

Academic article**การประยุกต์ใช้กระบวนการคิดเชิงออกแบบ:
กรณีศึกษาโครงการอันเนื่องมาจากพระราชดำริ แก่ล้งดิน****An Application of Design Thinking:
A Case Study of the 'Klaeng Din' Royal Initiative Project**บุริม โอทากานนท์¹Burim Otakanon¹

Received: 18 September 2025 | Revised: 22 December 2025 | Accepted: 22 December 2025

<https://doi.org/10.55003/acaad.2026.282203>**บทคัดย่อ**

ปัญหาความเสื่อมโทรมของทรัพยากรดินในพื้นที่ภาคใต้ของประเทศไทย โดยเฉพาะกรณีของดินเปรี้ยวจัดเป็นประเด็นที่มีความซับซ้อนและแก้ไขยากหรือเรียกว่า “Wicked Problem” การแก้ไขนี้ไม่ได้เป็นแค่การเปลี่ยนแปลงทางเคมีในดินเท่านั้น แต่ยังเกี่ยวพันกับระบบเศรษฐกิจฐานราก ความมั่นคงทางอาหาร และโครงสร้างสังคมของชุมชนเกษตรกร รากเหง้าของปัญหาทางวิทยาศาสตร์เกิดจากการสะสมของแร่ไพไรต์ (FeS_2) ในชั้นดินตะกอนน้ำกร่อยเมื่อมีการระบายน้ำออกจากพื้นที่พรุเพื่อการเกษตร แร่ดังกล่าวจะเกิดปฏิกิริยาออกซิเดชันเมื่อสัมผัสกับอากาศและน้ำ นำไปสู่การก่อตัวของกรดซัลฟิวริกตามกลไกเคมี $4\text{FeS}_2 + 15\text{O}_2 + 14\text{H}_2\text{O} \rightarrow 4\text{Fe(OH)}_3 + 8\text{H}_2\text{SO}_4$ ซึ่งส่งผลให้ค่า pH ของดินลดลงจนต่ำกว่า 4.0 สถานะความเป็นกรดจัดนี้ทำให้เกิดการละลายของโลหะหนักที่เป็นพิษ เช่น อะลูมิเนียมและเหล็ก ในขณะที่ธาตุอาหารที่จำเป็นกลับถูกตรึงไว้ในรูปของสารประกอบที่ไม่ละลายน้ำ ขบวนการทางเคมีที่เกิดขึ้นนี้ส่งผลให้พื้นที่เกษตรกรรมกลายเป็นดินร้างที่เพาะปลูกไม่ได้ผล นำไปสู่ภาวะความยากจนและการย้ายถิ่นฐานของประชากร การศึกษานี้จึงมีวัตถุประสงค์เพื่อวิเคราะห์กระบวนการดำเนินโครงการอันเนื่องมาจากพระราชดำริ “แก่ล้งดิน” ผ่านกรอบกระบวนการคิดเชิงออกแบบ (Design Thinking) เพื่ออธิบายถึงนวัตกรรมการแก้ปัญหาที่ยึดมนุษย์เป็นศูนย์กลางและมีความยืดหยุ่นสูง ซึ่งแตกต่างจากการแก้ปัญหาเชิงเส้นแบบเดิมที่มักล้มเหลวในการรับมือกับความซับซ้อนของปัญหา

โดยการศึกษาในครั้งนี้นำการวิจัยเชิงคุณภาพผ่านการทบทวนวรรณกรรมอย่างเป็นระบบและการสังเคราะห์เชิงประเด็น โดยรวบรวมข้อมูลจากรายงานประจำปี รายงานทางเทคนิค บทความวิจัย และคู่มือการพัฒนาดินของหน่วยงานหลักที่สนับสนุนในโครงการพระราชดำริ ได้แก่ สำนักงาน กปร. กรมพัฒนาที่ดิน และมูลนิธิชัยพัฒนา ข้อมูลเหล่านี้ถูกนำมาวิเคราะห์ย้อนหลังเพื่อถอดรหัสกระบวนการแก้ปัญหาออกเป็น 5 ขั้นตอน เริ่มต้นจากขั้นตอนการเข้าใจผู้ใช้ (Empathize) ซึ่งมีความสำคัญอย่างยิ่งในฐานะจุดเริ่มต้นของนวัตกรรม โดยเห็นได้ชัดจากการที่พระบาทสมเด็จพระบรมชนกาธิเบศร มหาภูมิพลอดุลยเดชมหาราช บรมนาถบพิตร เสด็จเยี่ยมราษฎรในพื้นที่จังหวัดนครราชสีมาในปี พ.ศ. 2524 เพื่อรับฟังและสังเกตความ

¹ สาขาวิชาการตลาด วิทยาลัยการจัดการ มหาวิทยาลัยมหิดล¹ Marketing Department, College of Management, Mahidol University

ผู้ติดต่อประสานงาน (Corresponding Author) email: burimota@gmail.com

ทุกขียากของเกษตรกรด้วยพระองค์เอง การทำความเข้าใจในมิติมนุษย์นี้ทำให้สามารถกำหนดปัญหา (Define) ได้อย่างครอบคลุม ทั้งในแง่ของโจทย์ทางวิทยาศาสตร์ที่ต้องจัดการกับแร่ไฟไรต์ และโจทย์ทางสังคมที่ต้องคืนความมั่งคั่งและศักดิ์ศรีให้แก่เกษตรกรผ่านการฟื้นฟูที่ดินให้กลับมาสร้างรายได้ได้จริง

นวัตกรรมสำคัญของโครงการเกิดขึ้นในขั้นการสร้างแนวคิด (Ideate) ซึ่งเป็นการนำเสนอวิธีการที่ “สวนทางกับสามัญสำนึก” หรือที่เรียกว่าโมเดล “Aggravate-to-Solve” แทนที่จะมุ่งเน้นการใช้ปูนขาวเพื่อปรับสภาพดินแบบชั่วคราวซึ่งให้ผลไม่ยั่งยืนและมีต้นทุนสูง โครงการแก่งัดดินกลับเลือกที่จะ “แก่งัด” หรือกระตุ้นให้ดินแสดงความเป็นกรดออกมาให้ถึงขีดสุดผ่านกระบวนการทำให้ดินแห้งและเปียกสลับกัน เพื่อเร่งให้แร่ไฟไรต์ทำปฏิกิริยาออกซิไดซ์จนหมดสิ้นไปจากชั้นดิน จากนั้นจึงเข้าสู่กระบวนการสร้างต้นแบบ โดยมีการจัดตั้งศูนย์ศึกษาการพัฒนาพิภพทอหงษ์ฯ ให้เป็นพื้นที่ทดลองในสภาพจริง พื้นที่เหล่านี้ทำหน้าที่เป็นสนามทดสอบความหลากหลายของวิธีการ ตั้งแต่การใช้น้ำล้างกรด การใช้ปูนมาร์ลปรับสภาพ ไปจนถึงการใช้ชีววิธีอย่างการปลูกหญ้าแฝกเพื่อปรับปรุงโครงสร้างดิน ซึ่งการสร้างต้นแบบขนาดใหญ่นี้ช่วยให้ทีมนักวิจัยสามารถตรวจสอบร่องและปรับปรุงวิธีการได้ก่อนที่จะขยายผลไปสู่ระดับประเทศ สำหรับการทดสอบและการเรียนรู้เชิงปฏิบัติ (Test and Iteration) โครงการได้พิสูจน์ความสำเร็จจากการทดลองในพื้นที่ของเกษตรกรจริง เช่น ในเขตบ้านโคกอิฐ-โคกโน จังหวัดนราธิวาส พบว่าผลผลิตข้าวเพิ่มขึ้นอย่างก้าวกระโดดจาก 5-10 ถึงต่อไร่ เป็น 40-50 ถึงต่อไร่ และในจังหวัดสุราษฎร์ธานี การจัดการดินอย่างเป็นระบบสามารถเพิ่มผลผลิตได้จาก 431 กก./ไร่ เป็น 708 กก./ไร่ บทเรียนสำคัญที่ได้รับคือการค้นพบว่าดินที่ได้รับการฟื้นฟูแล้วอาจกลับมาเปรี้ยวจัดได้อีกภายใน 8 เดือนหากขาดการจัดการน้ำที่ถูกต้อง ข้อมูลส่วนนี้ส่งผลให้เกิดการวนซ้ำของกระบวนการคิดเพื่อสร้างระบบการบริหารจัดการน้ำและการให้ความรู้ต่อเนื่องแก่ชุมชน

ในมิติวิชาการ ผลการศึกษาโครงการแก่งัดดินได้ตอบโจทย์ข้อถกเถียงสำคัญในวรรณกรรมด้านการคิดเชิงออกแบบ โดยโครงการได้ต่อยอดแนวคิดของ Rittel and Webber (1973) ที่ระบุว่าปัญหาที่แก้ไขยาก จำเป็นต้องใช้วิธีการที่ไม่เป็นเส้นตรงและมีความยืดหยุ่นสูง ท่ามกลางกระแสวิพากษ์วิจารณ์ในระดับนานาชาติที่มองว่าการประยุกต์ใช้ Design Thinking ในปัจจุบันมักกลายเป็นเพียง “ละครแห่งนวัตกรรม” (Innovation Theater) หรือการทำตามขั้นตอนอย่างผิวเผินโดยไม่ได้อาศัยการเปลี่ยนแปลงที่แท้จริง (Schwab, 2023) กรณีศึกษาแก่งัดดินได้พิสูจน์ให้เห็นว่า เมื่อนำหลักการ Design Thinking มาใช้เป็นปรัชญาในการแก้ปัญหาที่ฝังรากลึกในบริบทจริง จะสามารถนำไปสู่ผลลัพธ์ที่ยั่งยืนได้ทั้งในเชิงวิทยาศาสตร์และสังคม

นอกจากนี้ โมเดล “Aggravate-to-Solve” ยังได้ขยายขอบเขตทฤษฎีการแก้ปัญหาเชิงนวัตกรรมของ Buchanan (1992) ที่เน้นการสร้างสรรค์สิ่งที่ยังไม่มีอยู่จริง โดยชี้ให้เห็นว่าในบางกรณี นวัตกรรมที่ก้าวล้ำอาจต้องแลกมาด้วยการยินยอมให้ปัญหารุนแรงขึ้นชั่วคราวเพื่อเข้าถึงและทำลายรากเหง้าของปัญหาอย่างถาวร ซึ่งแนวคิดนี้ท้าทายหลักการแก้ปัญหาแบบมาตรฐานที่มุ่งเน้นการปรับปรุงทีละน้อย การวิเคราะห์ย้อนหลังของโครงการรัฐผ่านกรอบนี้จึงมีคุณค่าในการเปลี่ยนความรู้ที่ฝังอยู่ในตัวบุคคล ให้กลายเป็นโมเดลที่ชัดเจนและสามารถนำไปถ่ายทอดในระดับนานาชาติได้ โดยเฉพาะในโครงการพัฒนาที่นำโดยรัฐซึ่งมักขาดกระบวนการถอดบทเรียนที่เป็นระบบ ในเชิงทฤษฎี บทความวิชาการนี้ได้ขยายขอบเขตของ Design Thinking ไปสู่การเป็นเครื่องมือวิเคราะห์ย้อนหลังสำหรับโครงการรัฐ เพื่อถอดบทเรียนจากนวัตกรรมที่เกิดขึ้นโดยธรรมชาติ และสร้างเป็นโมเดลที่สามารถถ่ายทอดได้ ในเชิงปฏิบัติ โมเดล “Aggravate-to-Solve” ถือเป็นบทเรียนสำหรับการจัดการปัญหาซับซ้อนอื่น ๆ เช่น การจัดการน้ำท่วมในเขตเมือง หรือการฟื้นฟูระบบนิเวศที่เสื่อมโทรม ซึ่งต้องการการตัดสินใจที่อิงอยู่บนพื้นฐานความเข้าใจมนุษย์และการทดลองที่ยืดหยุ่นเพื่อให้เกิดความยั่งยืนอย่างแท้จริง

คำสำคัญ: การคิดเชิงออกแบบ ดินเปรี้ยว การพัฒนาอย่างยั่งยืน ปัญหาที่มีความซับซ้อนและแก้ไขยาก ศาสตร์พระราชา

Abstract

The degradation of soil resources in the southern region of Thailand, specifically the occurrence of severe acid sulfate soils (ASS), represents a multifaceted challenge that aligns with the conceptualization of a “wicked problem.” Such problems are characterized by their extreme complexity, where scientific, economic, and social variables are inextricably intertwined, rendering traditional linear interventions largely ineffective. The complexity of this issue extends beyond the mere chemical transformation of soil; it is deeply embedded within the fundamental economic systems, food security, and social fabric of local farming communities. Scientifically, the root cause of this challenge lies in the accumulation of pyrite (FeS_2) within brackish water sediment layers. When peat swamp areas are drained for agricultural expansion, this mineral undergoes a rapid oxidation process upon exposure to atmospheric oxygen and water. This chemical reaction, expressed as $4\text{FeS}_2 + 15\text{O}_2 + 14\text{H}_2\text{O} \rightarrow 4\text{Fe}(\text{OH})_3 + 8\text{H}_2\text{SO}_4$, results in the formation of sulfuric acid, causing the soil pH to plummet below 4.0. This extreme acidity triggers the dissolution of toxic heavy metals, such as aluminum and iron, while simultaneously locking away essential plant nutrients in insoluble forms. Consequently, these chemical processes transform once-productive agricultural lands into barren wastes, leading to entrenched structural poverty and the displacement of local populations. The primary objective of this study is to analyze the “Klaeng Din” (teasing the soil) Royal Initiative Project through the framework of Design Thinking (DT) to elucidate its human-centered innovation pathway and its inherent flexibility, which distinguish it from conventional linear problem-solving approaches that often fail to address such complexities.

The methodology employed in this study is qualitative, utilizing a systematic literature review and thematic synthesis of data gathered from annual reports, technical documents, research articles, and soil development manuals from key organizations supporting royal initiative projects, including the Office of the Royal Development Projects Board (ORDPB), the Land Development Department (LDD), and the Chaipattana Foundation. These data were analyzed retrospectively to decode the project’s problem-solving process into five distinct stages according to the Design Thinking framework. The process began with the Empathize stage, a critical starting point for innovation, which was exemplified by King Bhumibol Adulyadej’s direct engagement with the people of Narathiwat Province in 1981. By personally observing and listening to the hardships of farmers whose lands had become infertile, the project established a foundation of deep human empathy. This understanding facilitated the Define stage, during which the problem was articulated comprehensively as both a scientific challenge involving pyrite management and a social imperative to restore the dignity and economic security of farmers through land remediation.

The core innovation of the project emerged during the Ideate stage, characterized by a counterintuitive strategy termed the “Aggravate-to-Solve” model. Rather than focusing on temporary and costly pH adjustments through standard liming practices, the Klaeng Din project opted to “tease” or intensify the soil’s acidity to its maximum level. This was achieved through accelerated cycles of drying and wetting the soil to force the oxidation of all available pyrite. This stage was followed by the Prototype stage, realized through the establishment of the Pikulthong Royal Development Study Centre as a “living natural

museum.” These sites served as experimental fields to test a variety of integrated methods, including leaching, the application of marl for neutralization, and biological solutions such as the planting of vetiver grass to improve soil structure. These large-scale prototypes allowed the research team to identify practical limitations and refine their methods before national implementation.

In the Test and Iteration stage, the project provided empirical validation of its success through dramatic results in actual community farms. For instance, in the Ban Khok Ith–Khok Nai area of Narathiwat, rice yields increased from 5-10 tang per rai to 40-50 tang per rai. In Surat Thani, systematic soil management increased yields from 431 kg/rai to 708 kg/rai. A vital discovery during this stage was that reclaimed land could revert to extreme acidity within just eight months if proper water management was not maintained. This critical feedback led to an iterative refinement of the process, emphasizing the establishment of robust water management systems and ongoing farmer education to ensure long-term sustainability.

In terms of international academic contribution, the study of the Klaeng Din project addresses several key debates in the Design Thinking literature. First, it reinforces the concept proposed by Rittel and Webber (1973) that wicked problems require flexible, non-linear approaches, particularly amid global criticism that modern applications of Design Thinking often degenerate into mere “innovation theater”, characterized by superficial adherence to steps without achieving meaningful change (Schwab, 2023). The Klaeng Din case proves that when DT principles are embraced as a core problem-solving philosophy, they can yield sustainable outcomes in both scientific and social dimensions. Furthermore, the discovery of the “Aggravate-to-Solve” model expands upon Buchanan’s (1992) theory of innovative problem-solving, which emphasizes conceiving what does not yet exist. It demonstrates that groundbreaking innovation may sometimes require a willingness to temporarily intensify a problem to address its root cause permanently, a stance that challenges standard practices focused on incremental improvement.

The retrospective analysis of state-led projects through this framework is invaluable for translating tacit knowledge into explicit, replicable models that can be shared internationally. Theoretically, this article extends the scope of Design Thinking into a retrospective analytical tool for public policy and state-led innovation. Practically, the “Aggravate-to-Solve” model serves as a profound lesson for managing other complex issues, such as urban flood management or the restoration of degraded ecosystems, which demand decision-making rooted in human empathy and flexible experimentation to achieve true sustainability.

Keywords: Design Thinking, Acid Sulfate Soils, Sustainable Agriculture, Wicked Problem, King's Philosophy

1. Introduction

Some challenges are so complex and intertwined with multiple issues that they defy simple solutions. Climate change, for instance, involves intricate interactions between environmental degradation, economic systems, political interests, and social behaviors, making it nearly impossible to address through any single intervention. Similarly, global poverty persists not merely due to lack of resources, but because

of deeply rooted systemic inequalities, political structures, and cultural factors that resist straightforward fixes. These types of challenges are characterized as "wicked problems". Problems that often elude simple solutions due to insufficient knowledge, conflicting stakeholder opinions, and significant economic burdens (Alford & Head, 2017; Buchanan, 1992).

A prominent example of such a wicked problem in Thailand is the widespread issue of severe acid sulfate soils. These soils, typically found in coastal peat swamps, contain high levels of pyrite (FeS_2), a mineral that poses a hidden chemical threat to agriculture (Vijarnsorn, 2021). When the land is drained for farming, the pyrite is exposed to atmospheric oxygen, initiating a chemical reaction that produces sulfuric acid. As a result, the soil's pH can plummet to levels below 4.0, releasing toxic heavy metals and rendering the land barren (Zade et al., 2021). This degradation leads to severe socio-economic consequences, making it impossible for farming communities to secure a livelihood. Like climate change and poverty, this problem involves complex interactions between environmental science, agricultural practices, economic sustainability, and human welfare, characteristics that make it a textbook example of a wicked problem.

Traditional, top-down development strategies often fail to address such wicked problems because they do not fully comprehend the interplay between environmental science and human factors (Head, 2022). In sharp contrast, the "Klaeng Din" (a Thai phrase meaning "to tease the soil" or "to make it sour") Royal Initiative Project, initiated by His Majesty King Bhumibol Adulyadej (King Rama IX), achieved lasting success by employing a methodology that closely mirrors the principles of modern Design Thinking (Srichampa, 2024). While the project's success can also be analyzed through frameworks like "participatory development" or attributed to "strong leadership," the Design Thinking lens offers a unique advantage. It provides a structured process for deconstructing the iterative and human-centered innovation at the heart of the project, moving beyond broad descriptions of participation or leadership to reveal the specific, replicable problem-solving stages that led to its success.

Design Thinking is a human-centered, iterative problem-solving approach that prioritizes the needs of the people it serves. It relies on a cycle of repeated experimentation and learning to understand users and foster creative solutions through five key stages: Empathize, Define, Ideate, Prototype, and Test (Carlgren et al., 2016; Liedtka, 2018). This article argues that the 'Klaeng Din' project, while not explicitly labeled as such by its originators, embodies the core tenets of the Design Thinking process. By retrospectively applying this framework, we can deconstruct its success, revealing an intuitive, human-centered approach that offers a powerful and replicable model. The goal is to demonstrate how the project's achievements stemmed from a deep understanding of its users, creative ideation, and rigorous real-world testing. This approach yielded a solution that is both scientifically effective and economically sustainable, and it continues to benefit Thailand today.

2. The Challenge of Acid Sulfate Soils

Acid Sulfate Soils (ASS) are soils and sediments that contain iron sulfides, primarily the mineral pyrite (FeS_2). In their natural, waterlogged state, these soils are generally harmless and are referred to as

Potential Acid Sulfate Soils (PASS) (Osman & Osman, 2018). The problem arises when they are drained for agricultural or construction purposes. Upon exposure to air, pyrite oxidizes in the presence of water and oxygen, forming sulfuric acid (H_2SO_4) and transforming the soil into Acid Sulfate Soils. This process can cause the soil pH to drop dramatically, often below 4.0 (de Souza & Abrahão, 2022).

The consequences are relentless, creating a triple threat to the agricultural sector. First, the extreme acidity directly inhibits the growth of most crops, including rice (Msimbira & Smith, 2020). Second, it triggers a chain of harmful chemical reactions. Essential nutrients, such as nitrogen and phosphorus, become "locked" in the soil and are unavailable to plants, while toxic metals, including aluminum and iron, dissolve and are released in concentrations poisonous to plant roots (Ghori et al., 2019). Third, the soil's physical structure degrades, becoming dense and compacted when dry, with poor aeration and drainage (Osman, 2018). This combination of chemical toxicity, nutrient deficiency, and inadequate physical structure renders the land barren, leading to profound economic hardship and food insecurity for affected communities (Gomiero, 2016).

3. The "Klaeng Din" Royal Initiative Project: A Historical Overview

The "Klaeng Din" project is a soil improvement methodology that was born out of a direct response to human suffering. The initiative began in 1981 after His Majesty King Bhumibol Adulyadej visited the peat swamp areas of Narathiwat Province and witnessed the severe poverty of farmers whose land had been rendered infertile (Office of the Royal Development Projects Board, 2020). The problem arose when these swamps, rich in organic matter and pyrite, were drained for agriculture. This drainage exposed the pyrite to oxygen, causing the soil to become highly acidic and unproductive, creating immense hardship for the local population (Land Development Department, 2005).

In response, the Pikulthong Royal Development Study Centre was established in Narathiwat in 1983 to serve as a research hub and a "living natural museum" dedicated to solving this problem (Office of the Royal Development Projects Board, 2020). The project's central innovation was the counterintuitive concept of "Klaeng Din" or "teasing the soil." Instead of immediately trying to neutralize the acid, the method first intentionally aggravates the soil to make it as acidic as possible. This is achieved by repeatedly drying the soil out (promoting oxidation) and then flooding it (to wash away the acid), simulating and accelerating the natural seasonal cycle (Porpeang, 2021). The logic was to force all the pyrite to oxidize, thereby exhausting the soil's acid-producing potential and allowing researchers to understand the full extent of the chemical problem.

Once the soil reached its peak acidity, the research team then tested various remediation methods. These included:

Leaching: Washing the soil with large volumes of water to flush out the acid.

Neutralization: Using alkaline materials, such as marl and lime, to raise the soil pH.

Water-level Control: Carefully managing the underground water table to prevent the lower layers of pyrite from oxidizing.

Biological Solutions: Integrating other successful royal projects, such as planting vetiver grass to stabilize the soil and prevent erosion and applying the principles of "New Theory" agriculture for a holistic farming approach (Land Development Department, 2005; Porpeang, 2021).

Following successful trials at test sites such as Pikulthong and on Chaipattana Foundation land in Nakhon Nayok, these methods were disseminated nationwide, transforming previously barren lands into productive farms (Chaipattana Foundation, 2025).

4. Design Thinking as an Analytical Framework

Design Thinking is a problem-solving methodology tailored for complex and ill-defined challenges, particularly in business and social innovation. Its core principle is its human-centered nature, which mandates starting with a deep, empathetic understanding of the end-user's perspective (Chou, 2018; Nandan et al., 2020). This framework is not a rigid sequence of steps, but a flexible, iterative cycle built around five key stages: Empathize, Define, Ideate, Prototype, and Test (Bender-Salazar, 2023). This framework's emphasis on empathy, iteration, and real-world testing makes it an excellent tool for retrospectively analyzing the factors contributing to the success of complex projects like "Klaeng Din," which grew through deep engagement and adaptive learning rather than a rigid top-down plan.

5. Research Methodology

The study employs a qualitative methodology, combining a structured literature review with a thematic synthesis to analyze the Klaeng Din project through the five-stage Design Thinking framework. This framework is applied not because the project's originators formally used the terminology, but as an analytical lens to deconstruct the success of their highly human-centric and iterative innovation process. Data were collected from a range of sources. A systematic literature review was conducted using academic and government databases with keywords such as "Klaeng Din," "acid sulfate soil," and "soil improvement." To understand the specific methods and challenges, the research drew heavily on technical manuals, project reports, and publications from the Office of the Royal Development Projects Board, the Land Development Department, and the Chaipattana Foundation. This "grey literature" was essential for mapping the project's activities to the Design Thinking stages.

The analysis began with the Empathize stage, reviewing documents describing King Bhumibol's direct engagement with farmers. For the Define stage, the focus was on official project documents that articulated the problem. The Ideate stage was analyzed by examining reports detailing the various solutions proposed, centered on the core "Klaeng Din" concept. For the Prototype stage, the study examined descriptions of the large-scale test sites. Finally, the Test stage involved analyzing reports containing quantitative data on crop yields and documented feedback from participating farmers. This method reveals the underlying problem-solving process that was crucial to the project's success, providing a replicable model for addressing other complex challenges.

6. Limitations of the Study

It is essential to acknowledge the limitations inherent in a retrospective analysis. While the "Empathize" stage is a cornerstone of Design Thinking, this study relies on historical documents and official reports to understand the initial engagement with farmers. No new primary interviews were conducted with the original farmers or project participants. Therefore, the analysis of the empathy phase is an interpretation based on the documented actions and motivations of the project leaders, rather than on new, direct ethnographic data. This is a necessary constraint of applying a contemporary framework to a historical case.

7. Analysis and Findings: The "Klaeng Din" Project through a Design Thinking Lens

A deconstruction of the history of the "Klaeng Din" project reveals a process that aligns remarkably well with the five stages of the Design Thinking framework. Its success can be attributed to a human-centered, iterative, and adaptive approach to problem-solving.

Phase 1: Empathize – Understanding the Farmer's Plight

The project was initiated from a place of deep empathy. It began in 1981 with King Bhumibol Adulyadej's visit to Narathiwat province, where he engaged directly with farmers to witness their struggles firsthand (Office of the Royal Development Projects Board, 2020). The core problems they faced were clear:

Agricultural Failure: The soil had become too acidic and barren to support crop cultivation.

Economic Collapse: The loss of income from farming threatened the financial security of families and communities.

Social Instability: The economic deficit threatened food security and risked forcing people to migrate in search of a livelihood.

This direct observation of the human dimension of the problem laid the foundation for the entire project. It was conceived as a direct response to the community's needs, aimed at restoring the land and providing farmers with a sustainable livelihood.

Phase 2: Define – Articulating the Core Problem

With a deep understanding of the user's needs, the project then moved to define the problem with clarity and precision. The challenge was articulated as a dual-sided problem statement, addressing both the human and scientific dimensions:

The Human Problem: The challenge was framed around the farmers' needs: How can this project transform this unproductive land into fertile soil that provides a sustainable living and economic security for local communities?

The Scientific Problem: An in-depth study by soil scientists identified the root cause as the oxidation of pyrite (FeS₂) in the underlying clay layer, which produces sulfuric acid through the chemical reaction: $4\text{FeS}_2 + 15\text{O}_2 + 14\text{H}_2\text{O} \rightarrow 4\text{Fe}(\text{OH})_3 + 8\text{H}_2\text{SO}_4$ and leads to severe soil acidity (Land Development Department, 2005).

Defining both the "what" (the scientific mechanism) and the "why" (the human consequence), the project established a clear and powerful starting point. This guided the team away from superficial solutions toward a fundamental chemical and social resolution.

Phase 3: Ideate – Generating Counterintuitive Solutions

The ideation phase of the "Klaeng Din" project produced a truly groundbreaking solution that exemplifies a core principle of Design Thinking: challenging conventional assumptions. Traditional approaches to acid soil typically focus on immediate pH correction through lime application. However, the project team recognized that this would only provide temporary relief, as unoxidized pyrite beneath the surface would continue to generate acid. The breakthrough came from reframing the problem entirely. The team arrived at this counterintuitive solution through an iterative brainstorming process that involved soil scientists, agricultural experts, and input from observing the natural seasonal patterns of the region. The key insight emerged from asking: "What if we stopped fighting the acidity and instead deliberately triggered all the pyrite oxidation at once?" The ideation phase of the "Klaeng Din" project produced a truly groundbreaking solution, a classic example of "out-of-the-box" thinking. The core idea was unconventional: instead of immediately fighting the soil's acidity, the project would first intensify it. The method was to "trick" or "tease" the soil (klaeng Din) into becoming as acidic as possible, as quickly as possible. This was achieved by creating a system of alternating wet and dry periods, which simulates and accelerates the natural seasonal climate of southern Thailand (Porpeang, 2021). The logic was to "burn out" all the available pyrite, utilizing its potential to create more acid, thereby ensuring that any subsequent treatments would be more permanent.

A portfolio of other innovative solutions supported this primary strategy:

Washing with water (Leaching): Using large volumes of water to flush the newly formed acid from the topsoil.

Neutralizing with chemicals: Applying alkaline materials, such as marl and lime, to the soil to directly counteract acidity.

A combined method: Integrating both leaching and lime application while carefully controlling the underground water level to prevent deeper pyrite layers from oxidizing.

Using Biological Solutions: Incorporating other successful royal projects, such as planting vetiver grass to improve soil health and applying "New Theory" agriculture for integrated farm management (Porpeang, 2021).

Phase 4: Prototype – Creating a "Living Natural Museum"

The project brought its ideas to life by establishing large-scale prototypes that functioned as a "living natural museum," allowing concepts to be tested and refined under real-world conditions. Two key locations were used:

The Pikulthong Royal Development Study Centre (Narathiwat): Established in 1983, this 1,740-rai (approx. 278 hectares) center was the primary test site where the core methods were developed and demonstrated (Office of the Royal Development Projects Board, 2020).

Nakhon Nayok Site: This 130-rai (approximately 21 hectares) site, located on Chaipattana Foundation land, was used for parallel experiments, with different plots testing variations of the solutions. For example, one plot used only rainwater and vetiver grass, while another tested an integrated solution of lime with "New Theory" Agriculture (Chaipattana Foundation, 2025).

These prototyping efforts were crucial. During this phase, the team encountered several practical challenges that required adaptation. For instance, they discovered that the initial flooding schedule was too aggressive, causing soil structure damage. They adapted by developing a more gradual wet-dry cycle. Another challenge was determining the optimal timing for lime application, too early and the lime was wasted, too late and crops suffered. Through iterative testing, they identified the precise point in the treatment cycle when lime would be most effective. They allowed the team to learn, adapt, and understand practical challenges before scaling up the solutions, significantly reducing the risk of failure.

Phase 5: Test and Iteration – Real-World Validation and Refinement

The final and most critical stage was to test the refined solutions with the farmers themselves. The project expanded from research centers to actual community farms in provinces such as Narathiwat and Surat Thani. This 'from-lab-to-field' testing measured what mattered most to the end-users: crop yields and income. The results were dramatic:

In Narathiwat, at Ban Khok Ith–Khok Nai, rice yields on previously barren land increased from just 5–10 *tang* per *rai* to an impressive 40–50 *tang* per *rai* (Royal Initiative Projects, 2016). (*Note: 1 tang* $\approx$ 10–12 kg; 1 *rai* $\approx$ 0.16 hectares).

In Surat Thani, at Ban Don Khok, treating the soil increased single-crop rice yields from 431 kg/*rai* to 708 kg/*rai*. For a second annual crop, the addition of limestone nearly doubled the yield from 425 kg/*rai* to 831 kg/*rai* (Rampai, 2013).

A significant discovery during this phase was that reclaimed land could revert to being highly acidic if left unmanaged for as little as eight months. When farmers at one test site abandoned their plots due to labor migration, soil pH measurements showed a drop from 6.5 back down to 4.2 within two agricultural seasons. In a traditional linear project approach, this would be classified as a failure—evidence that the solution didn't work. Within a Design Thinking approach, it was invaluable feedback. This insight led to the crucial iteration that the solution was not a one-time fix but required ongoing water management and education. This cycle of testing, learning, and improving was the key to the project's long-term success.

8. Contribution to Design Thinking Debates

The application of Design Thinking to the Klaeng Din project contributes to several ongoing debates in Design Thinking literature. First, it addresses Rittel and Webber's (1973) original conceptualization of wicked problems as requiring flexible, non-linear approaches. Critics have argued that Design Thinking's popularization has led to oversimplification and "innovation theater" (Schwab, 2023), where organizations go through the motions without achieving meaningful transformation. The Klaeng Din case demonstrates that when Design Thinking principles are genuinely embraced, not as a rigid methodology but as a flexible

problem-solving philosophy, they can yield sustainable solutions even to deeply entrenched wicked problems.

Second, this analysis reveals an important insight about the "counterintuitive solution" principle in Design Thinking that is often understated in the literature. Buchanan (1992) emphasized that design thinking involves "conceiving and planning what does not yet exist," but the Klaeng Din case shows that truly breakthrough solutions may require not just creative ideation, but a willingness to temporarily make problems worse before making them better. This "aggravate-to-solve" approach challenges conventional Design Thinking practice, which typically seeks incremental improvements, as illustrated in Figure 1. The literature on Design Thinking rarely discusses this more radical form of reframing, where the path to solution requires first intensifying the problem to understand and exhaust its root cause.

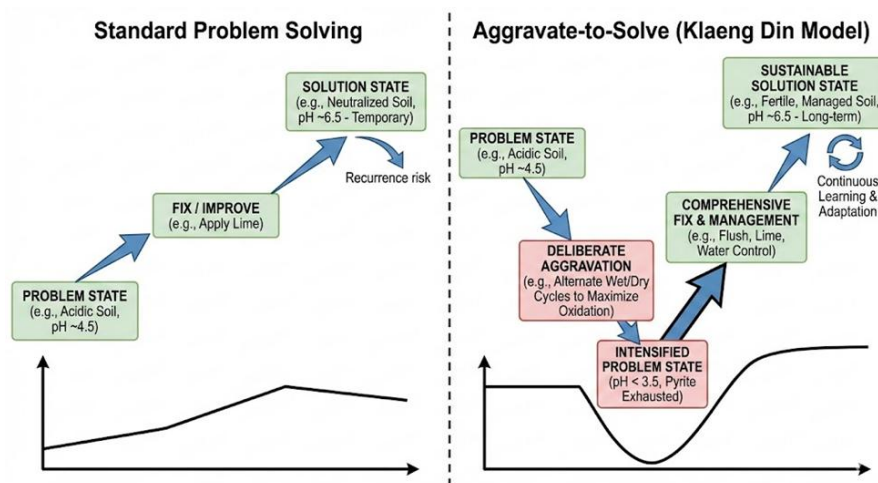


Figure 1 The 'Aggravate-to-Solve' Model: Visualizing the counterintuitive trajectory of the Klaeng Din methodology compared to standard interventions

Third, the case provides evidence for Design Thinking's value as a retrospective analytical tool for understanding successful state-led projects. While most Design Thinking literature focuses on prospective application, using it to design new solutions, this study demonstrates its analytical power for deconstructing why certain initiatives succeeded. This retrospective application is particularly valuable for government projects where formal Design Thinking was not explicitly employed, yet the principles were organically followed. By revealing the human-centered, iterative processes that led to success, this approach can help translate tacit knowledge into explicit, transferable frameworks.

The "Klaeng Din" Royal Initiative Project stands as a testament to an insightful and adaptive approach to problem-solving. A retrospective analysis through the lens of Design Thinking reveals a process that organically mirrors its core principles with remarkable fidelity. The project's success was not born from a rigid, predefined plan, but rather evolved through a flexible journey that prioritized human outcomes. It began with empathy, leading to a nuanced definition of the problem in both scientific and human terms. The ideation was unconventional, the prototyping was realistic, and the testing was iterative. The project's

willingness to learn from setbacks and adapt its approach is what ultimately ensured its long-term, sustainable impact.

This analysis also highlights the value of using Design Thinking as a retrospective tool. It is most helpful in understanding the success of complex government projects that were inherently human-centered and adaptive in their execution. It can reveal the intuitive, user-focused processes that may not have been formally documented but were critical to achieving sustainable outcomes. While other frameworks like "participatory development" effectively describe the collaborative nature of such projects, Design Thinking provides a more granular, process-oriented lens that deconstructs the specific stages of innovation, from initial empathy to iterative testing. By doing so, it translates the success of "Klaeng Din" into a more actionable and replicable model for addressing other wicked socio-environmental problems, demonstrating that the most effective solutions are often deeply human, creatively adaptive, and relentlessly iterative.

The following table summarizes the alignment of the "Klaeng Din" project's activities with the Design Thinking framework.

Table 1 The "Klaeng Din" Project Deconstructed through the Design Thinking Framework

Design Thinking Stage	"Klaeng Din" Project Activities	Key Insights & Outcomes
Empathize	King Bhumibol's direct engagement with farmers in Narathiwat (1981) to witness their struggles with barren, acidic soil firsthand.	A deep understanding of the farmers' plight was the project's starting point. The core problems were identified as agricultural failure, economic collapse, and social instability. The goal was established as human-centered: to restore the land for a sustainable livelihood.
Define	A dual problem statement was created, addressing both human needs (how to restore the land for sustainable living) and the scientific root cause (pyrite oxidation in drained peat swamps).	The problem was clearly defined as both a human need and a scientific mechanism. This guided the team away from superficial fixes and toward a fundamental solution to achieve the human-centered goals.

Design Thinking Stage	"Klaeng Din" Project Activities	Key Insights & Outcomes
Ideate	The team brainstormed the counterintuitive core solution of "Klaeng Din"—accelerating acidification through cycles of drying and wetting. They also developed a portfolio of other methods, including water leaching, lime neutralization, and the use of vetiver grass.	A radical, "out-of-the-box" solution was produced that departed from traditional techniques. A flexible toolkit of multiple adaptable methods was created, with the logic of exhausting the pyrite's potential to make future fixes permanent.
Prototype	Large-scale test sites, or "living natural museums," were established at the Pikulthong Centre (1983) and in Nakhon Nayok. Parallel experiments were conducted on different plots to test variations of the solutions.	Prototypes allowed the team to test, refine, and demonstrate solutions in a realistic environment. This process provided crucial learning and adaptation, significantly reducing the risk of failure before nationwide implementation.
Test & Iteration	Experiments were moved from study centers to actual community farms. Crop yields and economic returns were measured to validate success (e.g., rice yields in Narathiwat increased from 5-10 to 40-50 tang/rai). Feedback, such as the re-acidification of untreated soil, was used to iterate on the solution.	The method's success was validated with real-world data. The most crucial insight was that the solution required ongoing management, not a one-time fix. This led to a more robust and truly sustainable solution through iteration and farmer education.

Note. Data for this table were synthesized from various sources, including Buchanan, 1992 and the Office of the Royal Development Projects Board. (2020).

9. Conclusion

The "Klaeng Din" Royal Initiative Project stands as a testament to the power of human-centered, iterative problem-solving in addressing complex socio-environmental challenges. This retrospective analysis has demonstrated that the project's success was not born from a rigid, predefined plan, but rather evolved through a flexible journey that organically mirrored the core principles of Design Thinking. Beginning with deep empathy for affected farmers, moving through careful problem definition that bridged both scientific and human dimensions, generating counterintuitive solutions, creating real-world prototypes in "living natural museums," and engaging in iterative testing with actual communities, the project exemplified each phase of the Design Thinking framework with remarkable fidelity.

This study makes several important contributions to Design Thinking literature. First, it demonstrates that Design Thinking principles can yield sustainable solutions to deeply entrenched wicked problems when genuinely embraced as a flexible problem-solving philosophy rather than a rigid methodology. The project's success addresses critiques of "innovation theater" (Schwab, 2023) by showing authentic application in a complex real-world context. Second, the analysis reveals an understated principle in Design Thinking literature: the "aggravate-to-solve" approach, in which truly breakthrough solutions may require temporarily intensifying problems to understand and exhaust their root causes. This counterintuitive strategy challenges conventional Design Thinking practice that typically seeks incremental improvements. Third, the study establishes Design Thinking's value as a retrospective analytical tool for understanding successful state-led projects, demonstrating its power to deconstruct why certain initiatives succeeded and translate tacit knowledge into explicit, transferable frameworks.

The practical implications of this research extend beyond acid sulfate soil management. The Klaeng Din model offers a replicable framework for addressing other complex socio-environmental problems that share similar characteristics of wickedness. For instance, urban flooding in rapidly developing cities involves complex interactions between infrastructure planning, climate adaptation, economic development, and community well-being—challenges that could benefit from the same human-centered, iterative approach. Similarly, sustainable resource management in agricultural communities facing climate change could draw lessons from the project's emphasis on empathy, scientific rigor, counterintuitive solutions, real-world prototyping, and continuous learning from feedback. The key insight is that the most effective solutions are often deeply human, creatively adaptive, and relentlessly iterative.

This study acknowledges certain limitations inherent in retrospective analysis. While the Empathize stage is central to Design Thinking, this analysis relies on historical documents and official reports rather than new primary interviews with original farmers or project participants. Future research could benefit from ethnographic studies that capture contemporary perspectives of communities that have benefited from the Klaeng Din methodology. Additionally, comparative case studies examining other successful royal initiative projects through the Design Thinking lens could further validate and refine the framework's applicability to diverse wicked problems in Thailand and beyond. Longitudinal studies tracking the sustained impact of the

Klaeng Din approach over multiple decades would also provide valuable insights into the long-term effectiveness of Design Thinking-inspired interventions.

In an era where complex challenges—from climate change to public health crises to social inequality—demand innovative approaches, the Klaeng Din project offers a powerful reminder that sustainable solutions emerge not from top-down interventions or quick fixes, but from processes that deeply understand human needs, embrace scientific rigor, welcome unconventional thinking, test ideas in real-world conditions, and remain committed to continuous learning and adaptation. By revealing these principles through retrospective Design Thinking analysis, this study hopes to contribute to both academic understanding and practical application of human-centered innovation in addressing the wicked problems that define our contemporary world.

Table 2 Iterative Coding Process and Emergent Concepts

Design Thinking Stage	Raw Data / Key Events from the Project	Initial Codes (Thematic Labeling)	Emergent Concepts (Theoretical Insight)
1. Empathize	King Bhumibol's 1981 visit to Narathiwat to observe barren lands and listen to the hardships of impoverished farmers.	• Direct Field Observation • Active Listening to Stakeholders • Identifying Human Suffering	Human-Centricity: Grounding innovation in a deep, empathetic understanding of social and economic realities rather than just scientific data.
2. Define	Articulating a dual problem statement: the scientific mechanism of pyrite oxidation and the social imperative to restore farmer dignity.	• Root Cause Identification • Dual-Sided Problem Framing • Goal Setting for Sustainability	Integrated Problem Scoping: Transforming a "wicked problem" into a clear, actionable mandate that bridges environmental science and human welfare
3. Ideate	Brainstorming the "Klaeng Din" concept to accelerate	• Challenging Conventional Wisdom • Counterintuitive Solutioning	Disruptive Innovation: Embracing a radical path that temporarily

Design Thinking Stage	Raw Data / Key Events from the Project	Initial Codes (Thematic Labeling)	Emergent Concepts (Theoretical Insight)
	acidification via wet-dry cycles instead of seeking temporary lime-based fixes.	"Aggravate-to-Solve" Logic	intensifies a problem to permanently exhaust its root cause.
4. Prototype	Establishing the Pikulthong Centre as a "Living Natural Museum" to test integrated leaching, liming, and vetiver solutions.	- Real-World Simulation - Large-Scale Experimentation - Failure Mitigation Testing	Experimental Learning: Utilizing realistic prototypes to identify practical limitations and refine methods before national implementation.
5. Test & Iteration	Measuring yield increases in community farms and discovering that reclaimed soil reverts to acidity without ongoing water management.	- Empirical Validation - Feedback-Driven Refinement - Discovering Recurring Patterns	Sustained Adaptability: Viewing "failure" (re-acidification) as vital feedback to evolve the solution from a one-time fix into a continuous management system.

Note. Data for this table were synthesized by the researcher based on the thematic synthesis of various project documents and technical reports from the Office of the Royal Development Projects Board, the Land Development Department, and the Chaipattana Foundation.

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