Final Report (Group 6)

IDEA TO STARTUP

TPM414A

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1 Executive Summary

This report presents the outcome of our innovation journey in TPM414A – Idea to Startup. Our project explores how artificial intelligence and augmented reality can address labour shortages in precision agriculture, focusing on the grape-thinning process in vineyards. Through interviews with growers across six countries and analysis of existing solutions, we identified a clear market gap: thinning remains a highly manual, skill-dependent task that directly affects grape quality and profitability. Our proposed AI-powered AR system enables unskilled workers to perform thinning tasks with expert-level precision, reducing dependency on scarce skilled labour while maintaining high crop quality. The following sections summarize our customer insights, competitive analysis, value proposition, and Go/No-Go decision.

2 Iteration Journey

The project originated from an initial curiosity about how AI vision and robotics could be applied to physical work in agriculture. Our first research focused on high-value crops such as tomatoes and cucumbers, where we conducted exploratory interviews to understand key operational challenges. Most respondents highlighted disease detection as the dominant issue, which was an area already served by many existing AI and imaging solutions.
A turning point occurred when one of our team members (Mukil Saravanan) visited the greenhouse area near Delft and by chance met a couple who owned a small vineyard behind their house. They introduced us to the process of grape cultivation and explained the concept of thinning to be a highly manual, repetitive, yet expert dependent task that directly affects yield and quality. This discovery shifted our attention from general greenhouse crops to viticulture.
Initially, we envisioned a fully automated robotic system capable of performing grape thinning independently. However, further research and interviews revealed practical barriers: vineyards are typically grown in open, uneven terrains rather than controlled greenhouse environments, making full automation complex and costly. This insight led us to pivot toward an AI-aided tool designed to assist human workers instead of replacing them. We conducted interviews across six countries,Spain, Azerbaijan, India, the Netherlands, Russia, and Cyprus, all of which confirmed a severe shortage of skilled labour and demonstrated how inconsistent manual work directly impacts vineyard profitability. These findings reinforced the focus on an AI-guided AR solution that helps untrained workers perform with expert-level precision, addressing a clear global need for skill transfer in agriculture.

Figure 1: How we stumbled upon vineyards

3 From Problem to Plan: Customers, Competition & Commercialization.

3.1 Problem & Customer Definition

Owners of commercial grape growers in countries (including the Netherlands, Spain, Italy, etc) where skilled labour is (becoming) scarce and expensive. This includes:

- **Premium Wine Grape Growers:** These growers whose financial viability depends on producing wines that command a premium price, typically €13 per bottle or higher. Their focus is on achieving specific quality parameters in the grapes to produce complex, high-value wines.

- **Table Grape Growers:** These growers must meet strict market requirements for the size, shape, and appearance of their grape clusters to achieve target pricing.

Beachhead market: Owners of table grape growers and vineyards in the Netherlands. Because the problem is more pressing than in France, Spain, Italy, etc

Pain points of the customers

The situation facing Dutch viticulture is not just an operational challenge. It is a threat because of the three unavoidable factors:

1. **Structural collapse in the available labor force:** The Dutch horticulture and agriculture sectors are profoundly dependent on migrant workers, particularly from Eastern European nations like Poland, Romania, and Bulgaria [14]. This labor supply is now in decline due to rising wages and better employment opportunities in workers' home countries, creating a severe and structural labor shortage across the entire sector [21]. This crisis is not unique to the Netherlands. The global wine industry is acutely affected, with nearly half (45%) of all businesses reporting labor shortages. For wine producers specifically, this figure rises to 50% [8]. The problem is most severe for seasonal tasks (grape thinning falls here). It is confirmed from [19] that almost two-thirds (63%) of wineries and interviews (especially I2, I8, I9) indicate that they lack temporary workers. Growers are facing a future where they may be physically unable to perform this critical task. Thus, this forces them to seek automation not for efficiency, but for survival [12]

2. **Quality degradation:** Thinning is a critical practice for improving grape quality, which is dependent on sugar concentration in grapes as measured in degrees Bx (Brix) [22]. Failure to thin an overcropped grape leads to diluted, lower-quality grapes that fail to meet these standards, resulting in a significant price reduction [13].

3. **Increased crop loss due to disease:** Failure to thin results in congested grapes with poor airflow, which mostly leads to burst and rot the entire cluster. This affects a significant portion of the harvest. The economic impact of bunch rot is severe, leading to direct yield loss and potentially reducing the value of affected grapes by as much as 40% [15, 28]

Pain Relief: To eliminate skilled labor uncertainty. They require a reliable and consistent method to perform critical thinning operations without being dependent on a scarce, unpredictable, and often unskilled (not expert) workforce.

Gain Created: To achieve consistent quality and secure their harvest. This allows them to reliably produce grapes that meet the high standards for premium pricing and mitigate the significant financial risk of crop loss from disease.

Success Metric: The ultimate success metric is maximizing the economic value of the harvest per hectare. This is measured through a combination of:

- **Reduced Production Costs:** Specifically, lowering the high costs associated with manual labor.
- **Increased Revenue:** Achieved by consistently meeting the quality parameters (like °Brix) that command premium prices and by preventing yield loss from disease.

Other potential evaluation metrics for the technical efficiency of our solution: Time reduction, accuracy, cost and energy use, maintenance cost, ease of operation, and performance under various field conditions.

Customer and End-User Narratives

The thinning process affects multiple actors within the vineyard ecosystem, each experiencing the problem differently. To understand these perspectives, we distinguish between the customer (payer), who makes investment and management decisions and the end-user, who performs the task in the field. The following narratives describe how each group experiences the current situation and what outcomes they seek.

Customer (Payer) – The Vineyard Owner or Manager

The vineyard owner or manager faces a short, high-pressure window of 10–20 days during which thinning must be completed. Missing this period can lead to fungal diseases and up to 40% crop value loss, as grapes fail to meet quality standards. Skilled labour is increasingly scarce and expensive, with experts costing €25–30 per hour. Many vineyards are forced to reduce operations or sell land due to labour shortages. Their goal is to ensure timely, high-quality thinning with predictable results, without relying on a small pool of expert workers.

Figure 2: Competitive landscape mapping current grape thinning solutions and how our solution brings in value, against the key metrics such as Quality, Affordability, and labor Availability

End-User – The Seasonal or Unskilled Worker

Seasonal workers perform thinning manually, often without prior experience. The task demands precise visual judgment and causes fatigue, errors, and stress. Mistakes like cutting too many or too few berries directly reduce grape quality. Interview 17 revealed that about 10% of seasonal workers are newcomers each year, who perform poorly in their first season and require several years to improve. Our AR-assisted system bridges this gap by guiding workers visually, allowing even first-time users to perform with confidence and expert-level precision.

3.2 Existing Solutions

Skilled manual thinning: The grape growers primarily use skilled manual labor for thinning, which is the dominant and gold standard method for quality, but it is failing due to extreme skilled labor scarcity and high costs, as discussed in section 3.1. From the interviews, a detailed analysis (discussed in 2) is made of skilled and unskilled workers. The primary advantage is that a skilled human worker can make complex, context-aware decisions and perform delicate maneuvers to pluck out the right berries. A skilled manual labourer instantly judges multiple factors like:

- Selectively remove berries in complex environments (e.g., small, inward, undeveloped) without damaging adjacent, healthy grapes.
- Adapting to different varieties, trellis systems, and other environmental conditions
- Additionally, identifying early signs of disease, if any.

From the interviews, it is noted that these skills come with experience, and a lack of skills leads to sub-optimal thinning, leading to direct yield loss as mentioned in the above section.
The skilled workers in commercial table grape vineyards in the Netherlands get an average pay of approximately 18 euros per hour [6]. As a comparison, it is 3.6 euros higher than the Netherlands' minimum wage (14.40 euros dated July 1, 2025 [9]). An interview with a commercial Westland grape grower (I2) confirms this claim, while the interview (I9) suggests a higher salary as high as 30 euros per hour. It is also noted that I8 works on a volunteer basis with regular rewards. Interviews (I2, I8, I9) indicate an approximate labour hour just for thinning of 214 to 250 hours per hectare (depending on the expertise of labour). Although thinning is done for two to three weeks of viticulture, the direct cost just for manual thinning is 3852 to 4500 euros per hectare.

Chemical thinning: One common agent is Gibberellic Acid (GA3), which is sprayed (at 90% concentration of 10 to 20 ppm) just after flowering as the berry is about to form as depicted in Figure 7. From the interview [], it is understood that although, it can be easily applied for large farms with tractors, this technique is highly risky and sensitive to multiple factors including the dosage depending on grape variety, timing as it depends heavily on the climate and vine health, requiring almost hourly observation and incorrect factors lead to crop damage.

Additionally, this method is treated as a supplement before manual thinning; not as a complete solution, as chemical thinning cannot identify individual berries to remove overcrowding. Thus, this must still be followed by manual thinning by skilled workers. Typically using approximately 10 - 15 g of 90% GA_3 per hectare when diluted in 500 L of water [33]. This quantity of GA_3 costs approximately 130 to 190 euros per hectare in the current market in the Netherlands [17]. The total operational cost of the application includes the cost of tractors, sprayers, and other equipment.

Agricultural robots: These solutions completely or partially eliminate human involvement in thinning. From our market research, it is noted that only VineRobotiqs [34] claims there could be a potential chance for them to do thinning with a custom-designed end-effector tool. However, there is no evidence about their performance in grape harvesting and other tasks, even in controlled environment. A glimpse of the simulation video is available publicly. On the other hand, companies including Tortuga AgTech [2] as well as sophisticated tractor companies Naio Technologies [20] and Grégoire (EasyPilot) [11] offer line-guided tractors, which automate mobility but do not solve the delicate, meticulous task of thinning. As an emerging deep-tech company in the R&D stage, VineRobotiqs does not have public pricing. However, the capital cost for comparable agricultural robots is substantial, with prototypes often costing between €80,000 and €130,000. This positions their solution at the highest end of the price spectrum.

Genetically Modified grapes: The necessity of cluster thinning in genetically modified (GM) grapevines is not eliminated; instead, it becomes entirely dependent on the specific trait being engineered. For the majority of GM applications, which use tools like CRISPR to confer disease or stress resistance [16], the primary goal is to protect the vine's health (the "source") while deliberately preserving the cultivar's original identity and innate fruitfulness (the "sink") [29]. A disease-resistant 'Chardonnay' is still genetically a high-yielding 'Chardonnay' and, therefore, still requires manual cluster thinning to balance its crop load, manage disease risk like Botrytis, and concentrate sugars and phenolics for quality [23]. The only scenario that would reduce this requirement is a different modification strategy that directly targets cluster architecture, such as engineering "loose clusters" [24]. This modification acts as a "genetic thinning" by innately reducing cluster weight and Botrytis susceptibility, thereby potentially eliminating the need for the manual practice. However, they are not plausible yet.

Failed solutions:

- **Tortuga AgTech (USA):**Despite developing robotic fleets for harvesting, the company was not sustainable as a standalone entity. Its assets were acquired by Oishii in March 2025 to enhance indoor harvesting, indicating potential difficulties in creating a cost-effective solution for open-field operations. [1, 30]
- **Farmwise (USA):** This company raised $65 million for its AI-powered weeding robots but failed to achieve scalable profitability. It began winding down operations in late 2024, demonstrating the "valley of death" between a functional prototype and a sustainable enterprise. [18]

Key insights: These examples show that developing fully autonomous robots for agriculture is an extremely difficult and expensive engineering problem. Furthermore, with the high-cost and not easily scalable solutions, Robotics-as-a-Service (RaaS) model is challenging; unlike software, it is operationally complex to rent physical hardware to many different growers all within the same narrow seasonal window.
A detailed analysis of factors such as price, availability, and quality delivered is discussed in Table 1.

3.3 Our Solution & Revised Value Proposition

The proposed solution is an AI-powered Augmented Reality (AR) glass designed to bridge the critical knowledge gap in vineyard canopy management. Its primary function is to empower unskilled laborers to perform highly skilled, precision tasks like grape thinning. This form factor as illustrated in Figure 3 is crucial as it allows the end-user (the worker) to operate hands-free while receiving intuitive expert decisions in real time without having to stop, put down their tools, or consult a separate device. Figure 8 demonstrates the worker's point of view of using our solution. As the worker looks at a grape cluster, the system's camera scans it. The AI engine analyzes the cluster's structure and projects simple, unambiguous overlays (augmentations) such as red circles on berries to remove and green circles on berries to keep, directly onto their field of vision. The worker, requiring no prior experience, simply follows this visual guidance to execute a perfect, expert-level thinning task, eliminating the cognitive load and fear of error associated with decision-making on highly different grape clusters and varieties. The biggest advantage of our solution is that it directly addresses customers' key success metrics, such as cost efficiency, skilled labour, and quality assurance.

3.3.1 Key competitive advantages of our solution

Figure 2 summarizes the competitor landscape graphically.

Figure 3: A conceptual visualization of our solution. The system analyzes the grape cluster and provides real-time visual guidance (e.g., red/green circles) to the worker via AR glasses. *Created with the help of Google Gemini* [8]

Table 1: Competitive Landscape Analysis of Grape Thinning Solutions

Solution	**Quality**	**Affordability (1/Price)**	**Availability**	**Key Weakness / Market Barrier**
Chemical Thinning	**Low:** Low, inconsistent quality. It is risky and causes damage. [I17]	**High:** A low-cost option, making it initially affordable.	**High:** Chemicals are fast to apply and ample.	**Incomplete & Risky:** It's an incomplete solution (still requires manual thinning) and is highly sensitive to different parameters
Agricultural Robots	**High (in theory):** Designed for "best bunch quality".	**Very Low:** Exorbitant cost. Prototype costs are estimated at €80,000 to €130,000.	**Very Low:** Not available for the market. Still in the R&D/early pilots stage.	**Exorbitant Cost & Not ready:** Faces immense technical hurdles and a multi-million-euro R&D timeline. Not scalable.
Our Solution	**High:** Matches and even enhances skilled labor quality. Projected up to 10% increase in high-quality yield.	**High:** Vastly more affordable solution with a projected ROI within the first year.	**High:** Ready today. It immediately empowers the existing, available unskilled workforce.	**Breaks the Trade-off:** The only solution that solves all pain points and brings high quality, high affordability, and high availability simultaneously.

Additionally, growers might be tempted to hire cheaper, unskilled workers instead of extremely scarce and expensive experts. However, this is not a viable solution because of two major reasons

- **The Quality Tradeoff:** While an unskilled worker may cost only €14.40 per hour, they lack the judgment required for precision thinning. This leads to errors, inconsistent quality, and a high risk of fungal disease, which can cause a catastrophic 40% loss in crop value as discussed in detail earlier.
- **The Training Program Fallacy:** Growers cannot solve this by "teaching" the workers because the labor force is a continual influx of new and unskilled workers and has high turnover. Investing time and resources to train a new, temporary worker is an unrecoverable cost, as the worker may not return the next season. It is very evident from Interview I17 that workers are new learners and perform poorly without proper training and require hands-on training on critical judgment throughout the year.

Revised Value Proposition

For Dutch wine and table grape growers facing a critical skilled labor crisis, our AI-powered AR glass provides immediate relief and directly boost customer's bottom line. We eliminate the need for highly-

skilled workers for thinning grapes by empowering newly available, unskilled workers to thin grapes 20% [5] faster than experts and improve yield quality by up to 10% [4]. This translates to an estimate of at least 50 labour hours per hectare and approximately € 14400 per hectare, while reducing fungal disease by up to 60% [15, 28]. Additionally, our system provides important insights into grape health and other data like cluster counts, size, etc, to enable smarter, data-driven viticulture.
Calculations are documented in Appendix A

3.4 Stakeholders & Decision-Making Unit (DMU)

The Figure 4 illustrates the main stakeholders influencing the adoption of our AI-powered AR guidance solution for grape thinning, structured in a "cake-layer" format according to their proximity to the decision-making process. The inner layers represent direct decision-makers (users and payers), while the outer layers include supporting actors and the broader ecosystem that enables or regulates adoption.

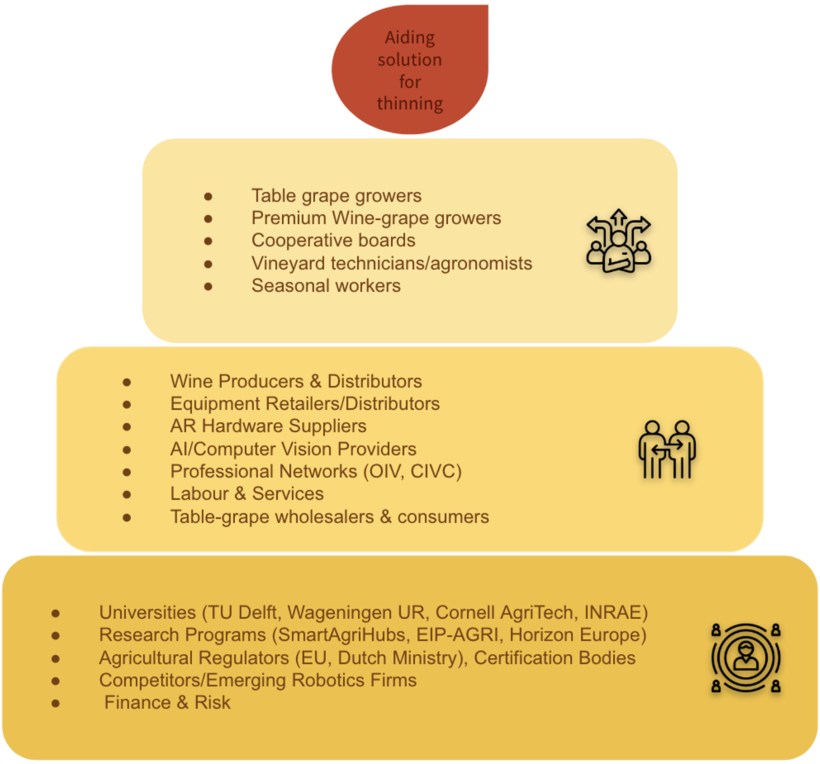

Figure 4: Stakeholder map illustrating the decision-making unit (DMU) and surrounding ecosystem. The full description of each layer is provided in Appendix B.2.

Summary
Overall, the stakeholder landscape reflects a multi-layered decision structure, where vineyard owners and agronomists are central to adoption decisions, but their choices are influenced by a wider ecosystem of suppliers, researchers, regulators, and market actors. Positioning our AR solution within this interconnected chain helps identify key entry points for pilot partnerships and market expansion.

Stakeholder Map
We also include our stakeholder map (Figure 5), which visualizes how different actors interact within the grape-thinning ecosystem. We created the stakeholder map early in the project to understand the people and organizations with whom we needed to talk to test and develop our idea. It helped us identify who is directly involved in vineyard operations, who supports or influences them, and who can enable broader adoption through research, regulation, or funding. This overview guided our interviews and outreach strategy throughout the project.

Figure 5: Stakeholder map for the AI-powered grape thinning solution.

3.5 Market Segmentation & Size

Beachhead Market – Dutch Vineyards

Our initial focus is on Dutch vineyards cultivating both wine and table grapes. Labour costs in the Dutch agricultural sector are among the highest in Europe, with effective hourly wages for field workers ranging from €18–30, including surcharges for peak-season employment [6, 9, 26]. The open-cultivation sector has reported increasing labour-cost indices and structural staff shortages [14, 19], creating a strong need for tools that make new workers more efficient rather than replacing them.

Although the Netherlands has a relatively small grape-production area, it is a hub for agricultural innovation and experimentation with digital tools [21]. Our product, therefore, targets this environment as a pilot market. Based on vineyard surface area, average labour time for thinning, and local wage levels, we estimate the Serviceable Obtainable Market (SOM) for AR-assisted grape-thinning solution in the Netherlands at approximately €0.5 billion annually. The goal is to capture around 40% of this SOM within the first two years through pilot implementations with high-tech vineyards and cooperatives.

Expansion Phases

In Phase 2 (Years 3–4), the solution will expand to the major European viticulture regions like France, Spain, and Italy, which together account for roughly 60% of Europe's vineyard surface and labour costs. Assuming similar training inefficiencies and seasonal staff turnover, we estimate a Serviceable Available Market (SAM) of approximately €4.9 billion.

In Phase 3 (Year 5 and beyond), the product will be adapted for other grape-growing regions such as China, the United States, and Turkey, among the world's largest producers [36]. This represents a potential Total Addressable Market (TAM) of around €11 billion. These figures align with global trends in precision-viticulture technologies that enhance workforce efficiency and data-guided decision-making [25].

The quantitative estimation of the values was derived from vineyard area data and qualitative insights from expert interviews. We used publicly available vineyard statistics from Wine Intelligence [35], Eurostat [7], and Saferoad CEDR [28], combined with an average estimated value of €3852 per hectare (based on interviews with vineyard managers)[I2, I8, I9]. Detailed calculations are provided in Appendix A.

Adjacent Market Segments and Expansion Path

While the initial focus is on grape thinning, the same AI–AR guidance technology can be applied to other precision tasks that rely on visual judgment and skilled manual labour. Within agriculture, it extends naturally to vineyard pruning and to plant health diagnostics, where visual cues such as leaf colour indicate nutrient deficiencies or disease [I17]. A mobile version could also assist home gardeners facing similar challenges.

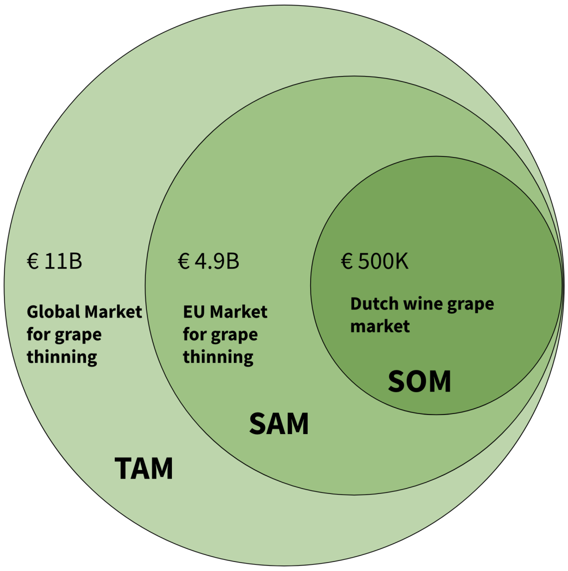

Figure 6: TAM–SAM–SOM segmentation for the AI-assisted grape-thinning solution.

Beyond agriculture, the technology can support fields such as renovation, construction, industrial maintenance, and fine craftsmanship, where workers depend on expert visual evaluation for accuracy. In these domains, AR overlays could guide alignment, assembly, or finishing steps, improving consistency and reducing the need for expert supervision.
Starting from viticulture and gradually adapting to these related sectors allows the solution to evolve into a broader AR skill-transfer platform, expanding the overall market potential beyond viticulture alone.

3.6 Why Now?

Skilled labour is hard to secure when growers need it most. Across the sector, producers report persistent staffing gaps and higher wages, which makes it difficult to execute time-critical thinning on schedule [26]. In practice, vineyards face baseline thinning workloads of about 214–250 h/ha, translating to roughly €3,900–€4,500 per hectare in labour cost during the window when timing matters most (deck figures).
Missing or rushed thinning has a clear cost. Thinning reduces congestion in clusters, improves ripening consistency, and helps meet quality specifications; when it is not done well, disease pressure rises and price realisation falls [3, 32]. In the literature and extension notes you reference, poor cluster conditions are associated with substantially higher disease incidence and value loss risk.
The technology and market context now favour adoption. AR-guided work has shown material gains in task speed and consistency (directionally 20–30% faster and better on-task execution), and vineyard-focused research indicates that guidance can lift quality outcomes (reported up to $\sim$10%) [4, 5]. At the same time, EU growers indicate a stronger intent to invest in equipment, and banks warn that if labour and efficiency pressure persists, sales could decline significantly in the near term [10]. Industry tracking also points to rapid growth in AR for agriculture [31].
Taken together, structural labour scarcity, measurable downside from poor thinning, and improved readiness of enabling tools create a practical opening for precise thinning that non-experts can operate quickly.

3.7 BMC Alignment

Our value proposition is precise grape thinning that non-experts can perform quickly, protecting quality and yield within a short seasonal window. The emphasis is accuracy, consistency, and on-time execution under labour constraints [32]. As we illustrated in the final BMC, this proposition targets the gap between harvesting-focused automation and inconsistent manual or chemical approaches.
Customer segments are two groups. Payers are owners and managers of commercial vineyards (table grapes and premium wine grapes) who focus on profit per hectare and timing risk. End-users are seasonal workers and crew leads who need simple, reliable guidance at the vine. The initial focus is the Dutch market, where labour scarcity and wage pressure make timely thinning most at risk [26].
Channels begin with direct engagement and pilots to prove speed, accuracy, and ease of use in real conditions; scaling comes through regional horticulture distributors and integrators that already serve vineyards. Customer relationships start high-touch during pilots (on-site setup, coaching, quick iteration), and shift to an in-season

service rhythm with clear response times, an operating protocol, and simple quality checks a crew lead can audit.

Revenue has two practical options highlighted in the deck: a one-time AR glasses sale at about €1,000 per unit, and a seasonal guidance subscription at about €75 per month (thinning/pruning). Where service delivery is preferred, a per-hectare seasonal fee remains an alternative. Pricing anchors to labour saved and avoided losses from poor thinning.

Key activities are field pilots, workflow and product iteration for non-expert operation, and in-season deployment with routing and quality audits. Key resources include thinning guidance know-how, field-ready units, pilot metrics, and early grower partners. Key partners include pilot vineyards/cooperatives, component suppliers and system integrators, and relevant research or innovation programmes. The cost structure combines hardware BOM/assembly and software development with field service (transport, setup, maintenance, QA); unit costs are expected to decline with standardised service and volume purchasing. Competitively, available robots emphasise harvesting or mobility rather than thinning (e.g., Tortuga/straddlers), which leaves a clear position for a precise thinning tool usable by non-experts [2].

3.8 Commercial Viability & Funding Plan

Growers adopt if the offer returns more value per hectare than it costs. In our case, value comes from three effects in the thinning window: skilled-labour hours saved, losses avoided when clusters are thinned correctly, and better price realisation when fruit meets buyer specifications [32]. Using the project baseline (thinning workload ∼214–250 h/ha), the deck's worked example indicates labour-only savings of about €14,400/ha, which creates headroom for pricing while leaving most of the surplus with the grower. Dutch wage references bound the valuation locally [6, 9]. The arithmetic that produces these figures is shown step-by-step in Appendix A.

We test a simple per-device P&L to check unit margins. Numbers follow the business-model slides: hardware revenue $\sim 1{,}000$ per unit; seasonal guidance subscription ~ 75/month (thinning/pruning); whitelabel COGS ~ 500 per unit; cloud ~ 10/month/device; support and operations $\sim 10\%$ of monthly revenue; marketing and sales $\sim 10\%$ of monthly revenue. For a four-month thinning season,

$$\text{Year 1 contribution} = (1{,}000 + 4 \times 75) - (500 + 4 \times 10) - (0.10 \times 300) - (0.10 \times 300) = 700,$$

$$\text{Year 2+ contribution} = 300 - 40 - 30 - 30 = 200 \text{ per year.}$$

This unit view is intentionally simple and keeps engineering overheads in the funding plan.

Margins depend on three levers. First, speed and accuracy: if pilots show a smaller time reduction or inconsistent quality, we improve guidance for non-experts and narrow the initial segment to easier canopy systems; vineyard AR work supports feasibility and directionally indicates efficiency gains [4, 5]. Second, cost to serve: if travel and setup dominate, we increase route density (clustered hectares, partner coverage) and standardise swap/repair to shorten on-site time. Third, pricing and offer: if grower value is lower than expected, we shift the mix (higher subscription, lower upfront; or a per-hectare service fee where adoption risk is high) and use financing to reduce friction.

Initial funding should cover software development for a reliable field release (roughly €60k–€100k as indicated on the slides), pilot hardware at about €500 per unit, cloud costs at about €10/month/device during pilots, and working budgets for support/operations and marketing/sales at around 10% of subscription revenue. This tranche bridges the period until subscriptions accumulate and partner coverage reduces per-unit service load.

The path to market is seasonal. Plan for one season to reach pilot-ready (field-reliable unit, operating protocol), one season for paid pilots and reference sites, and scaling in the following season through regional distributors and integrators. Go/no-go gates are tied to field KPIs (time per hectare, accuracy/consistency, damage rate), route-density targets, and unit contribution meeting or exceeding the Year-1/Year-2 figures above.

With labour-only savings at the project's baseline scale and the unit P&L shown here, the economics are workable if pilots confirm non-expert speed and accuracy and we maintain dense routes. If results fall short, we adjust pricing, reduce cost to serve, and iterate guidance until the breakeven condition is met; the supporting calculations and sensitivity live in Appendix A.

3.9 Top Risks & Jury Feedback

Customer discovery confirmed a clear need for solutions that reduce dependence on skilled vineyard labour. However, several key risks must be addressed before the concept can progress further.

1. Knowledge capture and accuracy.

The main challenge is translating expert knowledge in thinning and pruning into an AI system that provides reliable and practical guidance under different conditions. Vineyard experts rely on subtle cues and experience that are difficult to model. If the system is not accurate or trusted, adoption will be low. *Mitigation:* start with one vineyard type, collect data with expert supervision, and test early prototypes before scaling to other regions.

2. Adoption and perceived value.
Adoption depends on proving that the tool shortens training and improves consistency. In one interview (Interview 17), about 10% of seasonal workers were newcomers who needed several seasons to reach good performance, confirming that learning is slow. Research by Buayai et al. [4] also shows that even experienced workers can improve precision with AI-guided tools, indicating value for both novices and experts. Demonstrating these results in pilot trials will be essential.

3. Seasonality and financial sustainability.
Vineyard work is seasonal, with short labour peaks and limited off-season use. This creates uneven cash flow and dependency on short-term demand. *Mitigation:* adapt the system for other tasks such as pruning and canopy management, and explore related crops like soft fruits to balance seasonality.

Jury feedback.
The jury emphasised the need to quantify the current learning process in vineyard work—how long it takes to train new workers and how much improvement AI support can deliver. They also noted that the main value may lie not only in speed but in enabling faster and more consistent knowledge transfer across seasons. This feedback will guide the next steps, focusing on benchmarking learning curves and demonstrating clear benefits in training and work quality.

4 Go / No-Go Decision and Near-Term Milestones

Based on the interviews, jury feedback, and market analysis, the project receives a **conditional Go** decision. The shortage of skilled labour in viticulture has been clearly validated, and vineyard owners have shown interest in technology that can accelerate training and transfer expert knowledge to seasonal workers. The concept is therefore considered promising but requires further validation in both technical performance and market scalability.

To strengthen the business case, the next phase should also investigate similar labour and knowledge-transfer problems in related agricultural sectors such as soft fruits, orchards, and greenhouse crops. These markets face the same shortage of experienced workers and rely heavily on manual skill, which makes them potential early adopters of the technology. Exploring these sectors will help confirm scalability beyond vineyards and expand the total addressable market.

Near-Term Milestones

1. **Prototype development (Months 1–6)** Build a functional prototype of the AR–AI system capable of giving real-time visual guidance during grape thinning. Develop the underlying knowledge-transfer framework so it can be adapted to other crop types and tasks.
2. **Pilot testing (Months 7–12)** Conduct pilot trials with partner vineyards to compare manual and AI-guided work. Record performance data such as time per row, error rates, and training duration. In parallel, start exploratory interviews and small tests with soft-fruit or greenhouse growers.
3. **Validation and ROI assessment (Months 12–15)** Analyse results from the pilots to measure improvements in speed, consistency, and worker learning rate. Estimate potential return on investment for small and medium-sized producers and identify the most promising customer segments.
4. **Partnership and funding (Months 15–18)** Form partnerships with agricultural research institutes, hardware suppliers, and innovation funding programmes. Seek EU or national grants to support larger-scale field pilots and cross-sector testing.

If pilot results confirm technical reliability and measurable benefits in training time and quality, the project will continue towards a broader agricultural knowledge-transfer platform. If results are inconclusive, further refinement of the AI model and user interface will be carried out before wider implementation.

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A Calculations

Cost Savings per hectare (Optimistic Estimation)

Minimum hourly wage in Netherlands of a new, unskilled worker (say MHW) = 14.4 euros [9]
Total number of workers needed per hectare of vineyard (W) = 15 to 20 [I12]
Total time required for thinning per hectare = 214 to 250 hours [I2, I8, I9]
Percentage of time saved by our solution = 20% [5]
Time saved per hectare using our solution (say ST) = $250 * 0.2 = 50$ hours
Total cost saved per hectare with our solution (say CS)

$$CS = ST * MHW * W$$
$$CS = 50 * 14.4 * 20$$
$$CS = 14400$$

Thus, the customer saves a total of 14400 euros per hectare using our solution. Note that this does not involve other costs like cost of the our product etc.

TAM–SAM–SOM Market Size Calculations

Assumptions and Data Sources:

Global vineyard area (A_G)	= 7.1 million ha [35]
EU vineyard area (A_{EU})	= 3.1 million ha [7]
Dutch vineyard area (A_{NL})	= 173 ha [28]
Applicable share of market (%)	= 40% for global/EU, 70% for NL (assumptions)
Average value per hectare (V)	= €3852 (from vineyard manager interviews [I2, I8, I9])

Formula:

$$\text{Market Size (€)} = \text{Vineyard Area (ha)} \times \text{Applicable Market Share (\%)} \times \text{Value (€ per ha)}$$

Calculations:

$$\textbf{TAM (Global)} = 7.1 \times 10^6 \text{ ha} \times 0.4 \times 3852 = \mathbf{10.94 \text{ billion}}$$
$$\textbf{SAM (EU)} = 3.1 \times 10^6 \text{ ha} \times 0.4 \times 3852 = \mathbf{4.93 \text{ billion}}$$
$$\textbf{SOM (Netherlands)} = 173 \text{ ha} \times 0.7 \times 3852 = \mathbf{0.47 \text{ million}}$$

Interpretation: - The Total Addressable Market (TAM) represents all global vineyards where grape thinning is relevant. - The Serviceable Available Market (SAM) reflects European vineyards within realistic reach for expansion. - The Serviceable Obtainable Market (SOM) corresponds to Dutch vineyards targeted in early adoption pilots.
Data sources: Wine Intelligence [35], Eurostat [7], Saferoad CEDR [28], Groupe BPCE (sector outlook) [10], and interview-derived hectare valuations.

B Supplementary Material

B.1 Difference between skilled and unskilled worker for grape thinning

B.2 Stakeholder Descriptions

Core DMU – Users & Payers

The top layer of the cake represents the direct decision-making unit (DMU): vineyard owners, managers, and workers.
Table grape growers and premium wine-grape growers are the primary payers, they decide on purchasing or subscribing to the AR guidance system based on potential yield improvement, cost reduction, and reliability.

Table 2: Comparison of Worker Profiles for Grape Thinning

Metric	Skilled Worker (Expert)	Unskilled, New, Temporary Worker
Competency	Possesses **critical judgment**. Understands which berries to cut and when.	**Lacks judgment**. Requires constant supervision and training.
Quality	**High precision** and consistency. Delivers premium-grade clusters.	**High risk of costly errors** (e.g., damaging grapes), leading to lower quality.
Efficiency	Works quickly and independently. **No training required**.	**Slow and inefficient**. Requires significant training time and supervision.
Cost	**Very High Cost** (e.g., up to €30/hour).	**Lower Wage** (e.g., €14.40/hour), but high total cost due to errors.
Availability	**Critically Scarce**. Workforce is aging and shrinking.	**More Available**. The barrier is their skill, not their presence.

In smaller vineyards, cooperative boards play a coordinating role, making collective investment decisions.
Vineyard technicians and agronomists act as influencers or gatekeepers, assessing technical feasibility and validating the system's accuracy before adoption.
Seasonal workers are the end-users, responsible for operating the AR glasses during thinning. Their ease of use and comfort strongly affect adoption success.

Dependent Stakeholders – Ecosystem Partners

In this middlelayer, we list stakeholders whose business outcomes depend on or are enhanced by the success of vineyards adopting the technology.
Wine producers and distributors, and table-grape wholesalers and consumers, benefit indirectly from improved grape quality and more stable supply.
Equipment retailers/distributors and AR hardware suppliers act as commercial intermediaries who can distribute or integrate the hardware.
AI/computer vision providers contribute technological components, such as perception algorithms or data analytics.
Professional networks (e.g., OIV, CIVC) and labour and service providers help vineyards connect with experts, train their workers, and share practical knowledge about using new technologies. They are important because they make it easier for growers to learn, adopt, and keep using our solution over time, which helps the product spread and remain useful in the long run.

Context Stakeholders – Regulators & Enablers

At the base of the cake diagram, we outline the broader institutional and regulatory environment that determines the implementation of innovation.
Universities (e.g., Delft University of Technology, Wageningen University, Cornell University of Agriculture, INRAE) and research programs (SmartAgriHubs, EIP-AGRI, Horizon Europe) provide the knowledge base, validation studies, and funding for agricultural innovation.
Agricultural regulators (the EU and the Dutch Ministry of Agriculture) and certification bodies ensure compliance with product safety, data protection, and performance standards.
Competitors and emerging robotics firms define technological benchmarks and influence market readiness.
Finally, financial institutions and investors determine the availability of capital for scaling and commercialization.

C Additional Figures

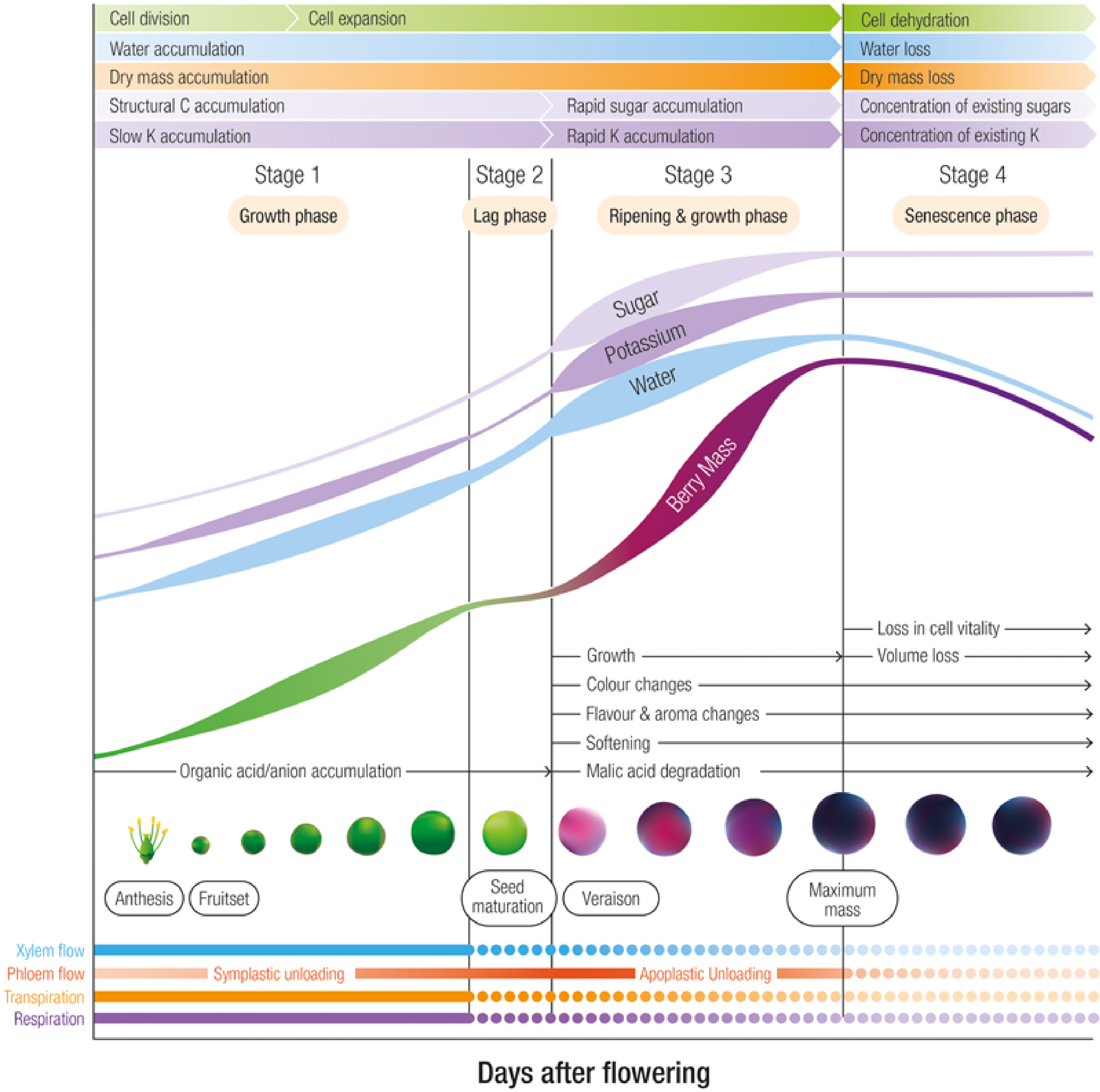

Figure 7: Stages of grape growing [27]

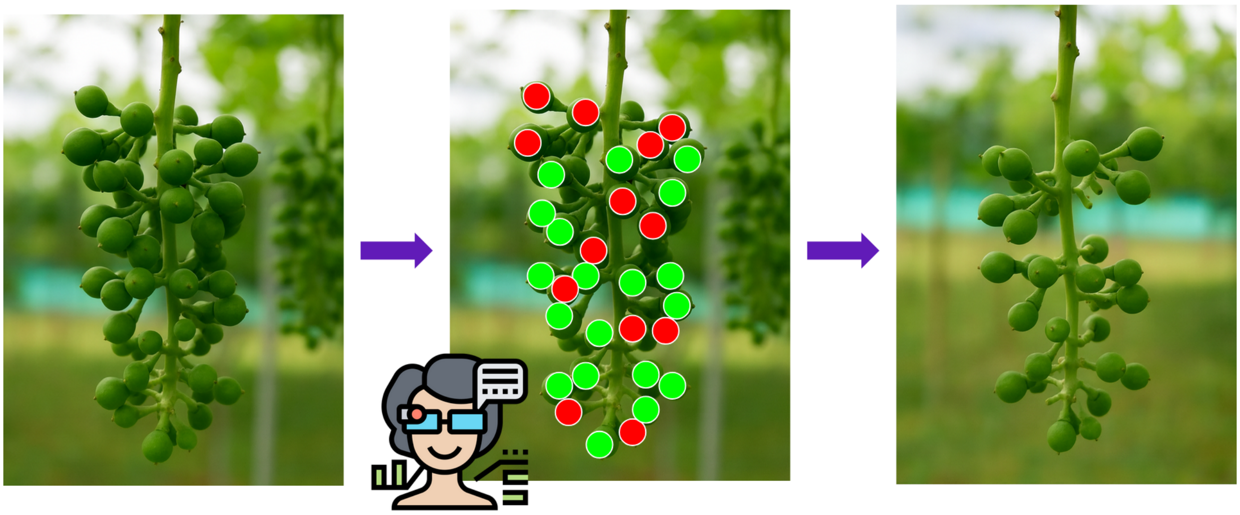

Figure 8: Worker’s Point of View of our solution