approximately 6-8 young adults who come to the farm to apprentice for six months to two years. Additionally, during the school year, approximately 500 students – mainly 3rd graders – visit the farm as a class for a week to learn about life on the farm. The children are integrated into farm chores and activities, such as animal feeding, barn cleaning and working in the garden. During the summer months, there are camps for children ages 9-15. The older campers are the most fully integrated into the farm schedule and work daily on the farm and in the various departments (dairy, bakery and store).

Project Goal

The goal of the project is to distribute equitably and rationally, the limited funds that are available for capital projects for the next fiscal year. Although each department has a separate budget, there is a single capital expense budget for all the departments of the farm. The total budget for this year is \$40,000.

The farm has historically been undercapitalized and the needs each year far outweigh the available funds. As a result, the process of determining how these funds are distributed can be a source of great tension within the organization. This is particularly true, as the BOG/GSAT method has been used instead of any formal process of decision-making.

In order to avoid this conflict, the management group has agreed to explore the possibilities offered to utilize the Expert Choice and Excel software to create a model based on the Analytical Hierarchy Process (AHP) for the decision process. The management group was particularly intrigued by the ability to incorporate educational and economic values in the model. As the organization has such diverse purposes, it was

decided that the farm's mission statement would form the basis from which to distribute capital funds. In part, the mission statement reads:

“Hawthorne Valley Farm is committed to land stewardship based on sustainable agriculture and to the distribution of high quality food. Through the development of economic and cultural relationships it strives to raise the social and ecological awareness of the individual.”

Background

The fiscal year of the organization is based on the school year. Although the fiscal year doesn't begin until Sept. 1, 2000, individual departments begin to organize their draft budgets by April. The process begins so early for two reasons. First, the summer months are extremely busy on the farm and it is difficult to spare the needed time to develop a budget in the summer months when farming, milk production and green markets are at their height. Second, there is a long approval process for the budget. Capital expenses are decided by the management group, but brought before the board for final approval. In order to meet the time deadlines for this project, the capital budget process had to begin even earlier than usual. Luckily, due to the agricultural cycle, many of the capital expenses are known well in advance. On the management's part, there was a willingness to go through this process early before the height of the farming season begins.

Although there are five departments in the farm, only three were included for capital fund distribution this year. The bakery was excluded, as all capital resources were directed to the bakery last year. The bakery badly needed equipment and structural repairs; therefore, it was agreed that the most effective use of the limited resources was to focus on upgrading this department. As a result, this department has been excluded from capital funds for this coming fiscal year.

The store is also excluded due to extenuating circumstances. The store is in the midst of planning a major expansion. Although there are equipment needs that would qualify as capital expenses, they are still not identified in the current planning phase. As a result, and due to the scope of the project, it has been decided that equipment will be included in the expansion budget. At this stage, it is anticipated that funding will be obtained through a loan.

Capital Expense Projects

The first step in the process was to identify the potential capital expenses for the next fiscal year. The capital expense projects are initially developed by the individual department managers (Dairy Processing Plant, Garden and Farm) assessing their needs for the next year. Each project is independent and can be chosen without choosing the others within that group. The suggested projects are described in the following sections.

Chart Recorder

A new chart recorder is desired because only one of the two chart recorders is working. The chart recorder tracks the time and temperature during the yogurt processing and is necessary for meeting regulatory requirements. Estimated cost - \$1,000.

Ventilation and Steam Heating System in Processing Room

A new heating system is desired because currently there is no heating in the processing room, which creates an uncomfortable work environment in the winter months. The lack of heating also increases condensation on the ceiling and walls during production. The condensation results in an increased growth of mildew on the walls and ceilings that must be cleaned to meet regulatory requirements. Ventilation would help to alleviate this situation. The ventilation/heating system will also help to improve product quality by reducing the chance of contamination by condensed water falling into the product. Estimated cost \$5,000.

Maintenance Work - Replacing baseboards in processing room with tiles

Funding for maintenance work is desired because currently when water is sprayed during cleaning, the water gets behind the walls and is causing deterioration. Replacing the baseboards with tile will help to improve the physical infrastructure of the processing room and help meet regulatory requirements. Estimated cost \$1,500.

Solar Greenhouse

A second greenhouse is desired that allows for year round production of some vegetables. The current greenhouse is only suitable for seasonal use. The addition of this greenhouse would increase sales and customer satisfaction by extending the availability of produce. This greenhouse would also appeal to apprentices (a significant labor force for the farm) and provide an added incentive to staying on the farm through the winter months. The greenhouse also has the potential for being utilized as an educational tool for students and apprentices. (Normally, the greenhouses are not in operation, or in full use, during the school year when visiting classes are here.) Estimated cost - \$15,000.

Cultivating Tractor

A new cultivating tractor is desired because the current cultivating tractor is inefficient. A new tractor will improve efficiency and increase output due to better visibility of the row crops. It will also reduce frustration for those who work with the current tractor. Estimated cost - \$15,000.

Crating System

A new crating system is desired to transport the harvested vegetables to the point of sale and distribution. Currently wooden and wax boxes are used for this purpose, which is ineffective due to breakage and stacking problems. A plastic crating system, which can

be stacked, will increase efficiency and improve the quality of the product. Estimated cost - \$4,500.

New Pipeline washer

A new pipeline washer is desired as an upgrade to the current system. The current pipeline washer will need to be replaced at some time in the future. Efficiency will be slightly increased, as the new washer would have to be filled less frequently. There would be an increase in product quality due to consistency in detergent output. Estimated cost \$1,000.

Vacuum Milking System

A new vacuum milking system is desired as an upgrade to the current system. The new system would improve the quality of life, as it would be quieter than the current system. Cost savings would result from increased energy efficiency. Estimated cost - \$3,000.

Hot water heater

A new hot water heater is desired to increase the hot water capacity. The current hot water heater is shared between the farm and dairy and is not adequate to meet the demand. A second hot water heater would be installed. This will increase product quality, as washing will be done with hot water at the necessary temperature for proper cleaning. A second heater will also act as a backup for the first water heater. Estimate cost -\$2,000.

Whey Tank

A whey tank is desired in order to increase the number of pigs which can be raised on the farm. The current system for transporting whey to the pigs severely limits the number of pigs that can be raised on the farm. If the farm chooses to purchase additional pigs, a whey tank is a necessity. This purchase would increase sales and efficiency. Estimated cost - \$1,500.

Barn Electricity

A new barn electrical system is desired because the current electrical system is a fire hazard. While the barn doesn't meet existing code, its current setup has been grandfathered under the old regulations. Even though it is not a regulatory problem, there is a large safety concern. The barn is also adjacent to many other buildings and a fire would be difficult if not impossible to contain. Estimated cost - \$15,000.

Bulk Tank Compressor

The existing bulk tank compressor will need to be replaced. It is getting older and the existing unit is becoming less reliable. It has broken down once in the past few months and there is a growing danger of this in the future. The compressor is a vital unit for milk storage and the

risk of it breaking down would have immediate and significant economic consequences. Estimated cost - \$6,000.

Objectives

An initial kickoff meeting was held with the department managers to develop the objectives that best matched Hawthorne Valley Farm's (HVF) mission and goals. Each manager liked the idea of creating a model that assisted in choosing the projects that best met HVF's objectives.

In consideration of the mission and goals of HVF, the objectives established in the model represent the areas necessary to consider in making the choices of which capital projects to fund. Expert Choice was chosen to model this decision because multiple objectives, multiple projects and the aggregation of the managers' inputs all serve to make the decision complex and not easily discernible upon an initial analysis of the problem. The objectives that were chosen to model reflect the mission and goals of Hawthorne Valley Farm. The objectives contained in the model are:

1. Improve Product Quality
2. Savings – Time, Money
3. Quality of Life
4. Time/Risk – Time urgency, Risk
5. Increased Revenues
6. Increased Environmental Sustainability
7. Education

A discussion follows describing and detailing each objective.

Improve Product Quality

Improving product quality is an important objective at HVF because of the farm's desire to offer the highest possible quality food products. An excerpt from HVF's mission statement states, "We strive to be a high quality food production, processing, and distribution center for the community and part of a vibrant regional food system, while keeping the health of the environment at heart."

The farm is always looking for ways to improve their products and this objective is often considered in decisions that occur on the farm.

Savings – Time, Money

As with most non-profit organizations, HVF runs a lean operation that is continually looking for ways to save time and money.

Time

A capital expense project that saves time is preferred. Time savings may come from purchasing new equipment that is more efficient, installing a new technology or upgrading an existing infrastructure.

Money

A capital expense project that saves money is preferred. Money savings may come from the same areas as those that save time such as purchasing new equipment that is more efficient, installing a new technology or upgrading an existing infrastructure.

Quality of Life

Another objective for HVF that is important and represented within their mission statement is the concept of a high quality of life for their employees and students. An excerpt from the HVF mission statement that states the importance of a high quality of life reads, “Hawthorne Valley Farm seeks to bring educational and enrichment opportunities for students of all ages, providing the opening to bring the land and people together. As an employer, it is our goal and charge to offer a challenging, rewarding, and balanced work environment that fulfills the physical and spiritual needs of our co-workers”.

Time/Risk – Time Urgency, Risk

This objective refers to the combined areas of both time urgency as well as the risk associated with foregoing a project.

Time Urgency

A more urgent project will be weighted more heavily than a project that may be deferred. Some projects will have time constraints or regulatory issues that necessitate a heavier weighting for funding the project.

Risk

The risk of not funding a project will influence the weighting of this objective. A project that has risks associated with deferral will be weighted more heavily than a project that can be easily deferred without ramifications.

Increased Revenues

Projects that increase revenues for the farm are preferable to those that merely sustain or do not affect current revenue levels.

Increased Environmental Sustainability

Projects that increase environmental sustainability are preferable to the farm. HVF states in their mission statement that “Hawthorne Valley Farm is a highly diversified, innovative organization – centered on a biodynamic farm – dedicated to sustainable agriculture practices and committed to its role as steward of the land”.

Education

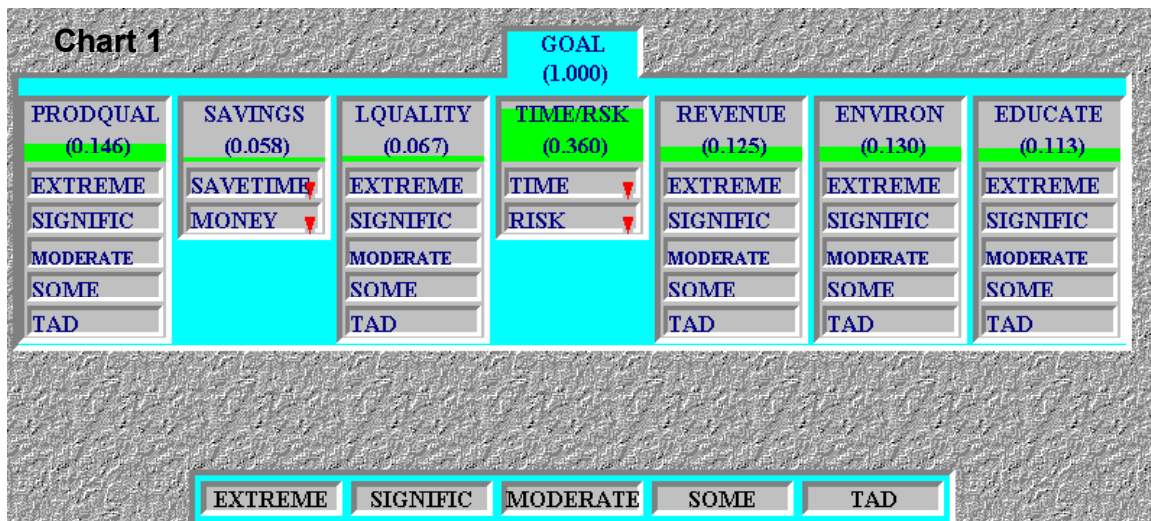
HVF seeks to bring educational and enrichment opportunities to students of all ages as part of their mission statement. They prefer projects that contribute to enhancing the educational goals of the organization.

Methodology and Implementation

Model Development

The team created a model using the software program Expert Choice, which embodies the Analytic Hierarchy Process (AHP). AHP focuses on the achievement of objectives such as those defined above. AHP enables the decision-makers to derive ratio scale priorities or weights as opposed to arbitrarily assigning them. Its use will lead to a rational decision which best achieves the multitude of objectives of the decision-makers.

Expert Choice allows the user to enter the decision model into the software in a hierarchical manner that allows the user to visualize the decision in a graphical form. See Chart 1.



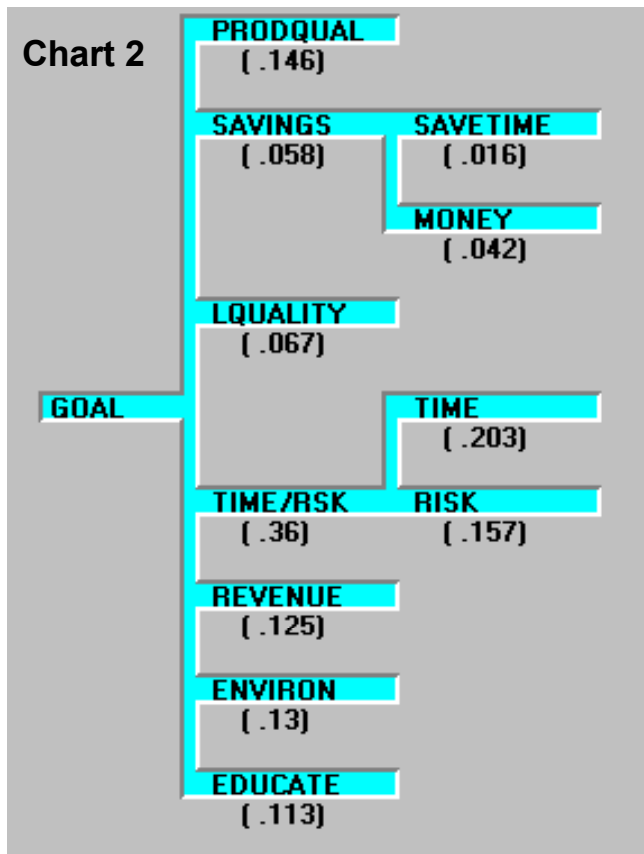
Prioritization of Objectives

A meeting was held with the department managers to derive the priorities for the objectives. The process did not work well due to the difficulty of keeping the group

focused on the task. Many of the priorities for the objectives were debated in such detail, such as whether the discrepancy was large or small, that progress was too slow. As a lesson learned, the department managers may have responded better if they had been able to work as a group but vote in secret. Hand held voting devices might have been a better choice for allowing prioritization of the objectives.

Because hand-held voting devices were not available, each manager was given a questionnaire based on the Expert Choice model to fill out in private. Each manager was instructed on how to make the pair-wise comparisons in order to prioritize the objectives. After each manager completed the pair-wise comparisons, the group reconvened.

The answers were gathered from the individual models. The second meeting focused on answers that were widely divergent. If the objectives were prioritized with only a minor degree of variation, for example moderately to strongly, the answers were simply aggregated. The discussion focused on objectives that were rated with a wide variation. The main discrepancies focused on the importance of the environmental and educational objects. In both of these instances, members of the group had opposite answers in terms of which items were more important (as opposed to simply a difference in the degree of importance). The managers felt strongly that group consensus was very important so they worked through the rankings until all the priorities were agreed to as a group. See Chart 2.



Through the derived rankings, the time urgency objective was judged to be the most important due to the significant and immediate impact, which would occur if the project were not funded. The next most important objective was risk followed closely by product quality and then environment. It seems logical that the environmental objective would take a higher precedence than educational as the farm is more directly focused on the environment. It is interesting to note that product quality received a higher ranking than the environment, but the environment was higher than revenue. These rankings are consistent with HVF's mission and values. The most urgent projects received the highest rankings followed by the goals and objectives that rank most important in the HVF mission statement. Note that these

priorities are ratio levels of measurement. The priority assigned to the Time Urgency objective is almost 5 times more important than the saving money objective.

A scale of intensities was developed for the objectives so that the capital projects could be rated. Five levels of intensities were defined in order to allow sufficient differences between the ratings of the capital projects with the respect to the objectives. The intensities below each objective are also judged by pair-wise comparisons in order of importance. As an example, a project that is judged to make an extreme contribution to HVF will receive a priority for that contribution that is almost 23 times more important than a project that only make a slight or tad contribution to HVF. The intensities and scales could have been set up uniquely under each objective but were not done so in this model.

The intensities and descriptions used in the model for each objective were as follows:

1. Extreme (0.342)– Project would have an Extreme impact on meeting the objective
2. Significant (0.321) - Project would have a Significant impact on meeting the objective
3. Moderate (0.191) – Project would have a Moderate impact on meeting the objective
4. Some (0.131) – Project would have Some impact on meeting the objective
5. Tad (0.015) – Project would have only a slight impact on meeting the objective
6. None (0.0) – This was not set up as a choice within the model but was left blank by the managers that effectively gave it a zero value.

Each manager was then given an updated copy of the model with the agreed upon objectives to fill out the rankings for each alternative capital project. The rankings were then consolidated to form an aggregate ranking for each alternative under each objective. Chart 3 shows the alternatives and the rankings associated with each objective after the aggregation of the managers’ responses.

Chart 3											
Alternatives	Total	Costs	ProdQual 0.1463	Save time 0.0156	Save money 0.0423	Lquality 0.0673	Time 0.2034	Risk 0.1568	Revenue 0.1248	Environment 0.1303	Education 0.1132
Crating System	0.550	4,500	0.749	0.969	0.157	0.83	0.591	0.352	0.173	0.455	SIGNIFIC
Whey tank	0.541	1,500	0.329	0.525	0.157	0.481	0.591	0.437	0.704	0.811	MODERATE
Solar Greenhouse	0.496	15,000	0.481	SOME	0.213	SOME	0.352	TAD	SIGNIFIC	0.843	0.704
Dairy Chart Recorder	0.464	1,000	0.497	MODERATE	TAD	TAD	0.497	0.984	SIGNIFIC		TAD
Hot water heater	0.450	2,000	0.874	0.157	0.329	0.213	0.62	0.704	0.213	0.213	
Cultivating Tractor	0.423	15,000	0.61	0.749	0.157	0.764	0.537	0.387	0.397	TAD	0.342
Dairy Structure Work	0.406	5,000	0.749	0.491	0.342	0.73	0.387	0.387			0.66
Vacuum Milking System	0.377	3,000	0.397	TAD	MODERATE	0.541	0.342	0.525	TAD	0.442	SOME
Bulk tank fridge	0.358	6,000	0.302	TAD	0.442	SOME	0.431	0.799	TAD	SOME	
Dairy Maintenance Work	0.349	1,500	0.302	0.749	0.442	0.302	0.515	0.329		0.749	
New Pipeline Washer	0.310	1,000	0.442	SOME	SOME	0.66	0.342	0.481	TAD	0.213	
Barn electricity	0.301	15,000	TAD	TAD	0.27	0.78	0.342	0.78	TAD	0.213	TAD

The entries in the columns representing the objectives (ProdQual, Save Time, etc.) are either one of the intensities for that column (using the standard intensity ratio scale value) if all the managers agreed, or a decimal value which represents the average of the intensities of the managers’ inputs. The values in the Total column represent a ratio scale measurement for how much contribution each project is anticipated to contribute toward HVF’s missions and goals. The Crating System that has a value of 0.550 contributes about 1.8 times as much as the Barn Electricity project. Because these totals are ratio

scale numbers, the numbers can be normalized without changing the ratios. The numbers were then normalized to 100 where the best alternative, Crating System, is assigned the value of 100. The assumption in this model is that a project cannot be partially funded. In other words, we will not fund a project at some fractional amount of its total cost.

We will look at 2 different approaches to solve this funding question. The first methodology is based on Cost/Benefit ratios.

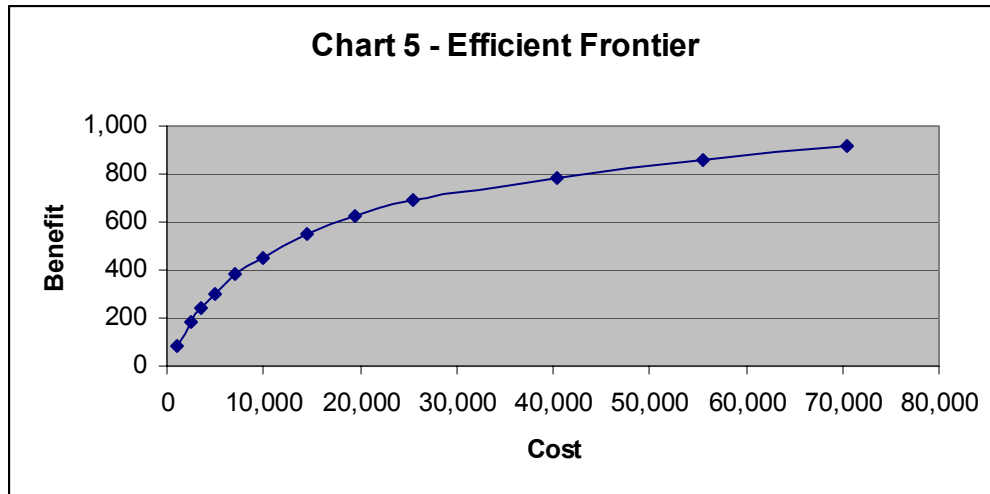
Benefit/Cost ratios – Sort & Allocate

In Chart 4, the capital projects have been normalized and a benefit/cost ratio determined by dividing the normalized benefit column by the cost column and scaling up by 100,000 for ease of comparison. A possible funding methodology is to fund the projects starting with the highest benefit/cost ratio and continuing until the \$40,000 capital budget is depleted.

Chart 4							
Alternatives	Total	Benefits	Costs	B/C	Cum Costs	Cum Ben	
Dairy Chart Recorder	0.464	84.4	1,000	8,436.36	1,000	84	
Whey tank	0.541	98.4	1,500	6,557.58	2,500	183	
New Pipeline Washer	0.310	56.4	1,000	5,636.36	3,500	239	
Dairy Maintenance Work	0.349	63.5	1,500	4,230.30	5,000	303	
Hot water heater	0.450	81.8	2,000	4,090.91	7,000	384	
Vacuum Milking System	0.377	68.5	3,000	2,284.85	10,000	453	
Crating System	0.550	100	4,500	2,222.22	14,500	553	
Dairy Structure Work	0.406	73.8	5,000	1,476.36	19,500	627	
Bulk tank fridge	0.358	65.1	6,000	1,084.85	25,500	692	
Solar Greenhouse	0.496	90.2	15,000	601.21	40,500	782	
Cultivating Tractor	0.423	76.9	15,000	512.73	55,500	859	
Barn electricity	0.301	54.7	15,000	364.85	70,500	914	

This methodology will give an approximation of the set of projects to choose which allows the most benefit while staying within the budget constraint. Looking at the cumulative cost column, using this methodology, all projects will be funded except for the Solar Greenhouse, Cultivating Tractor and Barn Electricity.

Chart 5 displays a benefit/cost efficient frontier graph that displays the diminishing marginal benefit as additional projects are selected with lower benefit/cost ratios.



Before making our final decision, the team determined that it made sense to use Excel solver and look at an optimization approach.

Excel Solver Optimization Method

Excel Solver seeks to find the combination of projects that maximizes the total benefits without exceeding the total budget. Using the benefit normalized ratio scales from Expert Choice, Excel Solver can be set up to run algorithmic optimization routines.

The spreadsheet that calculated the benefit/cost ratios was edited and set up for a Solver optimization solution. A column is added that represents decision variables that are treated as an on/off switch in Solver. Solver allows the user to add constraints, as in this case a maximum budget of \$40,000, only fund a project once, and a project cannot be negatively or fractionally funded. Solver is set up to maximize the total funded benefits column while staying within the constraint that the maximum total funded cost column must not exceed \$40,000. This funded benefits column represents the sum of the benefit amounts for each funded project. Solver treats the DV column as the on/off switch for determining whether a project is funded or not. If the DV value is 1, then the project is funded and the funded benefit column and funded cost column are displayed. If the DV value is 0, then the funded benefit and funded cost columns are 0 for that project. The results from using Excel Solver are displayed below in Chart 6.

Chart 6

Alternative	Benefits	Cost	DV	F. Benefits	F. Costs
Dairy Chart Recorder	84.4	\$ 1,000	1	84.363636	\$ 1,000
Whey tank	98.4	\$ 1,500	1	98.363636	\$ 1,500
New Pipeline Washer	56.4	\$ 1,000	0	0	\$ -
Dairy Maintenance Work	63.5	\$ 1,500	1	63.454545	\$ 1,500
Hot water heater	81.8	\$ 2,000	1	81.818182	\$ 2,000
Vacuum Milking System	68.5	\$ 3,000	1	68.545455	\$ 3,000
Crating System	100.0	\$ 4,500	1	100	\$ 4,500
Dairy Structure Work	73.8	\$ 5,000	1	73.818182	\$ 5,000
Bulk tank fridge	65.1	\$ 6,000	1	65.090909	\$ 6,000
Solar Greenhouse	90.2	\$ 15,000	1	90.181818	\$ 15,000
Cultivating Tractor	76.9	\$ 15,000	0	0	\$ -
Barn electricity	54.7	\$ 15,000	0	0	\$ -
				725.63636	\$ 39,500

The results from Excel Solver demonstrate that all projects should be funded except for the New Pipeline Washer, the Cultivating Tractor and Barn Electricity.

Conclusion

Each methodology approach, Benefit/Cost and Excel Solver calculated the best set of project alternatives based on the derived weights of the objectives. However, the results from using the Benefit/Cost ratio approach differed from the Excel Solver solution.

Both approaches determined that the Barn Electricity and Cultivating Tractor projects should not be funded. However, the Benefit/Cost ratio approach suggested funding the New Pipeline Washer and not funding the Solar Greenhouse. The Excel Solver method recommended the opposite.

The team decided that the Excel Solver approach was the appropriate choice because it produced the optimal solution. It used up all of the funding except for \$500 while the Benefit/Cost ratio approach left \$14,500 unused from the total capital budget.

The selection of Expert Choice software to model this decision using the Analytic Hierarchy Process assisted in this complex decision. It helped to clarify and support the objectives with logical approach to decision making. It assisted in structuring the decision and allowing for the synthesis of the results. These results were then used in Excel to develop both the Benefit/Cost ratio approach as well as the Excel Solver optimization approach.

The team recommends that Hawthorne Valley Farm fund all of their capital expense projects except for the New Pipeline Washer, Cultivating Tractor and Barn Electricity. These results have been shared with the management staff at Hawthorne Valley Farm. They have been pleased that the process, which in the past caused much dissention and consternation, had a positive outcome. As the capital budget process is still underway, the management group wants to wait until later in the summer to finalize the capital

budget. In the meantime, the managers will obtain more detailed cost estimates for proposed projects and determine if there are any additional projects that should be considered. The group is enthusiastic about using this model for creating the capital budget items and has asked that a presentation be given to the Farm Board of Trustees explaining the decision process.

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