Name: Braden Caleb Perumal

Student Number: ST10287165

Lecturer: Mr E Adam

Module: PROG7311

PROG 7311 POE Part One

FUTUREFORWARD TECHNOLOGIES (PTY) LTD

AGRI-ENERGY CONNECT

Project Proposal

A digital platform bridging sustainable agriculture and renewable energy

PRESENTED TO	PRESENTED BY
BID COMMITTEE, DEPARTMENT OF AGRICULTURE AND GREEN INITIATIVES	FUTUREFORWARD TECHNOLOGIES (PTY) LTD

FUTUREFORWARD TECHNOLOGIES (PTY) LTD

Table of Contents

FUTUREFORWARD TECHNOLOGIES (PTY) LTD

Table of Contents continued…

1.Introduction

FUTUREFORWARD TECHNOLOGIES (PTY) LTD

In South Africa, agriculture remains as one of the biggest sectors that boosts and sustains the South African economy as it is the source that provides food security for millions as well as employment for a large portion of the population. Majority of the south African farmers are currently being exposed to extremely tough challenges that include ever rising energy costs, water scarcity, outdated farming methods and limited access to advanced technology which can make several processes more efficient and effective. Although there are several challenges, there is also a growing demand for renewable energy solutions that is further fuelled by environmental concerns, government incentives and the national push toward a more sustainable and resilient future. (saipa, 2025) (Nxumalo, 2022)

By recognizing the need to merge these two critical sectors which are agriculture and renewable energy, the proposed Agri-Energy Connect platform is a well throughout and designed platform that aims to build a digital ecosystem where agriculture and green energy innovation meet. This platform will serve as a central hub for farmers, energy providers, educators, funders and policymakers to collaborate, share resources and accelerate the adoption of sustainable farming and renewable energy practices. (Beresnyak, 2023) (Hackemann, 2019)

This proposal outlines the complete vision, core objectives, technical foundation, and implementation strategy needed to build and scale the Agri-Energy Connect platform. With an emphasis on accessibility, modular design and nationwide scalability, FutureForward Technologies ensures that the platform is built using modern design patterns, robust software architecture and Agile development methodologies. The outcome is a secure, scalable and user-friendly digital ecosystem that makes a meaningful contribution to South Africa's sustainability agenda and digital transformation goals

FUTUREFORWARD TECHNOLOGIES (PTY) LTD

2. Why This Matters: The Power of Bridging Agriculture and Green Energy

Since the agricultural sector is one of the largest sectors contributing to the South African economy, it can also be regarded as the foundation of many rural economies and it remains highly exposed to prevalent challenges of which some include climate change, unpredictable rainfall, soil degradation and the rising cost of fuel and electricity. On the other hand, renewable energy technologies which includes solar, wind and biogas, tends to offer significant but unexplored opportunities for improving efficiency, reducing costs and promoting sustainability. South Africa is a golden country that has the capability to leverage renewable energy to make more efficient and effective farming practices but many farmers still lack awareness, access and as well as practical guidance on how to adopt and integrate these solutions into their daily operations. (Moore, 2021) (duRaan, 2024)

This platform has been designed to bridge the agriculture and renewable energy sectors through a unified digital ecosystem which will present transformations and revolutionary opportunities such as:

- Farmers will be able to gain access to reliable, renewable energy solutions that is specific to their needs, reducing dependence on costly and unstable grid power. (Lowal, 2023)
- Green energy providers will be able to connect directly with real agricultural use cases which unlocks the traditionally underserved market and allow for their solutions to be scaled more effectively. (Lowal, 2023) (Agriconnect, 2018)
- Collaboration is one of the main goals of the Afri-Energy Connect platform and allows for a wide range of stakeholders, which included farmers, engineers, NGOs and funders to communicate through integrated training modules, discussion forums, and shared project workspaces. (Lowal, 2023)
- The open access to knowledge enables rural farmers to become educated about and implement innovative methods such as community biogas systems, energy-efficient soil treatment, and solar-powered irrigation. (Lowal, 2023) (Agriconnect, 2018)

This bridge can only be built through an innovative digital platform that is inclusive, scalable and specific to South Africas unique social, economic and environmental landscape. Agri-Energy Connect is designed to be that bridge, which is a powerful, accessible platform that delivers meaningful value to both the agricultural and renewable energy sectors, while empowering rural communities to grow and thrive in a more sustainable and connected future. (Agriconnect, 2018)

Image source: (Forestel, 2021)

FUTUREFORWARD TECHNOLOGIES (PTY) LTD

3. Vision and Objectives

Vison Statement:

This primary vision of this project is to simply to digitally empower farmers across South Africa by creating an innovative, intelligent and accessible web-based ecosystem that connects the agricultural community with advanced green energy technologies. Agri-Energy Connect is more than just a digital tool, rather it is a transformative enabler that is designed and built to promote sustainable farming practices, reduce environmental impact, lower operational cost and uplift rural livelihoods through innovation and collaboration. (Martins, 2025)

This vision directly supports key national priorities which include food security, environmental administration and the widespread adoption of clean energy by ensuring that even small scale and remote farmers can benefit from technological advancements. By leveraging the collaboration feature, promoting education, enabling innovation and providing access to green energy solutions, this well structured platform envisions a future where every farmer, regardless of location or scale, is empowered to operate sustainably, efficiently and competitively within South Africas evolving agricultural landscape. (Martins, 2025)

Core Objectives:

- **Education**: Create a centralized digital that is made accessible for training and knowledge sharing on sustainable agriculture and renewable energy practices. (Mansuri, 2025)
- **Marketplace Access**: Connect the south African farmers with clean renewable energy solutions that are specific for their agricultural needs. This enables then to run their farming activities for efficient and effective. (Mansuri, 2025)
- **Collaboration**: When planning this platform, one of the core objectives that we came across is the facilitation for collaboration this platform is designed to enable collaboration from the start by ensuring real-time communication and project collaboration between farmers, engineers, NGOs, funders and policymakers through the use of interactive tools and shared workspaces. (Seed, 2025)
- **Support and Funding**: Make it easier for people to find and apply for funding opportunities for agricultural green energy projects, such as grants, subsidies or crowdfunding.
- **Scalability and Accessibility**: One of the main objectives is to build this platform with the future in mind. This simply means making sure that it is planned and designed to expand in in response to future growth as a result of user demand all while still being user-friendly and accessible to people with different levels of digital literacy. (Seed, 2025) needs. This enables

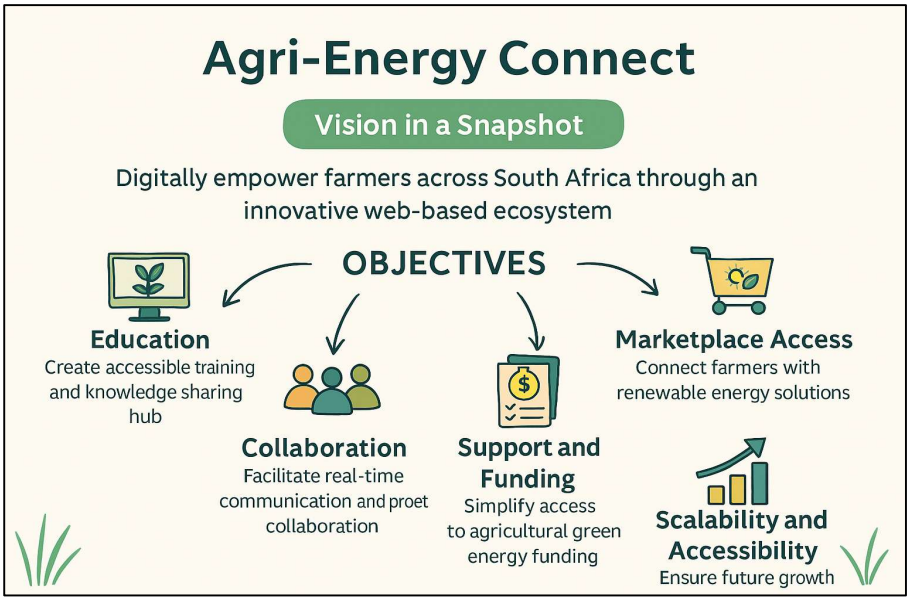

Figure 1: Agri-Energy Connect – Vision and Core Objectives Overview
This infographic visually captures the platforms core purpose and five key goals which are education, access to green energy, collaboration, funding support and future scalability, summarizing how the Agri-Energy Connect platform empowers farmers through innovation and digital transformation.

Image Source: (ChatGpt, 2025)

FUTUREFORWARD TECHNOLOGIES (PTY) LTD

4. High-Level Plan

4.1 Project Methodology: What is Agile & Why Does it Work Best

When proposing a platform (Agri-Energy Connect) of such magnitude, it requires adaptability, continuous feedback and incremental development, especially when placing into consideration the platforms diverse user base, which includes smallholder farmers with limited digital exposure, as well as energy providers and policy stakeholders. In order to meet these varied and evolving needs, we propose adopting the Agile methodology from the start as it is known to be a flexible and iterative approach to software development that promotes collaboration, rapid feedback cycles most importantly, continuous improvement. Agile ensures that the platform remains responsive to user input, aligned with stakeholder goals and capable of evolving alongside technological and environmental demands. (Gurnov, 2025) (Torode, 2025)

One of the key features of the Agile Methodology is that it organizes development into short, focused work cycles known as sprints which typically lasts/runs for two weeks. When examining each sprint, it will include all stages of the software development life cycle (SDLC), from planning and design all the way to development, testing, review and deployment. By using this approach, it enables the team to release functional features early and allow them to gather direct and valuable feedback from users which help them to implement continuous improvement throughout the project. The agile approach ensures that there is regular stakeholder engagement which makes sure that the development stays aligned with real world expectations and the ever evolving needs that arises from the users needs which overall, results in a solution that is both practical and relevant. (Zhezherau, 2018) (Miller, 2018)

This approach is well-suited for the Agri-Energy Connect, as it allows us to test key features which include marketplace tools, educational modules and grant integration, in smaller, manageable releases. It allows farmers, energy providers and other users to begin interacting with parts of the platform early in the development cycle so that they can provide solid user and valuable feedback that helps shape the final product to be successful and effective. The flexibility of Agile significantly contributes to making responses to changes easier, whether it is driven by shifting energy policies, emerging technologies or even new funding opportunities, it ensures that the platform remains relevant and future ready at all times. (plutora, 2022)

Figure 2: Agile Sprint Lifecycle for Agri-Energy Connect
This diagram shows how the platform is developed step-by-step in short, repeatable cycles. It highlights how Agile supports flexibility, early feedback, and faster delivery—perfect for building a platform that serves diverse users like farmers and energy providers.

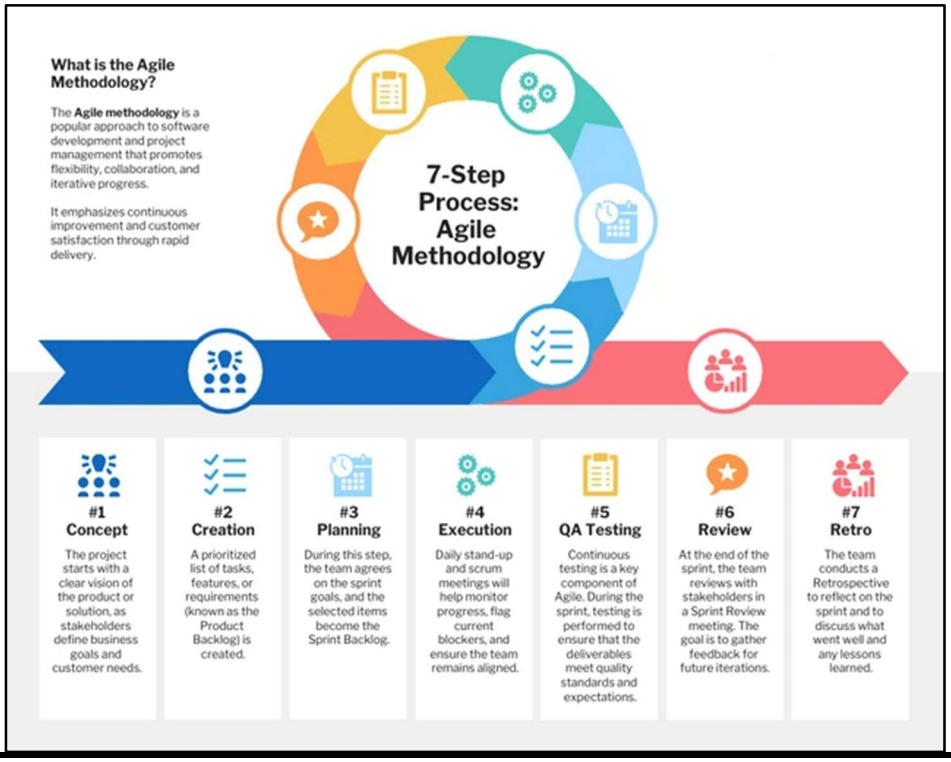

Image Source:

(venngage-agile, 2018)

FUTUREFORWARD TECHNOLOGIES (PTY) LTD

4. High-Level Plan Continued…

4.2 Evaluating Other Development Approaches

4.2.1 Waterfall Methodology (Not Suitable)

In simple terms, the waterfall methodology follows a linear, step by step development process in which each phase, all the way from requirements gathering to maintenance, must be fully completed before moving on to the next. This is also a good approach to follow, but for complex projects that has several functional requirements it is not suitable as this approach works best when all requirements are clearly defined from the start and is unlikely to change during the projects lifecycle. The waterfall approach does offer great structure and predictability but due to its rigid nature, it makes it less effective for an innovative, user-driven platforms such as the Agri-Energy Connect, where evolving needs and continuous feedback are key to building a successful solution. (Lewis, 2019)

When considering it in terms of Agri-Energy Connect, using the waterfall approach would significantly delay the opportunity for farmers, green tech providers and other stakeholders to engage with the system until the later stages of development. This simple means that user feedback will not be given in an early release as there will be no early release, which impacts the continuation of the project as developers will not know if users are satisfied and whether they need to make necessary improvements to better the product .As a result this, there is an increased risk of building features that do not fully align with the what is needed or expected. the waterfall approach limits our ability to respond to evolving factors which is inevitable and which includes policy changes, shifting climate conditions and the introduction of new technologies, all of which are crucial in a dynamic, sustainability-focused project such as this. (thecrmteam, 2022) (Radigan, 2023)

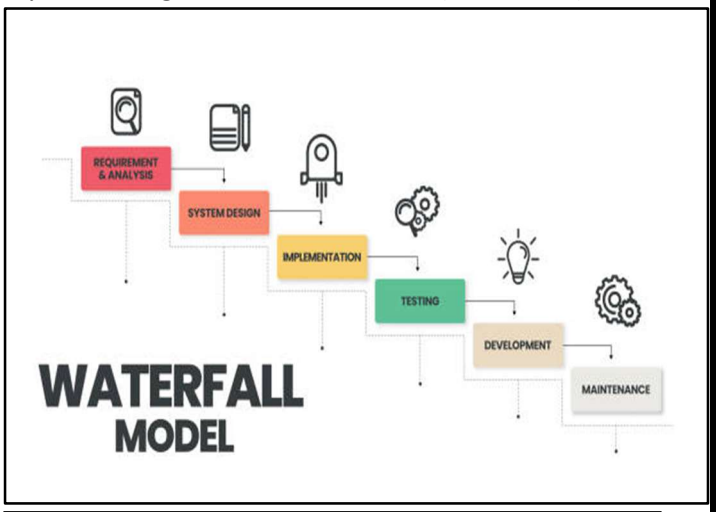

Figure 3: Waterfall Development Lifecycle Overview. **Image Source:** (Labs, 2023)

Therefore, Waterfall does not offer the flexibility or user collaboration necessary for a project of this nature. It is not suitable simply due to these reasons:

- It assumes requirements are fixed which are not ideal for evolving user needs in farming/green energy. (thecrmteam, 2022) (Radigan, 2023)
- It limits user involvement until late stages.

4. High-Level Plan Continued…

4.2.2 **Hybrid Approach**(Not Suitable)

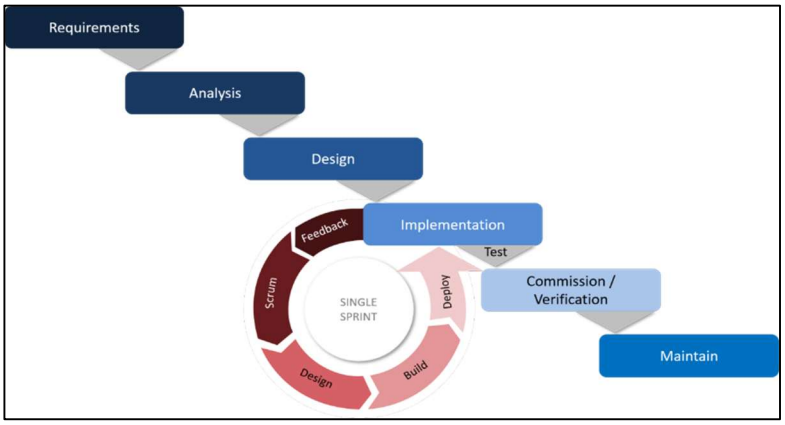

Figure 4: Hybrid Project Management

In the above figure (fig 4) , we can see that the hybrid methodology is simply just blends elements from both Agile and Waterfall with the goal to take advantage of each models strengths. When using the hybrid approach, we will usually make use of the waterfall methodology during early planning and infrastructure which allows for flexibility and iterative progress. This approach is especially useful in large enterprise environments where different teams, such as software, hardware and operations, work on distinct timelines and require customized workflows in order to stay aligned. (teamgantt, 2022)

When considering the Agri-Energy Connect platform, it does not involve parallel hardware development or large-scale enterprise IT operations. As a fully web-based platform, its components are best developed through continuous feedback, rapid iteration and frequent user testing. If we are to use the hybrid methodology, we will create unnecessary complexity and overhead without delivering the meaningful benefits that this platform aims to achieve. Agile is the only approach that provides the flexibility, responsiveness and as well a user cantered adaptability which is required in order to build a platform that truly meets the needs of its diverse users. (projectmanager, 2024)

4.3 Project Phases & Deliverables and System Architecture Diagram

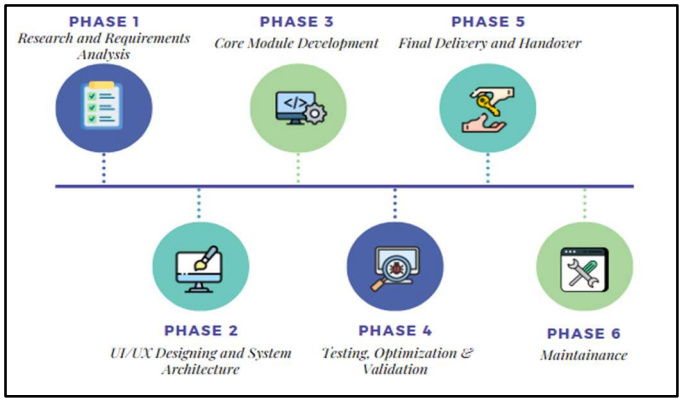

Figure 5: Diagram illustrating the phases and deliverables of the project using the agile approach with SDLC.

Image Source: FutureForward Technologies

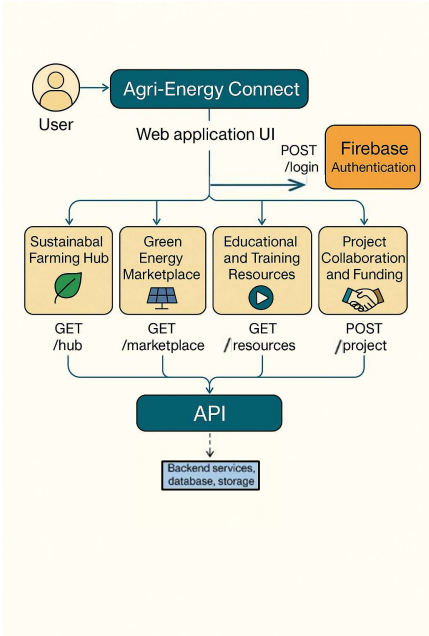

Figure 6: System Architecture Diagram

Image Source: (ChatGpt, 2025)

4.4 Dependencies and Risks

- Access to farming and green energy experts for validation. (BlackRock, 2019)
- Reliable internet connection for rural user testing.
- Delays in third-party API integration (e.g. grant funding info).

Overall, this structured, Agile-driven high-level plan ensures that the platform will be adaptive, user-centric and fully aligned with the evolving needs of South Africa's agricultural and renewable energy sectors.

5. Non-Functional Requirements

5.1 Critical Non-Functional Requirements and Their Role in Project Success

In simple terms, Non-functional requirements (NFRs) refers to the quality attributes of a system that shapes how well it performs, scales and supports its users in real world scenarios. In the context of the Agri-Energy Connect platform, these requirements are imperative due to its purpose which is to serve a diverse user base across both rural and urban areas which includes individuals with limited internet access and digital literacy. By carefully mapping out the NFRs, we can ensure a reliable, accessible, and responsive experience. The following NFRs are therefore derived to be classified as critical to the platforms overall success: (Bell, 2024) (Krüger, 2020)

- ***Scalability:*** (Edward, 2020)

Scalability ensures that the platform can handle increased demand as more farmers, green energy providers and government agencies come on board. In the context of the Agri-Energy Connect platform, it must be able to support a growing user base, manage seasonal traffic spikes which include grant application periods. It needs to be able to scale efficiently as the volume of data increases. This includes expanding datasets that include user profiles, forum discussions, product listings and educational content, without compromising performance or user experience.

- ***Security:*** (scaledagile, 2021)

Security is of paramount importance and is given the sensitive nature of the data shared and stored on the platform which includes personal user information, financial transactions, grant application documents and even proprietary farming techniques. If there are no robust security measures in place, user trust would be at risk, potentially jeopardizing adoption and long-term platform credibility. Agri-Energy Connect is compelled to implement strong encryption, secure authentication, role based access controls and continuous monitoring to protect both users and data integrity.

- ***Usability:*** (Bell, 2024) (scaledagile, 2021)

Usability refers is a NFR as it is one of the key priorities simply due to the fact the platform needs to be designed for a broad audience which includes farmers and stakeholders who may have limited technical skills or access to low-end devices. The interface must be intuitive, easy to navigate and accessible in multiple languages. It should also perform reliably across both mobile and desktop platforms in order to ensure that all users regardless of device or digital experience are able to engage with the platform confidently and effectively in order to create efficiency in their practices.

- ***Performance:*** (Edward, 2020) (scaledagile, 2021)

Performance plays a critical role in user satisfaction and the overall adoption of the Agri-Energy Connect platform. A slow or unresponsive platform can quickly discourage engagement, particularly in regions with limited or unstable internet connectivity. Key user actions which include browsing the marketplace, streaming training videos or participating in forum discussions, must be smooth and responsive. Agri-Energy Connect must aim for optimized load times, minimal latency and efficient resource usage to ensure a seamless experience across all supported devices and connection types.

5.Non-Functional Requirements Continued…

5.2 Implementation Strategy

- ***Scalability Implementation:*** (Bell, 2024)

In order to implement scalability into the Agri-Energy Connect platform, we will adopt a cloud-based microservices architecture and leverage services such as Azure App Services and Azure Kubernetes Service in order to independently deploy, manage and scale individual components of the platform. This modular design enables key features such as the forum, training hub and marketplace, to scale dynamically based on user demand, ensuring performance and resource efficiency. When it comes to data storage, Azure Cosmos DB will be used to support horizontal scalability and enable fast and reliable access to growing datasets across distributed user bases while load balancers, auto-scaling, and Content Delivery Networks (CDNs) will ensure seamless performance even in rural areas. This approach guarantees the platform remains responsive, efficient, and future-ready. (Chiaramonte, 2024)

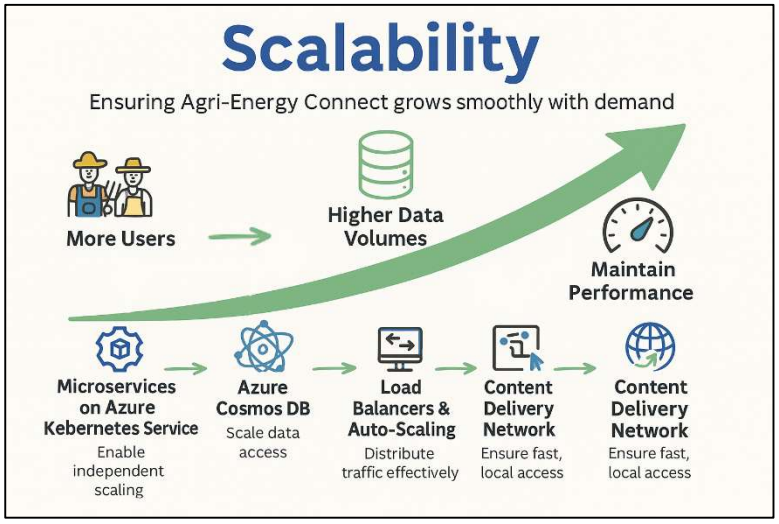

Figure 7: Scalability Strategy for Agri-Energy Connect
This figure shows how the platform scales with demand, using cloud tools like microservices, Cosmos DB and CDNs to ensure fast, reliable performance as users and data grow.

Image Source: (ChatGpt, 2025)

- ***Security Implementation:*** (Edward, 2020)

Security will be a core part of the platforms architecture. In order to implement reliable security procedures into this platform, we will use Firebase for secure user authentication, HTTPS to encrypt all communications, and role-based access controls (RBAC) in order to help manage permissions across user types, which includes farmers, suppliers and administrators. When this platform is in use, all sensitive data that is being used, stored or transmitted will be encrypted using advanced algorithms in order to ensure privacy and compliance adherence. In order to further strengthen protection, we will conduct regular vulnerability scans, enforce API rate limiting and apply other proactive measures to defend against common cyber threats, which include brute-force attacks, injection attempts and unauthorized access. (Ghosh, 2018)

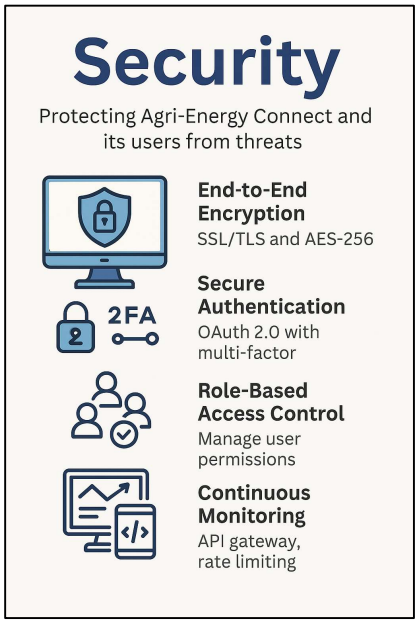

Figure 8: Agri-Energy Connect – Security Overview.

Image Source: (CoPilot, 2025)

..Non-Functional Requirements Continued…

5.2 Implementation Strategy continued…

- ***Usability Implementation:*** (Bell, 2024)

The platform will be designed as a web application and will have a responsive layout as a result of Material UI and Bootstrap which will ensure a clean, intuitive interface across desktop and mobile browsers. In order to accommodate users with limited digital skills, the web app will include interactive onboarding tutorials, audio-assisted navigation and contextual tooltips that will be leveraged to simplify actions. It will support multiple South African languages, feature clear iconography and adopt large clickable areas for accessibility. Key pages like the marketplace and forums will follow a consistent layout structure, reducing confusion and improving ease of use for first-time users. (Loarte, 2017)

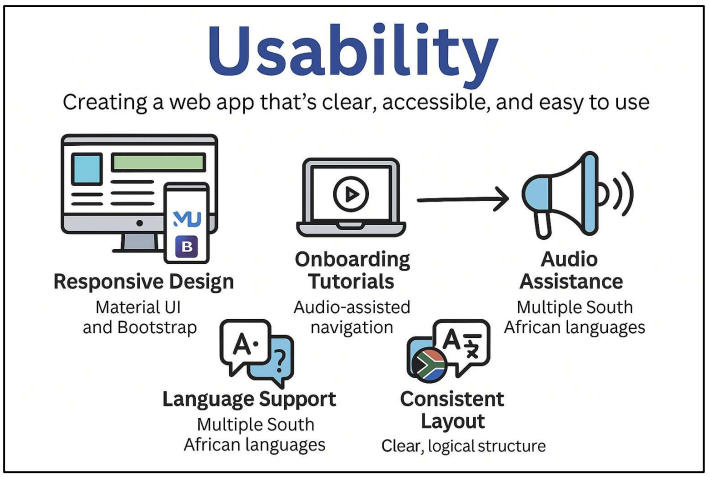

Figure 9: Usability Strategy for Agri-Energy Connect
This visual aid summarizes how the platform ensures ease of use through responsive design, language support, guided navigation, and intuitive layouts, making it accessible to users of all digital skill levels.
Image Source: (CoPilot, 2025)

- ***Performance Implementation:*** (Bell, 2024) (Edward, 2020)

In order to ensure high performance, the platform will incorporate several optimization strategies. Caching mechanisms such as Redis will be used to speed up data access, while compressed static assets and lazy loading of media-rich content will reduce initial load times. A Content Delivery Network (CDN) will distribute static files efficiently which is especially important for users in bandwidth-constrained rural areas. Additional backend optimizations will include SQL indexing, asynchronous API calls, and geo-routing to direct users to the nearest server, minimizing latency. Continuous monitoring of resource usage, combined with CPU and memory optimization techniques, will help maintain stable performance even during peak traffic periods. (Ostatnia, 2018)

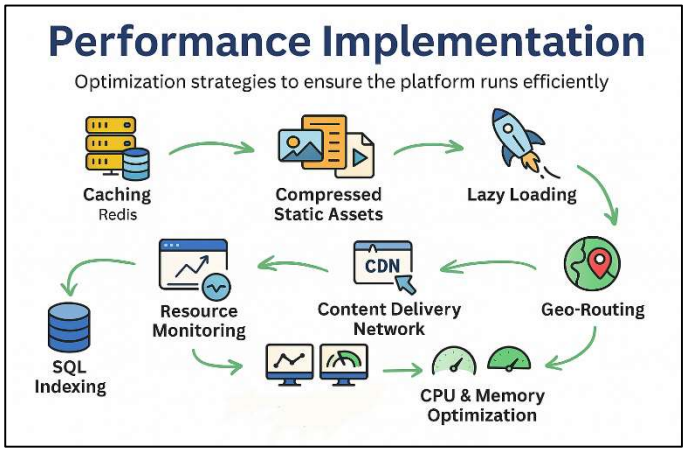

Figure10: Performance Implementation Strategy
This infographic illustrates how Agri-Energy Connect maintains high performance through caching, compression, CDNs, geo-routing, and backend optimizations, ensuring fast, reliable access even in rural or high-traffic conditions.
Image Source: (CoPilot, 2025)

FUTUREFORWARD TECHNOLOGIES (PTY) LTD

5.Non-Functional Requirements Continued…

5.3 Impact on Planning and Execution

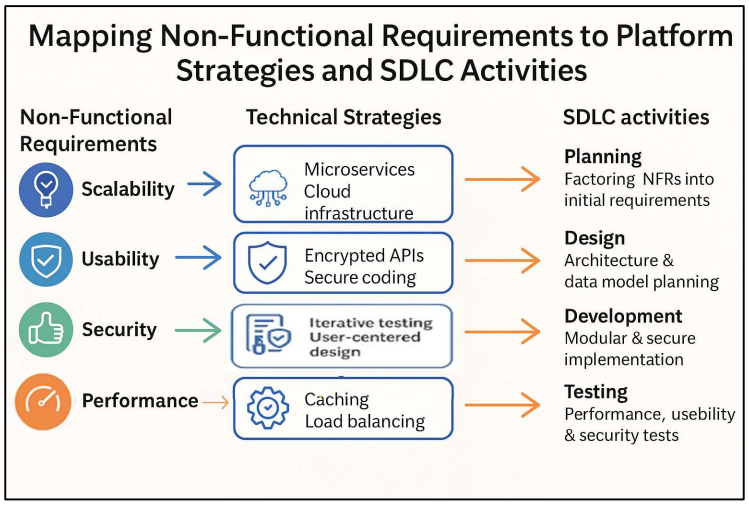

Figure 11: Mapping Non-Functional Requirements to Platform Strategies and SDLC Activities
This figure illustrates how each core non-functional requirement including scalability, security, usability and performance, is embedded across the platform's technical strategies and aligned with every stage of the Agile SDLC, ensuring quality is consistently prioritized throughout development.

Image Source: (ChatGpt, 2025)

When analysing the above figure (fig.10), it is made clear that each non-functional requirement directly influences key technical and design strategies throughout the platform. This structured integration ensures that scalability, security, usability and performance are not overlooked since they are not required to make the platform function, rather they are considered in the projects development lifecycle from the start. By embedding these quality attributes into every phase which is from planning to deployment, the platform is positioned for long-term reliability, efficiency and user trust. These NFRs help significantly helps us shape how we plan, prioritize and execute the Agri-Energy Connect platform. When examining it in detail it is made more clear of its impact: (ibm, 2016)

- *Planning Phase:* In this phase we allocate specific time and resources in order to identify performance benchmarks, usability testing strategies and cloud scaling requirements. NFRs are factored into the technical backlog from the outset. (Harness Team, 2023)
- *Design Phase:* System architecture decisions are influenced by scalability and security. If we take for example, the choice of microservices and encrypted APIs is a direct response to these NFRs. (Harness Team, 2023)
- *Development Phase:* Development is structured around modularity in order to allow parallel work on independent services which includes user registration and training modules. Code is written following secure development practices in order to be safe and efficient.
- *Testing Phase:* Automated performance, usability and penetration tests are scheduled into each sprint cycle. Rural connectivity conditions are simulated in order to ensure the system performs in realistic use cases. (Harness Team, 2023)
- *User Engagement:* Because usability is a top priority when developign this platform, we conduct iterative user testing throughout the project, using feedback from real farmers to guide interface refinements and instructional content. (Harness Team, 2023)

Overall, all of these non-functional requirements forms the foundation upon which the platforms, reliability and long-term adoption is built on. Since we embed them into every phase of the SDLC through Agile iterations, we can ensure that the final product is not only functional but also scalable, secure, accessible and future proof.

5.4 Impact on Development Strategy

- ***Planning:*** Wireframes and flows account for usability first.
- ***Execution:*** DevOps pipeline includes performance benchmarking in every sprint.
- ***Team Roles:*** Dedicated NFR engineer monitors metrics for performance, uptime, and security incidents.
- ***Feedback Loops:*** Usability testing is integrated into each sprint review.

6. Role of Design and Architecture Patterns

6.1 Impact on Development Strategy

In simple terms design patterns reusable, proven solutions to common problems that arise during software development. They provide guidance on how to create, organize and manage communication between objects in a way that promotes clean, maintainable and scalable code.
On the other hand, architecture patterns operate at a higher level than design patterns as they define the overall structure of the system and how its components interact. They guide decisions around scalability, maintainability, deployment and integration across the platform.
When these two combine, they provide and promote clarity, flexibility, scalability and as well as long-term maintainability, while helping to reduce code duplication and technical obligations and burdens. They both serve as a foundational layer for large, modular platforms such as the Agri-Energy Connect, which are expected to grow, evolve and adapt over time to meet changing user needs and technological advancements. (refactoringGuru, 2024) (Gupta, 2020) (Kohzadi, 2018)

6.2 Relevance and Importance of these patterns in the Agri-Energy Connect platform

Design and architecture patterns are regarded as advanced and important tools in modern software development. They are not new technologies but rather they are considered as reusable, best-practice solutions that are used for common design challenges. In simple terms, we can think of them as tried-and-tested templates that help developers build systems that are secure, maintainable and adaptable. In the case of this platform, which has to serve a diverse user base, integrate with multiple services and remain reliable over time, these patterns are imperative and builds a foundation for this platforms mong term success. (ryax, 2019) (Montalván, 2023)

In this project, we must ensure that the platform grows with user demand, adapts to new features, and remains stable under various usage scenarios. Architecture and design patterns help us achieve this by offering structure and consistency in the way we build the system. They reduce complexity, improve clarity and most importantly shape the platform to become future ready. (Montalván, 2023)

Agri-Energy Connect is a national-scale digital platform with multiple feature modules which ranges from farmer training and a green energy marketplace to funding support and collaborative hubs. It is imperative that it must remain responsive, scalable and extensible to:

- Serve rural and urban farmers
- Support energy suppliers, funders and policy officials
- Enable future integrations like analytics dashboards or new modules

6. Role of Design and Architecture Patterns continued…

When we leverage the use of design and architecture patterns it provides us with a blueprint for achieving a responsive, scalable and extensible platform. Their role in Agri-Energy Connect includes:

- ***Ensuring modularity:*** This mean that features can be built and scaled independently.
- ***Maintaining clarity:*** It ensures that multiple developers can work without confusion.
- ***Supporting agility:*** It makes it easier to change or enhance specific features.
- ***Enforcing best practices:*** It ensures secure, testable and clean code.

6.3 Suggestions: Recommended Design & Architecture Patterns

- **MVC (Model–View–Controller)**

  - *Type:* Architecture Pattern
  - *What it does:* Separates data (model), interface (view) and logic (controller) components.
  - *Benefit:* Keeps the system organized, especially for role-based dashboards like Farmer and Admin. (Sheldon, 2019)

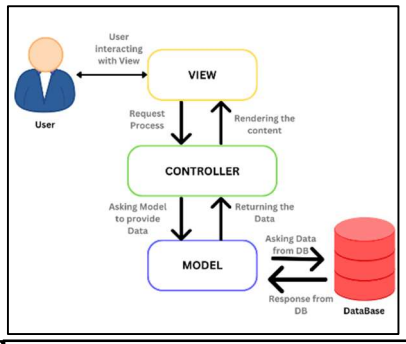

Image Source: (Benn, 2025)

Figure 12: MVC (Model–View–Controller)

- **Repository Pattern**
  - *Type:* Design Pattern
  - *What it does:* Provides an abstraction layer between the application and data access logic.
  - *Benefits:* Makes database operations reusable, maintainable and testable. (Sally, 2024)

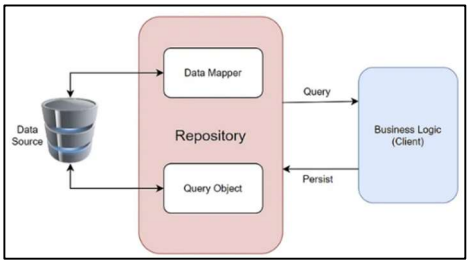

Image Source: (surajit, 2019)

Figure 13: Repository Pattern

- **Observer Pattern**
  - *Type:* Design Pattern
  - *What it does:* Enables components to subscribe to and receive real-time updates when something changes.
  - Benefits: Perfect for live grant alerts, forum updates or collaborative messages. (gururefactoring, 2019)

- **Factory / Abstract Factory Pattern**
  - *Type:* Design Pattern
  - *What it does:* Allows dynamic object creation without specifying exact classes.
  - *Benefits:* Enables flexible registration for different user types (which include Farmer and Supplier) and device-specific UI layouts. (Silva, 2017)

FUTUREFORWARD TECHNOLOGIES (PTY) LTD

6. Role of Design and Architecture Patterns continued…

6.3 Suggestions: Recommended Design & Architecture Patterns continued…

- **Singleton Pattern**
  - *Type:* Design Pattern
  - *What it does*: Restricts a class to a single instance across the entire app.
  - *Benefits:* Ideal for managing global settings like language preferences and session configurations. (Mahammad, 2020)

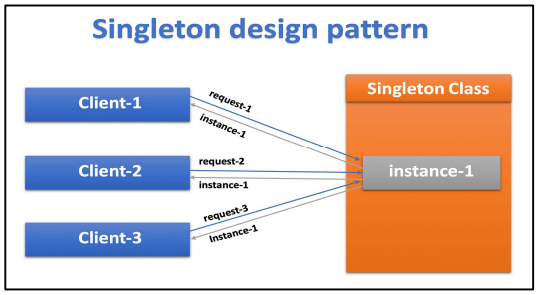

Image Source: (Kumar, 2024)

Figure 14: Singleton Design Pattern

- **Memento Pattern**
  - *Type:* Design Pattern
  - *What it does:* Captures and restores an object's previous state.
  - Benefits: Supports save-draft functionality in applications, marketplace posts or training quizzes. (sourcemaking, 2019)

- **Microservices Architecture**
  - *Type:* Architecture Pattern
  - *What it does:* Breaks the platform into small, independently deployable services.
  - *Benefits:* Increases scalability and reduces downtime which is essential for handling seasonal demand spikes (Ashtari, 2022)

- **API Gateway Pattern**
  - *Type:* Architecture Pattern
  - *What it does:* Acts as a single point of entry for all backend services, managing routing and access.
  - Benefits: Simplifies and secures access to services with role-based routing and rate-limiting. (Ozkaya, 2021)

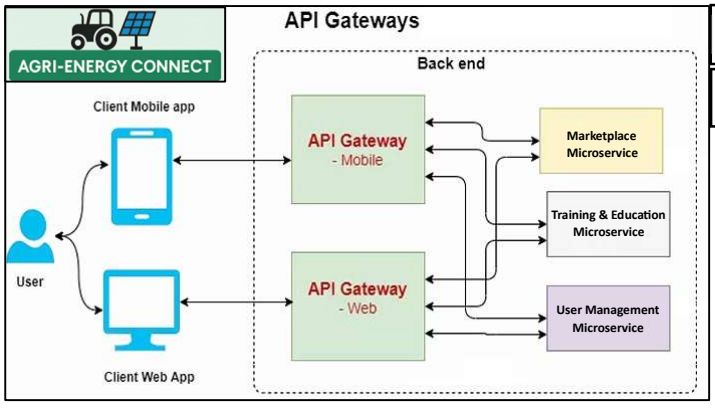

Figure 15: API Gateway Pattern

Image Source: (Ihuman, 2022)

6. Role of Design and Architecture Patterns continued…

6.4 Integration and Implementation Strategy for the architecture and design patterns.

Pattern	Use/integration in Agri-Energy Connect
MVC (Model–View–Controller)	Central to the web app. Clean separation between UI (farmer dashboard), logic (training, forum, marketplace), and data (CosmosDB). (servicestack, 2025)
Repository Pattern	For clean and testable data access layers (especially in training module and product marketplace). (Patel, 2024)
Observer Pattern	For real-time grant alerts, forum updates and live collaboration messages. (Patel, 2024)
Factory / Abstract Factory	For dynamic user registration (Farmer, Supplier, Funder), and UI themes (which includes mobile-optimized layout). (Patel, 2024)
Singleton Pattern	Global state management which includes language preference, login session and environment config. (Patel, 2024)
Memento Pattern	Allow users to save progress in grant applications, product listings, and training quizzes. (Patel, 2024)
Microservices Architecture	Used at the architectural level to modularize each core featureenhancing independent scalability and maintainability.
API Gateway Pattern	Manages secure access to backend services with role-based routing and rate limiting. (solo, 2025)

6.5 Justification and Value on the application of these patterns

Design and architecture patterns in Agri-Energy Connect promote modularity, adaptability and high performance. They allow services like the training hub, forums and marketplace to be built independently and iteratively, supporting faster development and long-term maintainability.
MVC separates UI from logic and data, streamlining updates and debugging. Singleton manages global settings efficiently. Observer and Memento improve engagement with live updates and draft-saving. Microservices and API Gateway ensure modular, secure and scalable platform delivery, simplifying future integrations.
By integrating these patterns, the platform becomes modular, maintainable, and easier to extend which is essential for supporting a growing and diverse user base across the country. These patterns reduce development risks by enforcing proven practices, simplifying future upgrades, enabling quick developer onboarding and ensuring the platform remains compatible with new technologies over time. (Khan, 2024) (binmile, 2017) (Burford, 2025)

Using design and architecture patterns:

- Reduces onboarding time for new developers.
- Makes the platform adaptable to evolving farming methods and tech integrations.
- Simplifies integration with government APIs for grants or subsidies.
- Facilitates analytics add-ons (which includes farm productivity dashboards).

7. Why choose FutureForward Technologies for this project?

At FutureForward Technologies (Pty) Ltd, we bring a strong combination of technical expertise, industry understanding and a deep commitment to sustainable development. Heres why we are the right team for this project:

- *Sector Understanding*: We are aware of the challenges that South Africa is facing and we have aligned every component of Agri-Energy Connect with the unique needs of rural farmers, green energy providers and national sustainability goals.
- *Smart Design:* We have planned and designed a platform that is built using modern, scalable architecture with the aim to ensure future growth without compromising performance.
- *User-Focused Approach:* Our team is well experienced and design with all users in mind, including those with limited digital experience. They ensure that the system is intuitive, accessible and multilingual.
- *Agile Delivery:* Our company had developed the habit of adopting the Agile methodology which allows for flexibility, regular improvements and close collaboration with all stakeholders throughout the project.
- *Strong Security:* At FutureForward Technologies, we apply the best practices in data protection and system security in order to ensure trust and reliability for every user.

We do not just develop software, rather we strive to deliver long-term value by building digital ecosystems that are practical, impactful and ready for the future.

8. Conclusion

Agri-Energy Connect is more than just a proposal, rather it is an innovative and practical response to South Africas emerging needs in agricultural and green energy sectors. This platform offers a bold and achievable digital solution that has the power to bridge the gap between energy and agriculture.

By simply embedding non-functional requirements in every phase of our dur development lifecycle and leveraging proven design and architecture patterns, we can ensure that the platform will be secure, scalable, accessible and easy to maintain. The use of Agile methodology enables continuous refinement as a result of real-time feedback, while strategic planning ensures alignment with national priorities.

We are confident that Agri-Energy Connect is the is the correct choice to help make South Africa more efficient and effective as it is designed to empower farmers, connect industries and uplift communities which turns sustainability goals into reality.

We thank the bid committee for the opportunity to present this proposal and look forward to bringing this vision to life.

FUTUREFORWARD TECHNOLOGIES (PTY) LTD

9. References

Agriconnect, 2018. *Renewable Energy: could it benefit your farm?.* [Online]
Available at: https://www.lltshow.com/show-news/renewable-energy-benefit-farm-
[Accessed 04 04 2025].

Ashtari, H., 2022. *What Are Microservices? Definition, Examples, Architecture, and Best Practices for 2022.* [Online]
Available at: https://www.spiceworks.com/tech/devops/articles/what-are-microservices/
[Accessed 07 04 2025].

Bell, V., 2024. *Nonfunctional Requirements in Software Engineering: Examples, Types, Best Practices.* [Online]
Available at: https://www.altexsoft.com/blog/non-functional-requirements/
[Accessed 06 04 2025].

Benn, 2025. *The MVC Architecture.* [Online]
Available at: https://medium.com/@sadikarahmantanisha/the-mvc-architecture-97d47e071eb2
[Accessed 07 04 2025].

Beresnyak, T., 2023. *Harnessing Renewable Energy: A Sustainable Future for Farming.* [Online]
Available at: https://extension.psu.edu/harnessing-renewable-energy-a-sustainable-future-for-farming
[Accessed 04 04 2025].

binmile, 2017. *Software Architecture: 10 Key Patterns for scalable and efficient applications.* [Online]
Available at: https://binmile.com/blog/software-architecture-pattern/
[Accessed 07 04 2025].

BlackRock, 2019. *ALADDIN® RISK.* [Online]
Available at: https://www.blackrock.com/aladdin/products/aladdin-risk?cid=ppc:aladdin_us:aladdin_emea_nb_risk_phrase:google:nonbrand_prod:ei&gad_source=1&gbraid=0AAAAAClKPJ_2F6ywJUW8r56X7rRxVAPBM&gclid=CjwKCAjwktO_BhBrEiwAV70jXtLxceGH1BLcRO9-2kf7XBxJDKuI-6div936NInHoG6
[Accessed 05 04 2025].

Burford, D., 2025. *Reasons for using design patterns.* [Online]
Available at: https://www.codeproject.com/Tips/808058/Reasons-for-using-design-patterns
[Accessed 07 04 2025].

ChatGpt, 2025. [Online]
Available at: https://openai.com/chatgpt/overview/

Chiaramonte, M., 2024. *Application scalability: key strategies and best practices.* [Online]
Available at: https://vfunction.com/blog/application-scalability/
[Accessed 06 04 2025].

CoPilot, 2025. [Online]
Available at: https://copilot.microsoft.com/

duRaan, L., 2024. *Sustainable Agriculture: A Cornerstone of South Africa's Future.* [Online]
Available at: https://www.moore-southafrica.com/news-views/november-2024/sustainable-agriculture-a-cornerstone-of-south-afr
[Accessed 04 04 2025].

Edward, G., 2020. *Non-Functional Requirements: Scalability.* [Online]
Available at: https://www.modernanalyst.com/Resources/Articles/tabid/115/ID/4968/Non-Functional-Requirements-Scalability.aspx
[Accessed 06 4 2025].

Forestel, K., 2021. *How The Rise of Renewable Energy is Changing Construction.* [Online]
Available at: https://dozr.com/blog/rise-of-renewable-energy-changing-construction
[Accessed 04 04 2025].

Ghosh, S., 2018. *Ìntegrating Security Controls into Project Management Practice.* [Online]
Available at: https://projectmanagement.ie/blog/integrating-security-controls-into-project-management-practices/
[Accessed 06 04 2025].

Gupta, R., 2020. *Software Architecture Patterns: What Are the Types and Which Is the Best One for Your Project.* [Online]
Available at: https://www.turing.com/blog/software-architecture-patterns-types
[Accessed 07 04 2025].

Gurnov, A., 2025. *What Is Agile Methodology in Project Management?.* [Online]
Available at: https://www.wrike.com/project-management-guide/faq/what-is-agile-methodology-in-project-management/
[Accessed 05 04 2025].

gururefactoring, 2019. *Observer Patter6E.* [Online]
Available at: https://refactoring.guru/design-patterns/observer
[Accessed 07 04 2025].

Hackemann, J., 2019. *Renewable energy, the key to sustainable agriculture in SA.* [Online]
Available at: https://www.bizcommunity.com/Article/196/358/192711.html#:~:text=Solar%20energy%2C%20as%20well%20as,that%20productivity%20is%20not%20affected.
[Accessed 04 04 2025].

Harness Team, 2023. *The Seven Phases of the Software Development Life Cycle.* [Online]
Available at: https://www.harness.io/blog/software-development-life-cycle-phases
[Accessed 06 04 2025].

ibm, 2016. *What is the software development life cycle (SDLC)?.* [Online]
Available at: https://www.ibm.com/think/topics/sdlc
[Accessed 06 04 2025].

Ihuman, A., 2022. *The Role Of API Gateways In A Microservice Architecture.* [Online]
Available at: https://dev.to/anita_ihuman/the-role-of-api-gateways-in-a-microservice-architecture-

m21
[Accessed 07 04 2025].

Khan, A., 2024. *Design Patterns and Their Benefits.* [Online]
Available at: https://dev.to/sardarmudassaralikhan/design-patterns-and-their-benefits-2ngk
[Accessed 07 04 2025].

Kohzadi, H., 2018. *Mastering Design Patterns in .NET: Combining Patterns for Scalable and Maintainable Code.* [Online]
Available at: https://medium.com/turbo-net/mastering-design-patterns-in-net-combining-patterns-for-scalable-and-maintainable-code-079a8394eae0#:~:text=Why%20Combine%20Design%20Patterns?,managing%20resources%20and%20workflows%20efficiently.
[Accessed 07 04 2025].

Koorts, A., `2017. *Hybrid Project Management.* [Online]
Available at: https://www.linkedin.com/pulse/hybrid-project-management-andre-koorts/
[Accessed 05 04 2025].

Krüger, G., 2020. *Non-functional Requirements: What They Do, Examples, and Best Practices.* [Online]
Available at: https://www.perforce.com/blog/alm/what-are-non-functional-requirements-examples.
[Accessed 06 04 2025].

Kumar, R., 2024. *Singleton Pattern in C# - Best Practices and Real-World Examples.* [Online]
Available at: https://www.linkedin.com/posts/rohatash-kumar-immediate-joiner-641ab517_singleton-design-pattern-activity-7238248402642161666-E7hM/
[Accessed 07 04 2025].

Labs, G., 2023. *Software development lifecycle: From ideation to deployment.* [Online]
Available at: https://www.grorapidlabs.com/blog/software-development-lifecycle-from-ideation-to-deployment
[Accessed 05 04 2025].

Lewis, S., 2019. *What is a Waterfall model? Definition and guide.* [Online]
Available at: https://www.techtarget.com/searchsoftwarequality/definition/waterfall-model
[Accessed 05 04 2025].

Loarte, P., 2017. *Usability in the Development of a Project Management Software Reinforced with Machine Learning.* [Online]
Available at:
https://www.researchgate.net/publication/334371101_Usability_in_the_Development_of_a_Project_Management_Software_Reinforced_with_Machine_Learning
[Accessed 06 04 2025].

Lowal, S., 2023. *Benefits of renewable energy in agriculture.* [Online]
Available at: https://farmingfarmersfarms.com/2023/09/benefits-of-renewable-energy-in-agriculture/
[Accessed 04 04 2025].

Mahammad, V., 2020. *What is Singleton pattern and what is the advantage of it..* [Online]
Available at: https://medium.com/star-gazers/what-is-singleton-pattern-and-what-is-the-advantage-

of-it-43f09509aa7f
[Accessed 07 07 04].

Mansuri, U., 2025. *What are the Core Activities of a Software Development Process?.* [Online]
Available at: https://www.kovair.com/blog/what-are-the-core-activities-of-a-software-development-process/
[Accessed 04 04 2025].

Martins, J., 2025. *How to write a vision statement: Steps and examples.* [Online]
Available at: https://asana.com/resources/vision-statement
[Accessed 04 04 2025].

Miller, N., 2018. *The 9 Key Benefits of Using the Agile Methodology.* [Online]
Available at: https://kissflow.com/project/agile/benefits-of-agile/
[Accessed 05 04 2025].

Montalván, J. Y., 2023. *The Importance of Good Architecture and Design Patterns for High-Performance Software.* [Online]
Available at: https://www.linkedin.com/pulse/importance-good-architecture-design-patterns-software-jos%C3%A9-yadiel/
[Accessed 07 04 2025].

Moore, M., 2021. *SA's Agriculture Sector – a Key Driver of Economic Growth.* [Online]
Available at: https://www.futuregrowth.co.za/insights/sa-s-agriculture-sector-a-key-driver-of-economic-growth
[Accessed 04 04 2025].

Nxumalo, C., 2022. *Renewable Energy in South Africa.* [Online]
Available at: chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.gtac.gov.za/wp-content/uploads/2022/08/Keynote_an-overview-of-the-renewable-energy-landscape-in-South-Africa_Chanda-Nxumalo.pdf
[Accessed 04+ 04 2025].

Ostatnia, O., 2018. *Performance planning and implementation.* [Online]
Available at: https://www.ibm.com/docs/pl/aix/7.1?topic=management-performance-planning-implementation
[Accessed 06 04 2025].

Ozkaya, M., 2021. *API Gateway Pattern.* [Online]
Available at: https://medium.com/design-microservices-architecture-with-patterns/api-gateway-pattern-8ed0ddfce9df`
[Accessed 07 04 2025].

Patel, K., 2024. *Integration Design Patterns.* [Online]
Available at: https://medium.com/@erkgpatel/integration-design-patterns-dd8ab80ab425
[Accessed 07 04 2025].

plutora, 2022. *Adopting Agile Methodology: 6 Steps to Improved Delivery.* [Online]
Available at: https://www.plutora.com/blog/adopting-agile-methodology-steps
[Accessed 05 04 2025].

projectmanager, 2024. *Agile vs Waterfall.* [Online]
Available at: https://www.projectmanager.com/guides/agile-vs-waterfall-hybrid-projects
[Accessed 06 04 2025].

Radigan, D., 2023. *Agile vs. waterfall project management.* [Online]
Available at: https://www.atlassian.com/agile/project-management/project-management-intro
[Accessed 05 04 2025].

refactoringGuru, 2024. *What's a design pattern?.* [Online]
Available at: https://refactoring.guru/design-patterns/what-is-pattern
[Accessed 07 04 2025].

ryax, 2019. *Design pattern: what is it and why use it?.* [Online]
Available at: https://ryax.tech/design-pattern-what-is-it-and-why-use-it/
[Accessed 7 04 2025].

saipa, 2025. *Agriculture in South Africa.* [Online]
Available at: https://www.saipa.co.za/newsletters-resources/agriculture-in-south-africa/
[Accessed 04 04 2025].

Sally, 2024. *Repository Pattern.* [Online]
Available at: https://www.cosmicpython.com/book/chapter_02_repository.html
[Accessed 07 04 2025].

scaledagile, 2021. *Nonfunctional Requirements.* [Online]
Available at: https://framework.scaledagile.com/nonfunctional-requirements
[Accessed 06 04 2025].

Seed, P., 2025. *How to capture the goals and objectives for a software project.* [Online]
Available at: https://www.softwaredevelopment.co.uk/blog/defining-the-goals-and-objectives-for-a-software-project/
[Accessed 04 04 2025].

servicestack, 2025. *ASP.NET MVC Integration.* [Online]
Available at: https://docs.servicestack.net/mvc-integration
[Accessed 07 04 2025].

Sheldon, R., 2019. *model-view-controller (MVC).* [Online]
Available at: https://www.techtarget.com/whatis/definition/model-view-controller-MVC
[Accessed 07 04 2025].

Silva, K. D., 2017. *Abstract Factory Design Pattern: The Ultimate Guide for Beginners.* [Online]
Available at: https://medium.com/@kalanamalshan98/abstract-factory-design-pattern-the-ultimate-guide-for-beginners-4b0f97694b00
[Accessed 07 04 2025].

solo, 2025. *API gateway pattern.* [Online]
Available at: https://www.solo.io/topics/api-gateway/api-gateway-pattern
[Accessed 07 04 2025].

sourcemaking, 2019. *Memento Design Pattern.* [Online]
Available at: https://sourcemaking.com/design_patterns/memento
[Accessed 07 04 2025].

surajit, 2019. *Respository Pattern.* [Online]
Available at: https://medium.com/@surajit.das0320
[Accessed 07 04 2025].

teamgantt, 2022. *Methodology in Project Management.* [Online]
Available at: https://www.teamgantt.com/waterfall-agile-guide/hybrid-approach
[Accessed 06 04 2025].

thecrmteam, 2022. *5 reasons why Agile is better than Waterfall.* [Online]
Available at: https://thecrmteam.com/5-reasons-why-agile-is-better-than-waterfall/
[Accessed 05 04 2025].

Torode, C., 2025. *Agile project management (APM).* [Online]
Available at: https://www.techtarget.com/searchcio/definition/Agile-project-management
[Accessed 05 04 2025].

venngage-agile, 2018. *Agile Methodology Process Infographic Template.* [Online]
Available at: https://venngage.com/templates/infographics/agile-methodology-process-infographic-template-c1b4768e-55b0-43d7-bfac-a4d9b8e4d7d7
[Accessed 06 04 2025].

Zhezherau, A., 2018. *The Benefits and Advantages of Agile.* [Online]
Available at: https://www.wrike.com/agile-guide/benefits-of-agile/#alex-zhezherau
[Accessed 05 04 2025].

FUTUREFORWARD
TECHNOLOGIES (PTY) LTD

Contact Us

www.fftechnologies.com

+27-67-123-4568

info@fftech.com

References

Agriconnect, 2018. *Renewable Energy: could it benefit your farm?.* [Online]
Available at: https://www.lltshow.com/show-news/renewable-energy-benefit-farm-
[Accessed 04 04 2025].

Ashtari, H., 2022. *What Are Microservices? Definition, Examples, Architecture, and Best Practices for 2022.* [Online]
Available at: https://www.spiceworks.com/tech/devops/articles/what-are-microservices/
[Accessed 07 04 2025].

Bell, V., 2024. *Nonfunctional Requirements in Software Engineering: Examples, Types, Best Practices.* [Online]
Available at: https://www.altexsoft.com/blog/non-functional-requirements/
[Accessed 06 04 2025].

Benn, 2025. *The MVC Architecture.* [Online]
Available at: https://medium.com/@sadikarahmantanisha/the-mvc-architecture-97d47e071eb2
[Accessed 07 04 2025].

Beresnyak, T., 2023. *Harnessing Renewable Energy: A Sustainable Future for Farming.* [Online]
Available at: https://extension.psu.edu/harnessing-renewable-energy-a-sustainable-future-for-farming
[Accessed 04 04 2025].

binmile, 2017. *Software Architecture: 10 Key Patterns for scalable and efficient applications.* [Online]
Available at: https://binmile.com/blog/software-architecture-pattern/
[Accessed 07 04 2025].

BlackRock, 2019. *ALADDIN® RISK.* [Online]
Available at: https://www.blackrock.com/aladdin/products/aladdin-risk?cid=ppc:aladdin_us:aladdin_emea_nb_risk_phrase:google:nonbrand_prod:ei&gad_source=1&gbraid=0AAAAAClKPJ_2F6ywJUW8r56X7rRxVAPBM&gclid=CjwKCAjwktO_BhBrEiwAV70jXtLxceGH1BLcRO9-2kf7XBxJDKuI-6div936NInHoG6
[Accessed 05 04 2025].

Burford, D., 2025. *Reasons for using design patterns.* [Online]
Available at: https://www.codeproject.com/Tips/808058/Reasons-for-using-design-patterns
[Accessed 07 04 2025].

ChatGpt, 2025. [Online]
Available at: https://openai.com/chatgpt/overview/

Chiaramonte, M., 2024. *Application scalability: key strategies and best practices.* [Online]
Available at: https://vfunction.com/blog/application-scalability/
[Accessed 06 04 2025].

CoPilot, 2025. [Online]
Available at: https://copilot.microsoft.com/

duRaan, L., 2024. *Sustainable Agriculture: A Cornerstone of South Africa's Future.* [Online]
Available at: https://www.moore-southafrica.com/news-views/november-2024/sustainable-

agriculture-a-cornerstone-of-south-afr
[Accessed 04 04 2025].

Edward, G., 2020. *Non-Functional Requirements: Scalability.* [Online]
Available at: https://www.modernanalyst.com/Resources/Articles/tabid/115/ID/4968/Non-Functional-Requirements-Scalability.aspx
[Accessed 06 4 2025].

Forestel, K., 2021. *How The Rise of Renewable Energy is Changing Construction.* [Online]
Available at: https://dozr.com/blog/rise-of-renewable-energy-changing-construction
[Accessed 04 04 2025].

Ghosh, S., 2018. *Ìntegrating Security Controls into Project Management Practice.* [Online]
Available at: https://projectmanagement.ie/blog/integrating-security-controls-into-project-management-practices/
[Accessed 06 04 2025].

Gupta, R., 2020. *Software Architecture Patterns: What Are the Types and Which Is the Best One for Your Project.* [Online]
Available at: https://www.turing.com/blog/software-architecture-patterns-types
[Accessed 07 04 2025].

Gurnov, A., 2025. *What Is Agile Methodology in Project Management?.* [Online]
Available at: https://www.wrike.com/project-management-guide/faq/what-is-agile-methodology-in-project-management/
[Accessed 05 04 2025].

gururefactoring, 2019. *Observer Patter6E.* [Online]
Available at: https://refactoring.guru/design-patterns/observer
[Accessed 07 04 2025].

Hackemann, J., 2019. *Renewable energy, the key to sustainable agriculture in SA.* [Online]
Available at: https://www.bizcommunity.com/Article/196/358/192711.html#:~:text=Solar%20energy%2C%20as%20well%20as,that%20productivity%20is%20not%20affected.
[Accessed 04 04 2025].

Harness Team, 2023. *The Seven Phases of the Software Development Life Cycle.* [Online]
Available at: https://www.harness.io/blog/software-development-life-cycle-phases
[Accessed 06 04 2025].

ibm, 2016. *What is the software development life cycle (SDLC)?.* [Online]
Available at: https://www.ibm.com/think/topics/sdlc
[Accessed 06 04 2025].

Ihuman, A., 2022. *The Role Of API Gateways In A Microservice Architecture.* [Online]
Available at: https://dev.to/anita_ihuman/the-role-of-api-gateways-in-a-microservice-architecture-m21
[Accessed 07 04 2025].

Khan, A., 2024. *Design Patterns and Their Benefits.* [Online]
Available at: https://dev.to/sardarmudassaralikhan/design-patterns-and-their-benefits-2ngk
[Accessed 07 04 2025].

Kohzadi, H., 2018. *Mastering Design Patterns in .NET: Combining Patterns for Scalable and Maintainable Code.* [Online]
Available at: https://medium.com/turbo-net/mastering-design-patterns-in-net-combining-patterns-for-scalable-and-maintainable-code-079a8394eae0#:~:text=Why%20Combine%20Design%20Patterns?,managing%20resources%20and%20workflows%20efficiently.
[Accessed 07 04 2025].

Koorts, A., `2017. *Hybrid Project Management.* [Online]
Available at: https://www.linkedin.com/pulse/hybrid-project-management-andre-koorts/
[Accessed 05 04 2025].

Krüger, G., 2020. *Non-functional Requirements: What They Do, Examples, and Best Practices.* [Online]
Available at: https://www.perforce.com/blog/alm/what-are-non-functional-requirements-examples.
[Accessed 06 04 2025].

Kumar, R., 2024. *Singleton Pattern in C# - Best Practices and Real-World Examples.* [Online]
Available at: https://www.linkedin.com/posts/rohatash-kumar-immediate-joiner-641ab517_singleton-design-pattern-activity-7238248402642161666-E7hM/
[Accessed 07 04 2025].

Labs, G., 2023. *Software development lifecycle: From ideation to deployment.* [Online]
Available at: https://www.grorapidlabs.com/blog/software-development-lifecycle-from-ideation-to-deployment
[Accessed 05 04 2025].

Lewis, S., 2019. *What is a Waterfall model? Definition and guide.* [Online]
Available at: https://www.techtarget.com/searchsoftwarequality/definition/waterfall-model
[Accessed 05 04 2025].

Loarte, P., 2017. *Usability in the Development of a Project Management Software Reinforced with Machine Learning.* [Online]
Available at:
https://www.researchgate.net/publication/334371101_Usability_in_the_Development_of_a_Project_Management_Software_Reinforced_with_Machine_Learning
[Accessed 06 04 2025].

Lowal, S., 2023. *Benefits of renewable energy in agriculture.* [Online]
Available at: https://farmingfarmersfarms.com/2023/09/benefits-of-renewable-energy-in-agriculture/
[Accessed 04 04 2025].

Mahammad, V., 2020. *What is Singleton pattern and what is the advantage of it..* [Online]
Available at: https://medium.com/star-gazers/what-is-singleton-pattern-and-what-is-the-advantage-of-it-43f09509aa7f
[Accessed 07 07 04].

Mansuri, U., 2025. *What are the Core Activities of a Software Development Process?.* [Online]
Available at: https://www.kovair.com/blog/what-are-the-core-activities-of-a-software-development-process/
[Accessed 04 04 2025].

Martins, J., 2025. *How to write a vision statement: Steps and examples.* [Online]
Available at: https://asana.com/resources/vision-statement
[Accessed 04 04 2025].

Miller, N., 2018. *The 9 Key Benefits of Using the Agile Methodology.* [Online]
Available at: https://kissflow.com/project/agile/benefits-of-agile/
[Accessed 05 04 2025].

Montalván, J. Y., 2023. *The Importance of Good Architecture and Design Patterns for High-Performance Software.* [Online]
Available at: https://www.linkedin.com/pulse/importance-good-architecture-design-patterns-software-jos%C3%A9-yadiel/
[Accessed 07 04 2025].

Moore, M., 2021. *SA's Agriculture Sector – a Key Driver of Economic Growth.* [Online]
Available at: https://www.futuregrowth.co.za/insights/sa-s-agriculture-sector-a-key-driver-of-economic-growth
[Accessed 04 04 2025].

Nxumalo, C., 2022. *Renewable Energy in South Africa.* [Online]
Available at: chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.gtac.gov.za/wp-content/uploads/2022/08/Keynote_an-overview-of-the-renewable-energy-landscape-in-South-Africa_Chanda-Nxumalo.pdf
[Accessed 04+ 04 2025].

Ostatnia, O., 2018. *Performance planning and implementation.* [Online]
Available at: https://www.ibm.com/docs/pl/aix/7.1?topic=management-performance-planning-implementation
[Accessed 06 04 2025].

Ozkaya, M., 2021. *API Gateway Pattern.* [Online]
Available at: https://medium.com/design-microservices-architecture-with-patterns/api-gateway-pattern-8ed0ddfce9df`
[Accessed 07 04 2025].

Patel, K., 2024. *Integration Design Patterns.* [Online]
Available at: https://medium.com/@erkgpatel/integration-design-patterns-dd8ab80ab425
[Accessed 07 04 2025].

plutora, 2022. *Adopting Agile Methodology: 6 Steps to Improved Delivery.* [Online]
Available at: https://www.plutora.com/blog/adopting-agile-methodology-steps
[Accessed 05 04 2025].

projectmanager, 2024. *Agile vs Waterfall.* [Online]
Available at: https://www.projectmanager.com/guides/agile-vs-waterfall-hybrid-projects
[Accessed 06 04 2025].

Radigan, D., 2023. *Agile vs. waterfall project management.* [Online]
Available at: https://www.atlassian.com/agile/project-management/project-management-intro
[Accessed 05 04 2025].

refactoringGuru, 2024. *What's a design pattern?.* [Online]
Available at: https://refactoring.guru/design-patterns/what-is-pattern
[Accessed 07 04 2025].

ryax, 2019. *Design pattern: what is it and why use it?.* [Online]
Available at: https://ryax.tech/design-pattern-what-is-it-and-why-use-it/
[Accessed 7 04 2025].

saipa, 2025. *Agriculture in South Africa.* [Online]
Available at: https://www.saipa.co.za/newsletters-resources/agriculture-in-south-africa/
[Accessed 04 04 2025].

Sally, 2024. *Repository Pattern.* [Online]
Available at: https://www.cosmicpython.com/book/chapter_02_repository.html
[Accessed 07 04 2025].

scaledagile, 2021. *Nonfunctional Requirements.* [Online]
Available at: https://framework.scaledagile.com/nonfunctional-requirements
[Accessed 06 04 2025].

Seed, P., 2025. *How to capture the goals and objectives for a software project.* [Online]
Available at: https://www.softwaredevelopment.co.uk/blog/defining-the-goals-and-objectives-for-a-software-project/
[Accessed 04 04 2025].

servicestack, 2025. *ASP.NET MVC Integration.* [Online]
Available at: https://docs.servicestack.net/mvc-integration
[Accessed 07 04 2025].

Sheldon, R., 2019. *model-view-controller (MVC).* [Online]
Available at: https://www.techtarget.com/whatis/definition/model-view-controller-MVC
[Accessed 07 04 2025].

Silva, K. D., 2017. *Abstract Factory Design Pattern: The Ultimate Guide for Beginners.* [Online]
Available at: https://medium.com/@kalanamalshan98/abstract-factory-design-pattern-the-ultimate-guide-for-beginners-4b0f97694b00
[Accessed 07 04 2025].

solo, 2025. *API gateway pattern.* [Online]
Available at: https://www.solo.io/topics/api-gateway/api-gateway-pattern
[Accessed 07 04 2025].

sourcemaking, 2019. *Memento Design Pattern.* [Online]
Available at: https://sourcemaking.com/design_patterns/memento
[Accessed 07 04 2025].

surajit, 2019. *Respository Pattern.* [Online]
Available at: https://medium.com/@surajit.das0320
[Accessed 07 04 2025].

teamgantt, 2022. *Methodology in Project Management.* [Online]
Available at: https://www.teamgantt.com/waterfall-agile-guide/hybrid-approach
[Accessed 06 04 2025].