Asian Journal of Agriculture and Rural Development
Volume 15, Issue 2 (2025): 339-350

# Measuring social return on investment of research projects on Thai functional fruits, fruit trees, and fruit products: A comprehensive study

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## Article History
**Received:** 17 January 2025
**Revised:** 16 June 2025
**Accepted:** 4 July 2025
**Published:** 30 July 2025

## Keywords
Economic and social benefits
Fruits and fruit's products
Measurement
Research projects
Social return on investment
Thailand research fund
Thailand.

## ABSTRACT
The Thailand Research Fund (TRF) paid for a total of 12 research projects on Thai fruits and fruit products. The studies looked at and measured the social return on investment (SROI). The fruits studied included functional fruits like mango, pomelo, papaya, and banana. We collected the data through structured questionnaires and in-depth interviews with the key informants of the 12 research projects. We employed the SROI analysis tool to analyze the data. The value of the net benefit of the research projects in terms of output and outcome was estimated to be 125,389,794 THB (Thai Baht), while the Thailand Research Fund (TRF)'s research funding for these projects amounted to 11,883,370 THB. Therefore, the SROI of the projects is estimated to be 10.55. This value implies that the TRF was able to achieve an SROI of 10.55 THB for each 1.0 THB investment in the research projects. The findings suggest that TRF's investment in the research projects on Thai functional fruits and fruit products was successful and effective as well as worth value. The study findings might be beneficial for TRF, research grant associations, and educational institutions to formulate appropriate policies for further research support.

**Contribution/Originality:** This study is unique in applying Social Return on Investment (SROI) framework to assess research funding impact on Thai functional fruits. In contrast to previous studies, this study quantifies both economic and social benefits, revealing a return of 10.55 THB for every 1 THB investment. This approach provides a reproducible framework for efficiently evaluating research funding.

DOI: 10.55493/5005.v15i2.5508
ISSN(P): 2304-1455/ ISSN(E): 2224-4433
**How to cite:** Kongmanee, C., Ahmed, F., Prommee, P., & Longpichai, O. (2025). Measuring social return on investment of research projects on Thai functional fruits, fruit trees, and fruit products: A comprehensive study. *Asian Journal of Agriculture and Rural Development, 15*(2), 339–350. 10.55493/5005.v15i2.5508


## 1. INTRODUCTION
Fruit is a significant profit crop in Thailand and is the basis for work in agricultural sectors, market operators at many levels, and food processing entrepreneurs. Each region of Thailand possesses a different geology and climate, resulting in various kinds of tropical fruit, which expands its plantations continuously. In 2011, Thailand had agricultural plots for 149.2 million Rai. Those areas were divided into fruit trees and perennial plants for

approximately 34.9 million Rai and increased to 36.94 million Rai in 2019 (Office of Agricultural Economics, 2018). From the viewpoint of economic value, the fruits in Thailand can be divided into two categories: a) fruits that are important economically (for profit) and have high export value (such as durian, longan, pineapple, mangosteen, rambutan, lychee, mango, and banana) with 10 most important exporting markets—China, Vietnam, Hong Kong, the United States, Indonesia, South Korea, Japan, Malaysia, Taiwan, and Canada; b) fruits that are financially potential in the future or local fruits that are consumed more domestically (such as santol, rose apple, sugar apple, monkey apple, Marian plum, guava, and Long Kong, also known as southern langsats). With many types of fruit, Thailand has the capacity to be a tropical fruit source and market with a high quality that meets international standards.

Considering the export value of fruit and produce from 2014 to 2018, it was found that the export value of fresh fruits increased continuously; i.e., the total export value of all types of fresh fruits in 2014 was 30,014.28 million baht. Fruit with the highest export value was durian at 12,435.70 million baht, followed by longan, mangosteen, mango, and banana. In 2018, the total export value of all fresh fruits increased to 62,207.62 million baht. Fruits with high export value are durian (30,186.97 million baht), longan (17,219.25 million baht), mangosteen (7,271.20 million baht), mango (2,017.05 million baht), and banana (725.43 million baht) (Office of Agricultural Economics, 2018). With the production potential and well-known tropical fruit market in the world, fruit production capacity can be increased by focusing on reducing production costs, improving quality, producing off-season, and including post-harvest production management to create marketing opportunities and increase revenue. Moreover, adding fruit value can be done by processing and upgrading from raw ingredients to functional food products with support from scientific research and development to innovate high-value product processing.

Therefore, the Thailand Research Fund (TRF) recognized the significance of the economic value of Thai fruits. Consequently, it supported research funding in a series of projects on the Thai Fruits—Functional Fruits, covering a variety of Thai fruits such as mangos, pomelos, papayas, and bananas. Over 100 researchers from different universities took part in this study. The goal was to find out how much flavonoids, carotenoids, enzymes, phenolic acids, prebiotics, and other chemotype substances were in Thai fruits and to study their bioactivity. The knowledge gained from these studies will show the value of Thai fruits and disseminate and publicize the benefits of Thai fruits for health improvement. In fact, this series of research funding is an economic investment that creates a body of knowledge that will contribute to economic and social changes or enhance well-being for people in the society (Isvilanonda, 2010). However, with budget constraints, Thailand has a relatively low ratio of research and development expenditure compared to gross domestic product (GDP), with a ratio of 0.21–1.11 percent during 2001 and 2019 (Ministry of Higher Education Science Research and Innovation, 2020). As such, it is necessary to estimate the value of a funded and completed research project or research series, taking into account the questions of worthiness, audience, and its impacts on society. It is expected that this estimation will be useful for formulating further research funding policies, supporting the limited research funding while maximizing the benefits of economic and social development. However, there is no empirical evidence of a social return on investment in the research package related to Thai fruits and fruit products. Therefore, this study aims to analyze the social return on investment (SROI) in the research package on Thai fruits—functional fruits series, fruit trees, and fruit products. The study's findings could assist research funding agencies, research institutes, and academia in applying for research grants in similar contexts.

## 2. LITERATURE REVIEW

Research is vital to economic growth, quality of life, and development sustainability. That is the reason many countries prioritize investing in research. Nonetheless, developing countries have budget constraints. Therefore, research funding needs to ensure that investing in a research project or research series provides a worthwhile economic or social return. Thus, the question arises, "Why is it necessary to evaluate the social return on investment in research?"

Research's impact assessment is a measure of its success. That begins with the evaluation of the output, followed by the outcome and impact of research on socio-economic changes. In this article, output is defined as a product of research through its objectives, such as knowledge, data, training, the number of researchers, publications, patents, innovations, and the scientific equipment and instruments it produces. One research project may result in a ready-to-use product or an output that serves as an input for further advanced research. The term "outcome" describes the transformation that occurs when beneficiaries, whether researchers or stakeholders, utilize the research. Therefore, an output can also be an outcome, i.e., increased revenue, lowered costs, higher efficiency, and product development policy guidelines. Impact is a continual consequence from research that affects the target group or the public by causing economic, social, and environmental changes. The impact can be either positive or negative. Consequences can be broadly categorized into a scientific consequence and a societal consequence. Scientific consequence is a scientific advance, intellectual capital, and research that furthers progress. Social consequence is research that answers what benefits society might gain, such as good products and services, quality of life, welfare, increased employment, increased productivity, and sustainable development (European Science Foundation, 2012; Walker et al., 2008). Research contributes to progress and knowledge capital, facilitating innovations and effective policies that yield economic and social benefits (Salter & Martin, 2001). The process of finding the relationship between research investment and its impact can be explained by the linear process conceptual framework of output, outcome, and impact. Knowledge from basic research is transformed into applied research and finally leads to technical and social innovation, which impacts the economy and society (European Science Foundation, 2012; Walker et al., 2008).

This article uses the framework of social return on investment (SROI) to look at data by calculating the project's outputs, outcomes, and social impacts and then comparing those numbers with the project's cost in money. The goal is to find out, "What is the social impact of a research project in terms of money per baht investment?" (Achavanuntakul & Yamla-or, 2017; Cordes, 2017; Nicholls, Lawlor, Neitzert, & Goodspeed, 2012). This approach is

an all-around method for understanding, measuring, and reporting the value of research that changes things in the economy, society, and the environment (Banke-Thomas, Madaj, Charles, & van den Broek, 2015; Nicholls, 2017; Nicholls et al., 2012; Scholten, Nicholls, Olsen, & Galimidi, 2006).

The SROI tool has been widely used to assess the impact of an organization, a social development project, a research project, and any public services such as public health and healthcare, social enterprise, public service, research, and government investment (Banke-Thomas et al., 2015; Benjasiri, 2015; Bertotti, Farr, & Akinbode, 2015; Faivel, Ghosh, Hilton, James, & Peppercorn, 2012; Jones, 2012; King, 2014; Kongmanee, Satsue, & Pittayapinan, 2018; Ruiz-Lozano et al., 2020; Thai Health Promotion Foundation, 2014; Wilson & Bull, 2013). In fact, the utilization of SROI tool depends on the nature of a project, investment amount, objective and project result, number of beneficiaries, operation period, and the impact. However, when comparing the SROI, it should be in the similar type of project or organization, with a similar manner, problem, scope of work, limitations, or contexts, and it should not be in totally different projects or organizations (Achavanuntakul & Yamla-or, 2017; Faivel et al., 2012).

## 3. MATERIALS AND METHODS

This study selected 12 research projects that had been conducted during the years 2013–2015 under the Thai Fruits—Functional Fruits series and received research funding totaling 11,888,370 baht, divided into 2 categories: 1) Scientific progress research for 10 projects with a budget of 7,826,370 baht or 65.9 percent of the total budget. 2) Commercial progress research for two projects with a budget of 4,062,000 baht, or 34.1% of the total budget.

The primary data was collected by individual in-depth interviews with structured questionnaires. Key informants were research leaders, researchers, research assistants, and stakeholders. The secondary data was retrieved from research reports, financial reports, and related documents. Data was analyzed by the social return on investment (SROI) analysis tool proposed by Nicholls et al. (2012) and by the output and outcome market value framework of scientific research project proposed by Kongmanee et al. (2018) which was further revised by examining the validity and adaptability to market output and outcome values and reviews of relevant documents, plus stakeholder interviews. Market value was defined under the basic principle of total production cost per product. Thereafter, project experts were consulted to further determine reasonable market value. The social return on investment (SROI) analysis consists of 6 steps as described below (Nicholls et al., 2012).

1. Determine the scope of the assessment. The evaluation period for this research project spans five years after its completion. The evaluation looks at the research project's inputs, such as the TRF budget and any other funds that may have been used, as well as the project's goals, activities, attributes, personal factors of the researchers, and the environment in which the research is conducted. It also looks at the project's outputs, outcomes, and impacts. This is done to get information and figure out the social return on investment, which can be used as a proxy for the project's total return.
2. Identify research's stakeholders through outputs and outcomes. This process involves (1) creating a stakeholder map; (2) identifying activities, outputs, and outcomes to create an outcome map; (3) interviewing about the research project or activities; (4) interviewing about the research output, outcome, and impact; (5) identifying indicators for measuring output, outcome, and impact; and (6) determining the value of output, outcome, and impact.
3. Gather data on outputs, outcomes, impacts, and their financial proxy. The information was gathered from January to July 2018 and came from relevant documents. It was used to look at the rate of outcomes, find financial substitutes, and turn the outcomes into a monetary value that clearly affected stakeholders.
4. Analyze attributions, deadweights, displacements, and outcome values. Analyzing attributions from other organizations was done through the TRF's funding proportion in research and others (if any) by setting a percentage value for deadweight rate. It serves as a measure of the outcomes that would occur if this research project had not been funded. We assessed the displacement rate by comparing a positive outcome for stakeholders with a negative outcome for other stakeholders. We obtained this part of the data through interviews with key informants of each research project, reviewing relevant documents, and consulting with research experts.
5. Calculate the SROI and categorize benefits by each stakeholder. The SROI is shown as the ratio of the total benefit received from the research project minus the benefit that is not generated from the research and then divided by the research budget from TRF. A sum value greater than 1 indicates that research is worthwhile.
6. Summarize the assessment. This process summarizes the total SROI and proposes alternative measures or development guidelines to promote value of TRF's research investment.

For the evaluation of outputs, outcomes, and impacts, the SROI framework analyzes achievements of a research project to measure its monetary values (quantitative) and non-monetary values (qualitative). (Figure 1) divides the project achievements into three parts.

i. Output evaluation from literature review of relevant documents, interviews with key informants, and onsite observations. The output value of all items is based on empirical evidence (Table 1).
ii. Outcome evaluation from stakeholders who use the output in the time frame of 5 years, consistent with investment principles of private sector and the existence of human knowledge, technology, skills, and expertise. This is an outcome assessment from stakeholders involved directly in the project. We set the outcome rate at 1.25% for graduate salaries and 6.25% for any net benefits from private companies. We only evaluate the benefits generated by the research based on net incremental benefits. The money result is then weighed by the percentage of research funding from TRF that can be traced back to the project and the amount of money that would have been made if the project hadn't happened (deadweight). In this case, the weight is 1 minus the deadweight percentage.

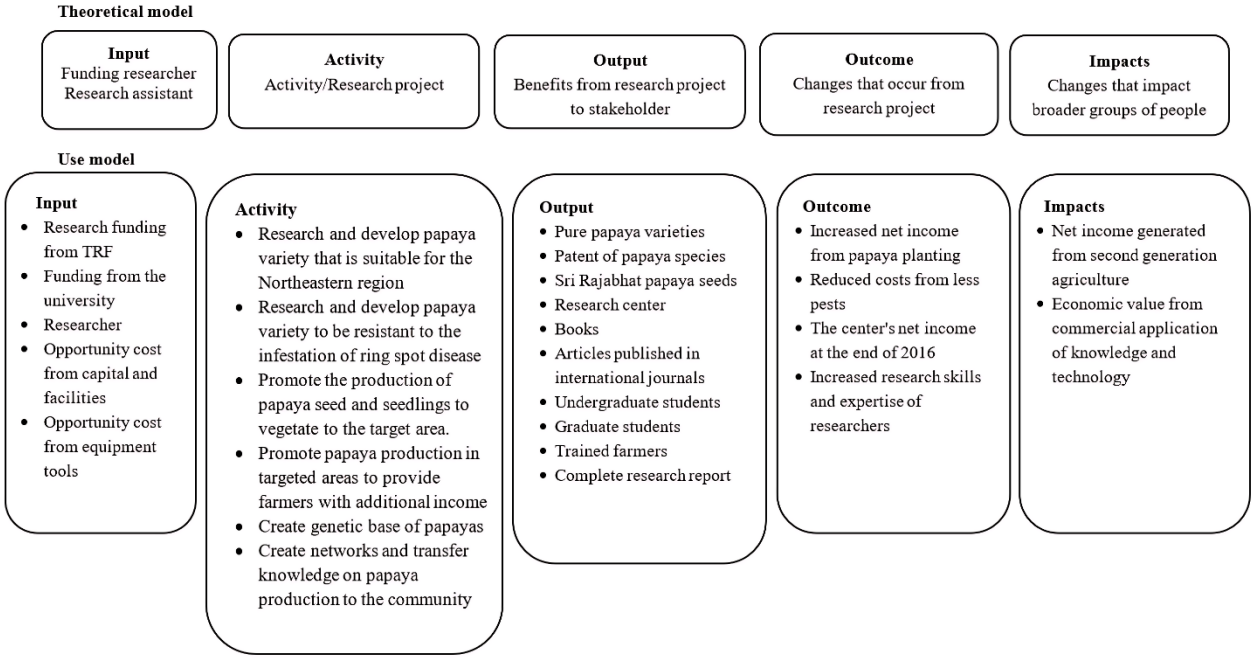


**Figure 1.** Theoretical model of the study.

iii. Impact assessment from the use of output by externals. The impact reports a value or benefit arising from the research project's output but not from the financial value because it risks overclaiming. The impact assessments can also include the positive impact on researchers or graduates participating as research assistants but identifies only qualitative impacts.

**Table 1.** Market value of output from research projects.

| Type of output | Market value (Baht) | Reference |
|---|---|---|
| Inventions (Products/Instruments/Methods /Laboratory techniques) | 200,000 | Guidelines of research funding of the office of the national research council of Thailand (NRCT) for an invention, it is required that one invention must be created from a grant of not more than 200,000 baht.[1] |
| Research articles published in Thai academic journals | 200,000 | For research funding from Prince of Songkla University and OHEC (Office of the higher education commission), in receiving a fund of 200,000 baht, at least 1 publication in a national academic journal/Petty patent is required. [2] |
| Research articles published in international academic journals[4] | 400,000 | For research funding from Prince of Songkla University and OHEC, in receiving a fund of 400,000 baht, at least 1 publication in an international academic journal/patent is required. [2]<br>To calculate the output value of a publication, the value is weighted by the output quality level, ranging from 0.25–1.00 depending on the. The publications in the ISI-based journal have their value divided by ranking: Q1: 800,000 baht, Q2: 700,000 baht, Q3: 600,000 baht, and Q4: 500,000 baht. |
| Research articles published in proceedings | 40,000 | For research funding from Prince of Songkla university and OHEC, in receiving a fund of 40,000 baht, at least 1 publication in proceedings is required. [2] |
| Bachelor's degree graduate | Pharmacist 5,353 baht/Month<br>Scientist 2,878 baht/Month | The national statistical office surveyed the average salary at the base salary level set when recruiting employees, classified by academic qualifications and positions, from all over the country. Data from the private compensation survey of 2013, conducted by the Ministry of Information and Communication Technology, included in-depth interviews with stakeholders and found a salary increase of 20 percent from the normal salary.[1] |
| Master's degree graduate | Pharmacist 10,481 Baht/month<br>Scientist | The national statistical office surveyed the average salary at the base salary level set when recruiting employees, classified by academic qualifications and positions, from all over the country. Data from the private compensation |

| Type of output | Market value (Baht) | Reference |
|---|---|---|
| | 5,882 baht/Month | survey of 2013, conducted by the Ministry of Information and Communication Technology, included in-depth interviews with stakeholders and found a salary increase of 20 percent from the normal salary.[3] |
| Doctorate's degree graduate | Pharmacist 10,481 baht/Month<br>Scientist 5,882 baht/Month | The national statistical office surveyed the average salary at the base salary level set when recruiting employees, classified by academic qualifications and positions, from all over the country. Data from the private compensation survey 2013, ministry of Information and Communication Technology, included in-depth interviews with stakeholders and found a salary increase of 20 percent from the normal salary.[3] |
| Trade secret | 400,000 | Equivalent to a patent. In receiving research funding from Prince of Songkla University for 400,000 baht, 1 research publication in an international academic journal or patent is required. |
| Laboratory prototype | 200,000 | Equivalent to a petty patent. In receiving research funding from Prince of Songkla University for 200,000 baht, 1 research publication in an international academic journal or patent is required. |
| Commercial prototype | 400,000 | Equivalent to a patent. In receiving research funding from Prince of Songkla University for 400,000 baht, 1 research publication in an international academic journal or patent is required. |
| Fieldwork prototype | 300,000 | Fieldwork experiments are more advanced or comprehensive than the operational level but are not commercial. Therefore, its market value falls between laboratory prototypes and commercial-level prototypes. |
| Book | 400,000 | Equivalent to a research publication in an international academic journal. |
| Handbook/Book 1 chapter | 40,000 | Equivalent to a research publication in proceedings. |
| Further research | Equivalent to the budget of new research | It is compulsory to have an ongoing project that uses at least 80% of the output and outcome from the previous research. |
| Complete research report | 10% of the research budget | If the research project does not submit a complete report, terminate the project when it is not yet completed, or the research is not qualified; it will not receive the final payment, which is often higher than 10%. |

**Note:** [1]Announcement of the office of the national research council of Thailand (NRCT) Re: Accepting project proposals for funding of promotional activities and research under the value-added invention to co-funding project for the year 2016.
[2] Research funding from the income of fiscal year 2016, research and development office, Prince of Songkla university.
[3]private compensation Survey 2013, national statistical office, ministry of information and communication technology, and in-depth interviews.
[4]To calculate the output value of publications, it will be weighted by the quality of the work from 0.25- 1 depending on the publishers.

## 4. RESULTS AND DISCUSSIONS

This package of research projects received funding for a total of 11,888,370 baht. Project number 1-11 received a total budget of 8,924,370 baht. Sub-project budgets ranged from 488,400 baht to 1,098,000 baht. There were three projects that received a grant of approximately 1 million baht. To help fund the Fresh Papaya Research and Development Center in Maha Sarakham Province, the Central Isan (Northeast) group received a scholarship from TRF for 2,694,000 baht over 3 years. They also got funding from their university, NSTDA (National Science and Technology Development Agency), and the Sub-district Administration Organization, totaling 1,300,000 baht. This was one thing that helped the project succeed.

Project leads include 12 projects specialized in physiology (50%), food and nutrition (33%), and pharmacology (17%). Half of the project leads were assistant professors, and 25% were in the position of Associate Professor. The remainder were professors and researchers. Later, during the evaluation, it was found that the project leads were promoted to higher positions (4 people, or 1/3 of them), from professors to assistant professors (1), from assistant professors to associate professors (2), and from researchers to expert researchers (1).

Stakeholders from the research project consisted of farmers, undergraduate students, graduate students, and the affiliated university. Table 2 shows an example of the relationship between outputs, stakeholders, and attributions for the research project's outcomes. Fresh Papaya Research and Development Center, Maha Sarakham Province, and the Central Isan Group accounted for 70.0% and 60.0% of the deadweight, with the impact shown in Figure 1. For other research projects, the attribution to the outcome was 100.0%, and there was no deadweight. That means, without research funding from TRF, the output of these research projects will not occur.

The research project has a social return on investment of 10.55, which is the ratio of the net benefit of the research project (125,389,794 baht) to the research budget received from TRF (11,888,370 baht). It signifies that when TRF funds 1 baht, the SROI will be 10.55 baht. As such, research funding is valuable. Among the stakeholders, farmers received the highest proportion of benefits at 69.35 percent, followed by the affiliated university and students, respectively (Table 3).

**Table 2.** An example of the relationship between stakeholders, outputs, outcomes, and attributions of the "Fresh Papaya Research and Development Center, Maha Sarakham Province and Central Isan Group" project.

| Stakeholders | Relevant numbers | Output | Outcome | Attribution (%) | Deadweight (%) | Displacement (%) |
|---|---|---|---|---|---|---|
| 1. Farmers | 4,000 | Trained and used seeds | Increased net income<br>Decreased cost of production | 70 | 50 | 60 |
| 2.Undergraduate students | 12 | Increased salary | - | 100 | - | - |
| 3. Graduate students | 2 | Increased salary | - | 100 | - | - |
| 4. Maha Sarakam Rajabhat university | 7 | Papaya seeds<br>Research center<br>Books<br>Academic articles<br>Complete research report | - | 100 | - | - |

**Note:** 1) The difference of net income from papaya yields before and after using the new variety and after the 18-month yield period. Partial budgeting, a specific method, was used for calculating the increased income and decreased costs.
2) The damage rate of diseased papayas was lower compared to the average rate of the previous variety.
3) More research experience meant an increased salary compared to students without research experience.
4) Deadweight is data from stakeholder interviews and consultation with project experts. The deadweight was set at 50 percent for two reasons: 1) even if there was no funding from TRF, this project had an opportunity for implementation because the project lead was able to get funding from other sources and 2) some papaya farmers had to cancel the plantation in the following year because of flooding.
5) The displacement rate was based on interviews and plot surveys in 2019. Prior to using that variety, farmers used the previous one which already yielded financial value. The value was used in calculating the yield that farmers used to receive from the previous papaya variety and then deducted from the yield from the new papaya variety in the ratio which was estimated to be equal to 60 percent or the displacement rate at 0.6.

**Table 3.** Social return on investment (SROI) of the research projects (Overall estimation).

| Stakeholders | Number | Ratio of benefits for stakeholders (%) | Total benefit value (Baht) | Attribution (%) | Dead-weight (%) | Displacement rate (%) | Net benefit value (Baht) |
|---|---|---|---|---|---|---|---|
| Farmers | 4,000 | 97.1 | 523,600,000 | 70 | 50 | 60 | 109,956,000 |
| Undergraduate students | 14 | 0.4 | 2,046,607 | 100 | 0 | 0 | 2,046,607 |
| Graduate and Ph.D. students | 11 | 0.5 | 2,538,241 | 100 | 0 | 0 | 2,538,241 |
| New researchers | 1 | 0.1 | 345,109 | 100 | 0 | 0 | 345,109 |
| Naresuan University | 18 | 0.7 | 3,523,161 | 100 | 0 | 0 | 3,523,161 |
| Thammasat University | 2 | 0.2 | 903,977 | 100 | 0 | 0 | 903,977 |
| Srinakharinwirot University | 2 | 0.1 | 273,987 | 100 | 0 | 0 | 273,987 |
| Kasetsart university | 6 | 0.4 | 2,002,846 | 100 | 0 | 0 | 2,002,846 |
| Mahidol University | 11 | 0.2 | 1,263,466 | 100 | 0 | 0 | 1,263,466 |
| Rajabhat Maha Sarakham University | 29 | 0.5 | 2,536,400 | 100 | 0 | 0 | 2,536,400 |
| Total benefit value (Baht) | | | 539,033,794 | | | | |
| Net benefit value (Baht) | | | 125,389,794 | | | | |
| Value of research funding from TRF (Baht) | | | 11,888,370 | | | | |
| Social return on investment (SROI) | | | 10.55 | | | | |

**Note:** 1) Stakeholder benefit ratio = Net stakeholder benefit x 100/Net benefit value.
2) Attributions or outcomes from other organizations = Research budget from TRF x 100/Total research budget.
3) Deadweight = Proportion of results that may occur at its own accord even when there is no TRF funding. The deadweight was assessed by stakeholders.
4) Net benefit value = Total benefit value x %attribution x (1-% deadweight) x (% displacement).
5) Social return on investment (SROI) = Total net benefit value / Value of research budget from TRF.

It is important to note that Table 3 shows the overall findings of social return on investment (SROI) for the 11 projects that were carried out under the research package. Table 4 displays the output, outcome, and SROI for each of the 11 projects. The Thai Fruits—Functional Fruits series of 11 projects generated a total value of 10,955,676 baht from a total research budget of 8,924,370 baht. The net financial return of the Thai Fruits—Functional Fruits project is positive, or 1.23 times the original research funding from TRF. Among the 11 projects of the Thai Fruits—Functional Fruits project series, 10 of them were scientific with relatively low results, in accordance with the nature of basic research at the primary level that needs further innovation. Three of these projects underwent development to facilitate further innovation and value-added research. The investment value of this project originated from a high-value research output, especially from the quality of academic publications and the extensive output, which furthered other research projects with funding from TRF, ARDA (Agricultural Research Development Agency), NRCT, and other agencies.

For the remaining 8 projects, their outputs followed their research objectives. Nonetheless, the academic publications in the TCI base do not create high value, or the output was discontinued for academic reasons, i.e., under TRF's funding, the research output was not practiced enough to create an outcome. At that time, the important outputs were either researchers, complete research reports, or reports that were waiting to be published. Some faced an obstacle preventing their commercial purposes (one project). The project in question yielded a social return on investment ranging from 0.18 to 0.98, indicating that TRF's investment was not deemed valuable. The fruitless research investment in these research projects exempts the value from knowledge dissemination, human capital from researchers' expertise, and other indirect impacts. Researchers have increased skills and expertise, more potential for further research, and students that were research assistants became graduates with bachelor's, master's, and doctoral degrees. They could secure employment more easily and receive higher payment compared to graduates with no experience in research projects. That created researchers and personnel for the country, which was in line with the TRF research funding plan focusing on creating a body of knowledge and developing researchers (Research Fund Office, 2009). These effects will increase the capacity in science and technology solutions and affect the country's economic growth in the future (Salter & Martin, 2001).

The Fresh Papaya Research and Development Center project, Maha Sarakham Province, and the Central Isan Group were quasi-development research, so outcomes and impacts were tangible. It received a budget of 2,964,000 baht from TRF and other grants from the affiliated university, SAO, and NSTDA for 1,300,000 baht (totaling 4,264,000 baht). The project has a very high financial return of 114,434,118 baht from seeds' sales innovation, meaning more income for farmers' production. Local authorities collaborated to provide farmers with a wide range of training. The project has a social return on investment of 38.61, indicating that TRF's in the project was of value.

**Table 4.** Social return on investment (SROI) by project.

| Project | Stakeholder | Output/Outcome value[1] (Baht) | Attribution[2] (%) | Deadweight[3] (%) | Total output/Outcome value (Baht) | Net output/Outcome value (Baht) | Research budget from TRF (Baht) | SROI |
|---|---|---|---|---|---|---|---|---|
| 1) Development of healthy mango jelly for the elderly | 1) Graduate students | 126,835 | 100 | 0 | 126,835 | 916,635 | 1,098,000 | 0.83 |
| | 2) Mahidol University | 789,800 | 100 | 0 | 789,800 | | | |
| 2) A study of pomelo intake on flavonoid levels in serums and on platelet function in healthy volunteers. | 1) Graduate students | 317,087 | 100 | 0 | 317,087 | 701,913 | 1,048,260 | 0.67 |
| | 2) Mahidol University | 384,826 | 100 | 0 | 384,826 | | | |
| 3) Mechanisms of anti-oxidative stress and apoptosis of EA.hy926 human endothelial cells from ripe papayas. | 1) Graduate students | 639,565 | 100 | 0 | 639,565 | 1,543,542 | 1,039,770 | 1.48 |
| | 2) Thammasat University | 903,977 | 100 | 0 | 903,977 | | | |
| 4) Effects of Tabtim Chan rose apple on antioxidants and vascular function in mice with high blood cholesterol. | 1) Undergraduate students | 383,739 | 100 | 0 | 383,739 | 671,859 | 881,200 | 0.76 |
| | 2) Naresuan University | 288,120 | 100 | 0 | 288,120 | | | |
| 5) Anti-mutation and anti-carcinogenic characteristics of Thai fruits. | 1) Graduate students | 128,297 | 100 | 0 | 128,297 | 2,476,252 | 878,460 | 2.82 |
| | 2) New researchers | 345,109 | 100 | 0 | 345,109 | | | |
| | 3) Kasetsart University | 2,002,846 | 100 | 0 | 2,002,846 | | | |
| 6) Potentials of lady finger and Pisang Awak bananas in preventing skin cancer in DMBA(7,12-Dimethylbenz a anthracene) and UVB (Ultraviolet rediation) induced mice. | 1) Graduate students | 140,704 | 100 | 0 | 140,704 | 1,298,869 | 781,650 | 1.66 |
| | 2) Naresuan University | 1,158,165 | 100 | 0 | 1,158,165 | | | |
| 7) Effect of pomelo juice on learning and memory impairments in type 2 diabetic mice. | 1) Graduate students | 203,382 | 100 | 0 | 203,382 | 477,369 | 739,870 | 0.65 |
| | 2) Srinakharinwirot University | 273,987 | 100 | 0 | 273,987 | | | |
| 8) Benefits of papaya in obesity-induced mice with a high-fat diet. | 1) Undergraduate students | 127,913 | 100 | 0 | 127,913 | 637,849 | 699,360 | 0.91 |
| | 2) Naresuan University | 509,936 | 100 | 0 | 509,936 | | | |
| 9) Study on the effect of long Laplae durian varieties on learning, memory, and | 1) Graduate students | 191,869 | 100 | 0 | 191,869 | 659,189 | 673,200 | 0.98 |
| | 2) Naresuan University | 467,320 | 100 | 0 | 467,320 | | | |

| Project | Stakeholder | Output/Outcome value[1] (Baht) | Attribution[2] (%) | Deadweight[3] (%) | Total output/Outcome value (Baht) | Net output/Outcome value (Baht) | Research budget from TRF (Baht) | SROI |
|---|---|---|---|---|---|---|---|---|
| sexual performance in male mice. | | | | | | | | |
| 10) Effects of Tabtim Chan rose apple on apoptosis and antioxidant activity in pancreatic beta cells of streptozo tocin-induced diabetic mice. | 1) Graduate students | 383,739 | 100 | 0 | 383,739 | 1,483,359 | 596,200 | 2.49 |
| | 2) Naresuan University | 1,099,620 | 100 | 0 | 1,099,620 | | | |
| Project | Stakeholder | Output/Outcome value[1] (Baht) | Attribution[2] (%) | Deadweight[3] (%) | Total output/Outcome value (Baht) | Net output/Outcome value (Baht) | Research budget from TRF (Baht) | SROI |
| 11) Biological activity of Thai fruit extracts in human breast cell tissue induced by estro-gen oxidative DNA damage. | 1) Mahidol University | 88,840 | 100 | 0 | 88,840 | 88,840 | 488,400 | 0.18 |
| **Total 11 projects** | | **10,955,676** | | | | **10,955,676** | **8,924,370** | **1.23** |
| Project | Stakeholder | Output/Outcome value[1] (Baht) | Attribution[2] (%) | Deadweight[3] (%) | Total output/Outcome value (Baht) | Net output/Outcome value (Baht) | Research budget from TRF (Baht) | SROI |
| 12) Fresh papaya research and development center, Maha Sarakham province, and the Central Isan group | 1) Farmers | 523,600,000 | 70 | 50 | 109,956,000 | 114,434,118 | 2,964,000 | 38.61 |
| | 2 ) Undergraduate students | 1,534,955 | 100 | 0 | 1,534,955 | | | |
| | 3) Graduate students | 406,763 | 100 | 0 | 406,763 | | | |
| | 4 ) Rajabhat Maha Sarakham University | 2,536,400 | 100 | 0 | 2,536,400 | | | |
| **Total 12 projects** | | | | | | **125,389,794** | **11,888,370** | **10.55** |

**Note:** 1) Any project with no outcome will be presented with the output value.
2) Attribution is calculated only from cash and does not include support for tools and laboratories of the parent agency.
3) Project 12's deadweight was 50 percent because researchers were confident that there was a 50 percent chance of receiving funding from another source.
4) The displacement rate of the 12th project was 60, for the benefit of farmers.

## 5. CONCLUSION AND RECOMMENDATIONS

The current study provides efforts to quantify the social return on investment (SROI) of the research package on Thai fruits—functional fruits series, fruit trees, and fruit products. The study found that the research project series on Thai fruits earned net benefit values of total outputs and outcomes of 125,389,794 baht while the total budget for the research package was 11,888,370 baht. The overall social return on investment for the research package was 10.55. In other words, for every 1 baht of TRF's fund, SROI is 10.55 baht, indicating that the investment in the research projects is worth value. It was also found that the research project with relatively high outcome values (i.e., SROI of 38.61) was from the Fresh Edible Papaya Research and Development Center, Maha Sarakham Province, and the Central Isan Group. In addition, there were four other projects with SROI greater than 1.0. Overall, the outputs and outcomes of the project series are consistent with the TRF research plan of 2007–2013 that focused on creating a research system, a body of knowledge, and researchers. Finally, this article has provided the following recommendations that might be useful for the TSRI, research funders, and academia.

1. The nature of science project funding should be continuous with a multiyear budgeting policy to provide projects with opportunities for research, trials, in-depth research, or supply chain research. For research projects that focus on building in-depth knowledge and building/developing researchers, the funding should support the research programs with outputs in 3 - 5 years.
2. The research ecosystem of the parent agency should be developed. It can be systematically designed throughout the research value chain. The investment budget should be increased to build modern laboratories for a university or its networks, integrating with research strategies, especially the adequacy, availability, and access to modern equipment and laboratories, and perhaps creating tool centers' networks and shared laboratories.
3. The affiliated university should receive direct benefits and all the output value from the upstream. Therefore, research funding should be in the form of a joint venture for an operation budget from the funder and the university for the integration of research across the institutions.
4. There should be incentives for researchers to be able to quickly apply for patents/petty patents or intellectual property to reduce results retention. When researchers are unable to fund their research, the knowledge is not recognized and furthered and would be of no value.
5. Promotion/incentive should be given for the evaluation of research projects that are unfinished, incomplete, or unsettled. If there is a possibility of continuing research, with serious and enthusiastic researchers with an average of additional research budgets, they should be supported because it would increase opportunities for outcomes or impacts of the research project.

**Funding:** This research is supported by Thailand Science Research and Innovation.
**Institutional Review Board Statement:** Not applicable.
**Transparency:** The authors state that the manuscript is honest, truthful, and transparent, that no key aspects of the investigation have been omitted, and that any differences from the study as planned have been clarified. This study followed all writing ethics.
**Competing Interests:** The authors declare that they have no competing interests.
**Authors' Contributions:** All authors contributed equally to the conception and design of the study. All authors have read and agreed to the published version of the manuscript.

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