

System analysis for technology transfer readiness assessment of horticultural postharvest

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Abstract. Availability of postharvest technology is becoming abundant, but only a few technologies are applicable and useful to a wider community purposes. Based on this problem it requires a significant readiness level of transfer technology approach. This system is reliable to access readiness a technology with level, from 1-9 and to minimize time of transfer technology in every level, time required technology from the selection process can be minimum. Problem was solved by using Relief method to determine ranking by weighting feasible criteria on postharvest technology in each level and PERT (Program Evaluation Review Technique) to schedule. The results from ranking process of post-harvest technology in the field of horticulture is able to pass level 7. That, technology can be developed to increase into pilot scale and minimize time required for technological readiness on PERT with optimistic time of 7,9 years. Readiness level 9 shows that technology has been tested on the actual conditions also tied with estimated production price compared to competitors. This system can be used to determine readiness of technology innovation that is derived from agricultural raw materials and passes certain stages.

1. Introduction

System are a form of integrated entity or element for reach objective[1]. System analysis is set of concepts, approaches, methodologies and tools for complex design. System complexity have a two things, there are dinamic and desain complexity. Analysis system begins by analyzing needs that show relationships between integrated entities, communities in achieving goals by building effective communication on each element. Technology transfer is process of transfer of knowledge through a technology, which is vertical on results of laboratory to application in community. A technology requires integrated readiness to be able to be applied by the community. Technology Readiness Level (TRL) is a measure of technological readiness level that is defined as an indicator showing how ready or mature a technology can be applied and adopted by a user / potential user [2]. Tekno-Meter is a tool that calculates TRL applied by the industry or for tangible products issued by Kemenristekdikti on 9 stages.



In the last four years, horticulture commodity in Indonesia have 35-40% of losses on farm to off farm, 60% of 40 occurs in postharvest handling [3]. Postharvest handling like GHP (*Good Handling Practices*) must doing on procedure, can be reduce the postharvest losses. GHP need more postharvest technology to save and reduce number of horticulture losses more 10-15% from 40%.

The objective of this work are assess of technology a readiness from each level, 1-9 on TRL and to minimize time of transfer technology in every level.

2. Related Work

TRL is a systematic measurement system that supports the assessment of the maturity or readiness of a particular technology and the ratio of maturity or readiness between different technology types [4]. These stages have parameters and questions provided to assess the readiness of a technology to be commercialized [5]. Commercialization effort is closely linked to understanding consumer behavior. Consumer is no longer choosing the product of the function alone, but the combination of components or parameters are measured and unmeasured [6].

New approaches are necessary to overcome some traditional barriers between researchers and industry for implementation of innovative technology [7]. The technological readiness provides pillar measures the agility with which an economy adopts existing technologies to enhance the productivity of its industries, with specific emphasis on its capacity to fully leverage information and communication technologies (ICT) in daily activities and production processes for increased efficiency and competitiveness [8]. PERT is targetted not just for scheduling type of project such as construction, computer programming, planning and maintainance project, but the method can be used to research and development product or technology, including TRL implementation scheduling effectively [9].

3. Problem formulation

3.1 Current condition

Various research on postharvest horticulture technology with many aims to facilitate and accommodate the problems that occur in society as the end user. Sometimes the results of research or innovation technology is not socialized to the community well and massive, so less useful. Gap or distance between innovation results with user acceptance of the technology must be calculated and connected to the maximum, so the technology can be used. Technology undergoes a bottleneck at the dissemination stage to the wider community that requires new technology, or most of the technology fails in the process.

Based on that problem, so there needs to be technical parameters preparation of technology can be applied. How a technology can compete and be ready to pass the assessment phase so that it can be applied to the community / industry as a user. Furthermore, it is important to measure the readiness of these technologies so that they can be mass produced and used by farmers as primary consumers and industries as producers of products.

3.2 System analysis technology transfer readiness assesment

Currently the use of the Tekno-Meter counting device can only assess most of the resulting technology, it is necessary to create parameters relevant to the product or technology characteristics that will be generated with levels from 1-9 so that technological readiness can be measured. This tool have 3 stages, first level 1-3 is basic technology research where parameters on that level describe about basic technology. Level 4-6 is level of technology development, parameters describe about how technology upgrade the production scale or pilot scale. The last, level 7- 9 is system/subsystem development parameters describe about technology can be exist on real industry.

Every technology produced should be attempted to meet the criteria or parameters that exist within the tool or Teknometer. Technological assessment if it stops at a certain level, should be attempted to improve the technology according to recommended criteria/parameters. It will be repeated if the technology has not been able to pass through stage 9. The parameters in the tool can be conditioned to maximum so that fulfillment of the criteria is not too long.

4. Methodology

4.1 Identification System

System identification as a needs analysis of technology transfer readiness assesment system which consist of system boundary/scoping. Beside that have objectives, stakeholder, resources, parameter on each level, time required for technology transfer. These element being analyzed in relation with stakeholder activities along this system. The data and information collection used in this system from the parameter on Teknometer, like experimental stage, kind of machinery, simulation, prototype, etc.

4.2 Business Process Model and Notation (BPMN)

Relation and connectivity between processes being depict literally in graphics to give a detail analysis of the system. A system analysis for technology transfer readiness assesment based on knowledge and information by expert interview, which is stakeholder or actor involved on this system. Stakeholder this is researcher, industry and Institute for Agricultural Technology Transfer (IATT), and with literature like technology information from books and document reports. Data and information like data of excellent technology, technology publication, feasibility technology and etc. The information obtained will be processed and displayed in BPMN 2.0.

4.3 A system analysis for technology transfer readiness assesment

Each technology generated should be assesment with certain parameters that are structured to saw the competitiveness of the technology, so it is certain that technology can be adapted by industry. The assesment to technology of each parameter and each level will be the input data to be processed in the approximate method approach. Other than that the time required by the technology from laboratory to be ready adopted requires optimum time. The optimum assesment of this system analysis is solved by Relief and PERT method:

4.3.1 Relief. RELIEF is a feature selection algorithm used in binary classification (generalisable to polynomial classification by decomposition into a number of binary problems) [10]. Relief method serves to determine the weight of each criteria that will affect the level or level specified and can show the interests of each criteria. Data for criteria or parameters which calculate the weight from case about postharvest technology such as, characteristic of technology, performance of the elements technology, operation components can be improve fresh red chili shelf life.

Assesment for this technology based on basic and development research, with answer kind of parameters to presented part of the level. For example, on existing condition level 1 have 3 parameters. Relief give a ranking with the weight on each parameters, and minimalist parameter can representated same conditon about the technology. Each level (N) have a number of parameter (n), on each level results minimum have 80 point from 100 than can be continue to next step.

4.3.2 PERT. *Program Evaluation and Review Technique* is a common method used in scheduling a complex system, so that the whole system can run with the maximum. PERT technique is a method that aims to reduce as much as possible delay, or disruption of production, and coordinate various parts of a job in a way through and accelerated the completion of the project [11]. PERT is analyzed using time data from each level of technological readiness level, so that the maximum time used in the implementation of a technology can or can be applied and useful in the community. Can be ascertained that a technology can be done from laboratory research to the community with a certain time in accordance with the technological specifications submitted [12].

Data collection for PERT method is from researcher whose have the technology to give a change and suggestion about assesment that new technology. They feel the stage, time for basic technology like research laboratory, kind of equipment, and environment study. They make their a shelf assesment to know the technology to be adopted by the industry.

$$T_e = \frac{T_o + 4T_m + T_p}{6} \quad ((1))$$

$$V = \frac{[T_p - T_o]^2}{[6]} \quad ((2))$$

Remarks :

To = optimistic duration

Tm = most likely duration

Tp = pessimistic duration

5. Result and Discussion

5.1 Identification System

A requirement analysis of system analysis for technology transfer readiness assesment of horticultural postharvest involve the availability of consumer need, kind of postharvest technology, integrated element and stakeholder which consist of reseacher, consumer, industry and technology provider. This system analysis can produce the technology adopted by industry and have a beneficial to society. An identification system are shown in Fig. 1 :

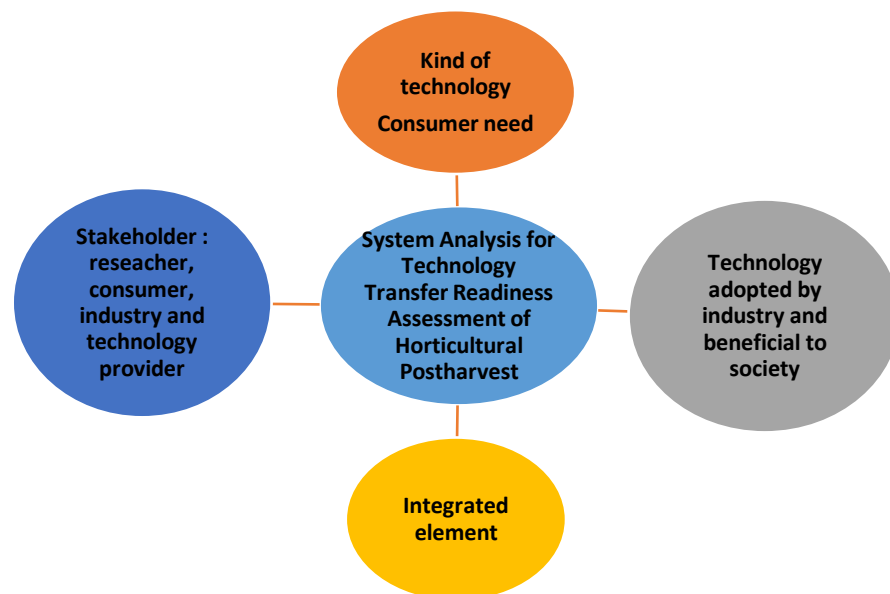


Figure 1. Identification of a system analysis for technology transfer readiness assesment

5.2 Business Process Model and Notation Analysis (BPMN)

Analysis of a system analysis for technology transfer readiness assesment of horticultural postharvest is based on kind and number of postharvest technology, availability technology of horticultural product in industry, and process on technology provider. The analysis process use BPMN are presented in Fig. 2:

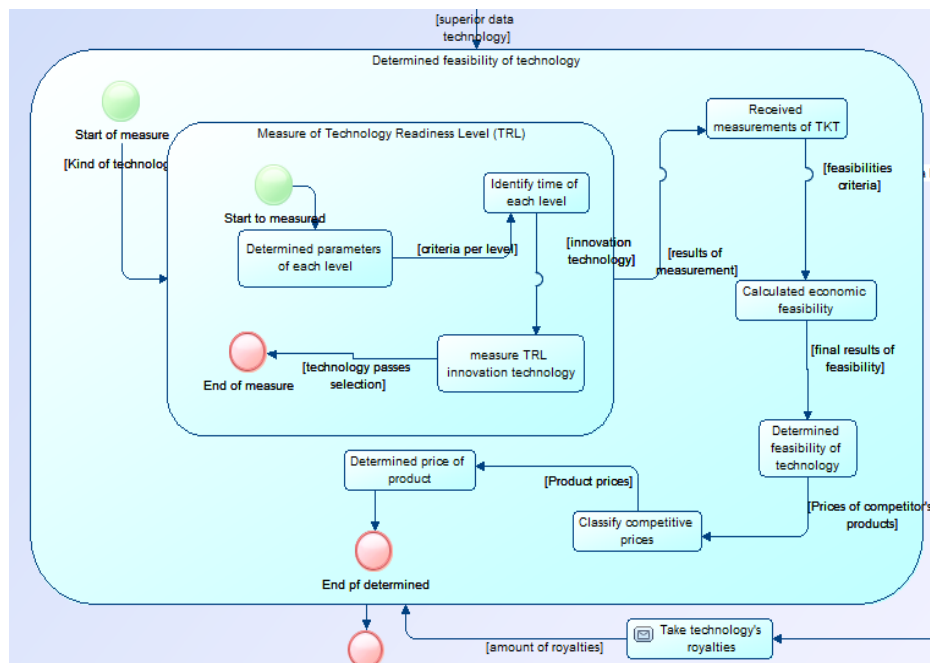


Figure 2. Analysis process of system technology transfer readiness assesment of horticultural postharvest in BPMN.

5.3 Results

Each level has certain parameters to select and rate a technology until it reaches the highest level. It is shown with parameters that have been modified and the result using the relief method on the effectiveness of the parameters used. For example, level 1 on the level of technology readiness consists of 3 parameters and relief method have a results for level 1, just have one parameter. The highest weight of 0.92 which emphasizes the literature or basic principles of the technology to be developed. Total parameter level 1 until 9 have a 76 parameters to get verification about technology which want to be transfered to industry. With relief method can be optimum the parameters, from 76 parameter to 49 parameters.

Table 1. Results optimum parameter on Relief Method.

Level	Existing	Relief Method	Score
1	3	1	100
2	12	5	95
3	9	8	95
4	8	4	90
5	8	6	86
6	6	2	80
7	13	8	62
8	9	7	53
9	8	8	22
	76	49	

Determination of levels in transfer technology is adjusted to the characteristics of the technology to be implemented. Levels are divided into 9 levels with each predefined criterion, the conditions of each statement in each level is 100 to proceed to the next level. A value less than 80 can not proceed to the next level. Critical factors that affect the readiness of technology can be known by the weight of use is in a certain level. For this problem, critical parameter have on level 7, because the weight as positive high point and on level 7, product must be transfer to system development. If the stage is not passed then the technology has no prospect to be commercialized

Table 2. Results PERT Method for time required of technology transfer.

Level	Existing	Relief	Optimistic time	Pesimistic Time	Expected time	Most like time
1	3	1	2	5	3	2
2	12	5	8	15	9	8
3	9	8	16	23	17	16
4	8	4	8	14	9	8
5	8	6	17	23	18	17
6	6	2	6	11	7	6
7	13	8	13	21	15	14
8	9	7	12	20	13	12
9	8	8	13	18	14	13
Month			95	150	105	96
Year			7,9	12,5	8,7	8,0

The result shown in Table 2 is that with scheduling using the PERT method, it is evident that if the judging process is conducted sequentially from level 1 to 9 then the time required is divided into optimistic time, pessimistic time and predicted time in the assessment or transfer process technology. With an optimistic time, technology transfer from laboratory preparation to the technology can be properly adopted and applied as a whole to 7.9 years. So, researcher or innovator must be sure and design the hole system of technology and the technology can be exist for long time.

6. Conclusion and Future Work

Technology Readiness Level (TRL) is an assessment prepared to select the readiness of a technology to be generated and can be widely used by the community. Each level on TRL have a number of parameters, that statement accordingly with every level means and effectiveness of technology. Parameter / statement every level must be optimum, from 76 statement just on 49 statement for whole assesment system with the weight method for every statement. Based on score at each level, postharvest technology of horticulture is only up to level 6 in its development, and can not proceed to the next level if it has not fulfilled the desired parameters. Technology transfer time from basic technology to operational condition on industry on selection used PERT : optimistic time : 7,9 years, pesimistic time : 12,5 years, expected time : 8,7 years. This level of technological readiness can be utilized to create an ideal system for all technologies with different properties. In addition, linkages between levels and between statements can explain in detail the assessment is optimum.

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