REQUEST FOR QUOTATION FOR SERVICES

Development of additional features of a mobile application helping smallholder farmers and cooling companies to optimise their post-harvest cold storage processes, with a focus on stability, scalability, and open-source

BASE Foundation, in collaboration with Empa (the Swiss Federal Laboratories for Materials Science and Technology) is seeking services for the further development of the data science-based mobile application, Coldtivate. The app provides real-time instructions to guide smallholder farmers in Low and Middle Income Countries on how to control storage of products to minimise food loss, and on when to sell the produce to maximise market value. The software interacts with modules using machine learning and physics-based food modelling. The first version of the mobile application has been already developed and was released on Android, iOS, and as a web app in May 2022. We are looking for a software developer company to further develop the app, provide maintenance of the existing modules and potentially build a long term relationship with BASE and EMPA for further developments within the app (note that the latter component is not part of this ToR).

Proposals should be submitted electronically before EoB CET April 18th, 2024. The quote submission details are outlined in Section 3 below.
1. Context

1.1 Background on BASE and Empa

BASE Foundation is a not-for-profit organisation that uses its unique combination of expertise to unlock investment in sustainable energy and meet the challenge of climate change.

For this project, BASE is partnering with Empa (Swiss Federal Laboratories for Materials Science and Technology), an interdisciplinary Swiss research institute for applied materials sciences and technology.

1.2 Project background and objectives

In January 2021 BASE and Empa were awarded funding by data.org for the creation, implementation and deployment of an open source, data-science-based mobile application that uses machine learning and physics-based food modelling to help smallholder farmers access sustainable cold storage. Together with a pay-per-use servitization business model, the Your Virtual Cold Chain Assistant (Your VCCA, www.yourvcca.org) project aims to cut postharvest food loss and increase the income of marginal farmers in Low and Middle Income Countries (LMIC). To this end, BASE and Empa are partnering with local technology providers, i.e. companies managing and operating solar-powered refrigerated containers, which function as refrigerated walk-in rooms for farmers to safely store their produce to prevent food spoilage and preserve crop quality to get a higher price when selling the produce. The cooling companies own, maintain, and operate the cold rooms, and farmers pay a small fee per day and crate stored, without the need of any upfront investment to buy the equipment. This project was selected following a competitive process of 1'260 other applications in January 2021 and has been awarded additional funding for the replication in multiple countries by GIZ in September 2021. To date, the solution is being rolled out in India, Nigeria, and the Philippines. For more information about the context of the project, we recommend watching these project videos: India, Nigeria. Since February 2024, the project is receiving funding from ECOWAS to replicate this initiative to Guinea-Bissau.

The mobile application, named Coldtivate, is free to download (at www.yourvcca.org/nigeria/the-app) and can be used as a web app, on Android and on iOS. Currently, the app can be used by cooling users and by companies offering cold storage to digitally manage the inventory inside of cold rooms, remotely monitor temperature, revenue, and occupancy, predict the remaining quality of the produce stored in the rooms, and forecast market prices for multiple crops across India.
The app features three user types: *registered employees*, who are cooling company representatives responsible for the management and set up of cold rooms, *operators*, who are the persons physically present at the rooms managing the interactions with the farmers, performing check-in and check-out operations at the cold rooms, and responsible to collect storage fees, and the *cooling users*, who are smallholder farmers and traders that are using cold storage.

As part of the next phase of the project, we are aiming to:

1. Making the existing app stable and scalable. This includes restructuring the database, optimising backend and cloud resources, rewriting the frontend (from Ionic to React / React Native), and potentially improving parts of the UI/UX.
2. Including additional language support (at least 4 more languages) and expanding the Knowledge Hub, which is Coldtivate’s repository for capacity building material (text, images, videos).
3. Including customers / buyers as one additional user type, and allowing them to purchase produce via the app.
4. Prepare code for open-source publication, including extensive documentation and testing suite.
5. Maintain and refine existing features of the app to meet user feedback.

These developments are crucial to enlarge the user base and ensure the sustainability of the solution. All planned features have been identified using a user-centred approach and validated with multiple stakeholders.

### 1.3 Team composition and gaps

The expertise within the BASE and Empa team lies mainly within the development of the underlying models that are required for the app to provide recommendations. These are data science-driven models and physics-based models. While some team members have experience with software development, there is a gap to be filled for the development of the back-end software as well as the front-end of the mobile application.

BASE and Empa are currently looking for a software development team to fill this gap in expertise and support with the further development of the Coldtivate app.

The software development team should be willing and able to collaborate closely with the scientists from BASE and Empa as well as to complete the handover from the software company that has been responsible for the first phase of the project.
2. Scope of work

2.1 Objective

BASE is looking for an innovative, talented and experienced software development team that can help the BASE and Empa team to further develop the data science-based mobile application Coldtivate.

The key existing functionalities of the app and development roadmap are described in the following sections. These include a description of the work done so far, including links to documentation and source code, and a high-level overview of the activities that we have identified to develop the final product. In the Appendix, we provide a list of FAQs that shed light on the current state of the application and the project working stack.

The scope of work includes the development of additional app features that have been requested by the direct users to improve app functionality and ensure a wide adoption. These include the stabilisation of the app with a focus on database restructuring and resource optimisation, the rewriting of the app frontend, the integration of an additional user type (‘customers’), and extended language support. Finally, the scope of work includes the maintenance of all existing features deployed in production until at least March 2025.

The scope of work does not include the development of the underlying models (physics-based models to predict food quality and machine learning models to forecast market prices), and isolated modules (Impact and Farmers Dashboard, App Impact Monitoring module), which have already been developed by the BASE and Empa teams.

BASE is seeking services for the period May 2024 - March 2025. Furthermore, based on interest, collaboration outcome and availability of funding, there are concrete possibilities to expand the engagement to develop further additional features and/or extend the maintenance period.

2.2 App development roadmap

The scope of the proposed consultancy is to support the expansion of the Coldtivate app. For more context, we are providing below the main milestones achieved in the period of October 2021 to March 2024. Section 2.2.2 contains a brief explanation of the main features to be developed as part of this phase of the project, and section 2.2.3 provides a tentative timeline.
2.2.1 Developed features

All components described below (with the exception of V7, which is work in progress at time of writing this RfQ) are deployed in production and can be explored by downloading the app (www.yourvcca.org/india/the-app) and registering a test company. We also recommend watching the following videos to get an overview of the app main features:

- For registered employees, specifically the cooling companies' management team: Watch Video (from minute 46).
- For operators: Watch Video (from minute 12).
- For cooling users: Watch Video.

V0: The app features two user types: registered employees and operators.

Registered Employees (RE, also called ‘service providers’) can:

- Sign up a company and sign up themselves on the app with an email and phone number.
- Invite other registered employees to join their company – an invitation link is sent per SMS. Once added, all registered employees have the same permissions of the app (i.e. there is no difference between the RE who signed up the company, and the ones that have been invited later on).
- Set up locations and cooling units.
- Invite operators to join their company and assign them to cold rooms – an invitation link is sent per SMS.
- Invited registered employees can sign up following an invitation URL sent by SMS.

Operators can:

- If invited to join the app, sign up following an invitation URL sent by SMS. They sign up with a phone number only. Operators cannot sign up in the app without invitation.
- Sign up cooling users (a.k.a. farmers) with a phone number (but no invitation link is sent). Upon registration, operators are prompted to complete a survey by asking cooling users about the most produced crops. The survey can also be filled in / edited at a later point by clicking on the cooling user’s name.
- Initiate a check in for a registered cooling user.
- Initiate a check out for produce that has already been checked in.

Both RE and operator can:

- Visualise produce in storage in the Dashboard tab.
- Monitor check in and check out operations (a.k.a. movements) in the History tab.
- Monitor room temperature, occupancy, and statistics on crates in the Planner tab.
- Visualise Revenue and Usage analysis per room in the Menu.

For all of the above, RE can see all rooms created as part of their company, whereas operators only see rooms to which they have been assigned to.
**V1:** Digital food Twin models (DT) are integrated into the app. These are computer models that mimic the physical and thermal properties of different fruits and vegetables including also the physics that control the heat exchange between the air in a cold room and them. These models map the effects of temperature changes in the cold room to the fruit or vegetable’s internal temperature and finally to derivative values such as the remaining quality and remaining shelf life. The DTs predict the remaining storage life (also called ‘Time To Pick Up’ or TTPU in short) for 26 different types of crops. The DTs are developed by Empa in the proprietary COMSOL Multiphysics software and compiled into I/O executable files that can be run without the need of a COMSOL licence. The digital twins depend on: crop type, days since harvest, and room temperature. So, each set of crates of the same crop type sharing the same initial quality has its own digital twin model. Temperature is either read from room sensors (integrated via API into Coldtivate) or manually inputted by operators. DTs are computed once at check in, and then recomputed every 6 hours. The output quality and time to pick up are shown for each check-in item in the dashboard of the app. Coldtivate supports API connection to sensors developed by Ecozen and UbiBot to extract real-time temperature data.

The COMSOL executables can be called via the command line with one argument being the path to the folder from which it will read and write certain fixed-names text files. From these text files the DT reads information that it needs for the simulation and that is extracted from the app (such as the temperature data in the last 6 hours or the current quality of the commodity). Likewise, the DT outputs values of the simulation like the final quality and time to pick up, which the app reads and updates in the database. The folder names of each model run correspond to the unique identifiers of the crate items in each check-in that require their own instance of a DT model (i.e. different commodities per check-in or different time since harvest / initial quality). The DT executables normally require a GUI when they’re called for the first time (to accept the terms of the COMSOL runtime installer) and every time they’re run as well. However, this is set up and managed in the app upon creation of one of its Docker containers, by installing the runtime with a setupconfig.ini file used to agree to the terms and by configuring an Xvbf server to bypass the need of a GUI.

**V2:** A machine learning model forecasting market prices across India is integrated in the app. The model has been developed by Empa with the support of the Mastercard Center for Inclusive Growth and is stored within docker containers. The model is trained to forecast the daily prices of four different commodities across markets in four Indian states up to 14 days in the future. To keep the predictions up-to-date, the container contains a script to scrape new data from the source websites and to regularly retrain the model.
If the company RE and operators belong to is based in India, both users can visualise market prices and forecast in the Market price page. If the company is not based in India, this feature is not visible.

**V3:** A new user type (cooling users a.k.a. farmers) can sign up in the app, to monitor what they have in storage, the room temperature and occupancy, as well as accessing the Knowledge Hub and a map of public cooling units. As a cooling user (with a smartphone), I am able to:

- Sign up to Coldtivate using phone number,
- Visualise a map of existing cooling units around my location,
- Visualise my crates stored in multiple rooms in the Dashboard page, as well as the history of my movements in the ‘History’ page, and temperature and occupancy of the rooms where the produce is stored in the ‘Cooling unit’ page.
- Receive notifications directly on the smartphone when the shelf-life of the crops in storage decays.

All functionalities developed in V0-V2 remain available for users who don’t have a smartphone: in this case, it is the operator who registers the cooling user on the platform. Users that have already been registered by operators, who would now like to sign up, can use the same phone number at sign up for their account to be upgraded from ‘cooling user with no smartphone’ to ‘cooling user with smartphone’.

**V4:** A machine learning model forecasting state-wise market prices across Nigeria is integrated in the app. The model mimics the ML model developed for India, with the important difference that the predictions are done for the following 8 months (instead of for the next 14 days) and per state (and not per market). These elements are constrained by the availability of the data needed to train the model. As a result, the Market Price interface, visible for all user types, is slightly different for Indian and Nigerian users. Users based in other countries see the page, but are informed that no model is available for their location.

**V5:** RE and cold room operators have access to the *Impact Dashboard*, which summarises performance data and is organised in three section:

- **Company view:** present summary statistics of all cold rooms belonging to a given company since registration in Coldtivate. Data summarises number of users linked to the company (RE, operators, farmers), number of crates and operations registered (with crop distribution), associated revenues, impact data on food loss and revenue evolution (extracted from user survey data) and CO2 emissions associated with cooling.
- **Aggregated view:** RE and operators can select a subset of cold rooms and a time period and visualise the indicators (same as Company view) for their selection.
• Comparison view: RE and operators can select a subset of cold rooms and a time period and compare the indicators (same as Company view) across cold rooms in a given time period.

Cooling users have access to the Farmers’ Dashboard, which, for each cooling user with a smartphone, summarises his/her data on number of crates and operations registered (with crop distribution), associated storage costs, and impact data on food loss and revenue evolution (extracted from user survey data). For both dashboards, the user data is collected by two types of surveys:

• **Baseline surveys** conducted when a cooling user registers (or is registered by an operator). These surveys are crop-specific and aim at understanding average production and loss level, reasons for loss, and average selling price. Cooling users that have not filled in these surveys for commodities they have checked in are reminded by in-app notifications. Similarly, cold room operators are reminded for all users that have done a check-in in one of their rooms.

• **After storage surveys** are weekly surveys that are conducted for all crops checked-out in the previous week by a given user, and aim at understanding how much of what was stored was lost after storage, reasons for loss, selling location and selling price. Cooling users and operators are reminded about the need to fill in these surveys on a weekly basis. Only surveys relative to the commodities checked-out in the previous week can be filled in.

The data from these surveys is compared and statistics about food loss and revenue evolution are calculated monthly.

To calculate the CO2 emission evolution, which compares the emissions associated with cooling the produce that has been stored in a room in a given time frame to the emissions associated with keeping that produce unrefrigerated, we use a Life Cycle Assessment methodology that calculates crop-type-specific emissions, which also depends on the technical specifications of the cold rooms. RE are asked to input this information in the Cooling Unit set up page.

**V6:** The following features are added to the app:

• RE and operators are able to download excel files that present the information about check-ins and check-outs stored in the Usage and Revenue screens. In addition, operators are able to download excel files that summarise the list of associated cooling users from the Cooling User page.

• The Knowledge Hub is extended with additional screens that summarise postharvest best practices to optimise cold room usage, and a comic strip aimed at explaining the benefit of cooling for farmers.

• RE are able to set crop-specific pricing when setting up a cooling unit. This means that they can modify the standard pricing scheme (which can be a combination of per day or
fixed, and per kg or per crate) for selected commodities. This is the price that will be shown in the operators screens during check-in and check-out.

- Improved check-in process: operators experience a more compact check-in process, and are able to associate a User ID to any registered cooling users. The User ID is created to reflect company offline registration processes, where a token / identifier is assigned to each farmer that registers with that company.

**V7 (to be finalised in April 2024):** We are integrating the following features:

- *Digital crate management system:* to link physical crates (stored in the cold room) with digital crates (checked-in in Coldtivate), operators can, at time of check-in, specify an identifier for the crates where the produce is being stored. The operators have access to a separate screen to retrieve the information about a given crate number. Additionally, the area of a cold room is mapped by three coordinates (row, column, and height) and each crate is assigned a set of coordinates. This information is especially useful for large cold rooms (>30 MT) for cold room operators to quickly locate items to be checked-out.

- *Digital payment method:* the check-out process includes the opportunity of displaying company coordinates for digital payment systems (as bank transfers in Nigeria and UPI in India).

- *Crate traceability across the cold chain:* crates checked out from a cooling unit (e.g. a static cold room) can be checked-in by an operator in another unit (e.g. a refrigerated truck) with a code (to reduce the time needed to insert the crate details such as crop type, weight, etc), and their shelf-life is tracked throughout this process. This feature ensures a smooth integration between cold rooms and refrigerated logistics services.

- *Cold rooms operators are able to modify the check-in entries,* to correct potential mistakes. RE are notified about which check-in has been modified. This option is only available on the day in which the check-in is performed.

- *Language support for Igbo, Yoruba, and Hausa:* Coldtivate content is translated in the main three Nigerian languages to lower accessibility barriers for end users.

- *Integration of Figorr sensors:* connection to the Figorr API to retrieve temperature information from cold rooms equipped with Figorr sensors.

- *Exportable Impact and Farmer Dashboards:* users are able to download pdf exports of the dashboard pages.

**2.2.2 Features to be developed**

In this section we provide an overview of the main features to be developed as part of this assignment. These are the activities for which a quote is expected. **Kindly provide a time and budget estimate for each of the features separately. We also welcome a min-max estimate if needed.**
1. **Making the app stable and scalable.** In the past months, we have been focusing on troubleshooting the app and making it more stable. Despite these efforts, we are aware of the current issues:
   
a. Resource overload: CPU / memory are sometimes at capacity due to suboptimal implementation of the Digital Twin (DT) models. The DT models are currently implemented as part of the main app code, but it should be evaluated whether having them as an external service would be beneficial.
   
b. Long query times due to nested structure of the existing database. The existing database should be simplified to improve efficiency. BASE / Empa will support in identifying which tables need restructuring and what are the most critical queries to improve. All existing data should be migrated to the new database.
   
c. Difficulties for users in low connectivity regions to access parts of the app. We would like to focus on making the app as lightweight as possible to allow these users to access the app more easily. Thorough testing of different app components and their accessibility in low-connectivity settings should be conducted, and mitigation strategies should be proposed and implemented.
   
d. App frontend sometimes fails to refresh and remains stuck in the wrong screen despite the implementation of loading screens. The Ionic framework seems to have some limitations, and we have been thus advised to rewrite the app frontend using React.

2. **Including additional language support and expanding the Knowledge Hub.**
   
a. As the app is being adopted across multiple countries, its availability in local languages is key to ensure wide adoption with rural communities. To date, the app is available in English, Hindi, Oriya, Gujarati, and will soon (by April 2024) include translations in Yoruba, Igbo, and Hausa. Because of the adoption in Guinea-Bissau, we are planning to translate the app in Portuguese, French, and Creole, and potentially one additional local language. The translations are managed by the i18n tool, and BASE / Empa take care of coordinating with translators and returning .json files with the translated content.
   
b. The Knowledge Hub is Coldtivate repository for capacity building material (text, images, videos). As we develop additional capacity building and awareness raising material, we are planning to include an additional 5-10 pages to the Knowledge Hub. This section of the app should be accessible offline once the users have logged into the application.
3. **Including customers as one additional user type.** The lack of market linkage discourages farmers from using cold storage, i.e. they sometimes prefer to sell at lower prices right after harvest, rather than storing their crops in the cold room waiting for better prices during a market day. In addition, farmers might struggle with transporting the produce to the markets, and connecting to buyers. The cold room operators sometimes play the role of aggregators, pooling together crates belonging to different farmers and taking care of their sale and delivery to the end customer. To digitalise this process, we are planning to include in Coldtivate an additional user type. ‘Customers’. If cooling users decide to mark a specific set of crates stored in the cold room as ‘available for purchase’, customers will be able to see in the app all information relative to that set of crates (including TTPU) and to buy the crates. The information about the remaining quality of the crates powered by the TTPU model increases the transparency of the transaction. The following aspects associated to a purchase should be considered:
   - Change of ownership of the crates;
   - Payment of transaction;
   - Possibility for cold room operators to sell farmers’ produce in bulks.

A small transaction fee (around 3.5%) will be collected for the purchase of each crate and will be retained by BASE / Empa to support the app hosting costs.

4. **Prepare code for open-source publication.** We are planning to release the app open-source by March 2025, and would thus like to focus on:
   a. Agreeing on a open-source standard to be followed;
   b. Include exhaustive documentation of the app and all integrated modules (both in-code and as external technical documentation);
   c. Implement 95-100% test coverage of app code;
   d. Release code as open-source on platform of choice;

5. **App maintenance May 2024 - March 2025.** Perform corrective and predictive maintenance for all user types in parallel to the development of new features for the duration of the assignment (May 2024 - March 2025). We are planning for an engagement of 2-4h / day on business days, with 24-48h expected response time. This time should be clearly budgeted for in the proposal as a separate item. Further expansion beyond this period can be discussed upon agreement.

### 2.2.3 Timeline

Below we present a tentative timeline to clarify project priorities and expected workload distribution. As such, the table is only intended to serve as an indication and will be refined upon project initiation.
<table>
<thead>
<tr>
<th>Output</th>
<th>Delivery date</th>
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</thead>
<tbody>
<tr>
<td>Translation of app content in 3 additional languages</td>
<td>May 2024</td>
</tr>
<tr>
<td>Improvement of app backend structure and resource optimization</td>
<td>June 2024</td>
</tr>
<tr>
<td>Integration of ‘consumer’ user type</td>
<td>July 2024</td>
</tr>
<tr>
<td>Improvement of UI/UX experience, rewriting of app frontend</td>
<td>October 2024</td>
</tr>
<tr>
<td>Expansion of Coldtivate’s Knowledge Hub</td>
<td>November 2024</td>
</tr>
<tr>
<td>Translation of app content in 1-2 additional languages</td>
<td>January 2025</td>
</tr>
<tr>
<td>Release of app code open-source (including testing suite and</td>
<td>March 2025</td>
</tr>
<tr>
<td>documentation)</td>
<td></td>
</tr>
<tr>
<td>Corrective and predictive maintenance, user support</td>
<td>Throughout the project timeline</td>
</tr>
</tbody>
</table>

### 2.3 Tech stack and prerequisites

To ensure high efficiency and clear requirement definition throughout the project, a close collaboration is needed between the software developers and the BASE and Empa teams. Therefore, we are planning to use an Agile methodology with weekly Scrums and a CI/CD pipeline.

The mobile application has been developed using the following technologies:

- **Backend:** Python (Django), Docker
- **Frontend:** Ionic, Angular
- **Database:** PostgreSQL
- **Hosting (test and production environment):** Azure
- **DevOps:** GitLab CI/CD
- **Project management:** Jira/Confluence/GitLab

We are looking for a team who masters these technologies to avoid the need of replicating / migrating the infrastructure on different systems, with the exception of the frontend, where we are looking for developers able to rewrite it in React / React Native.
Additional requirements include:

- Experience with mobile app development and deployment on Google Play Store and App Store;
- Celery;
- Desired but not necessary: familiarity with machine learning, COMSOL Multiphysics software and Xvfb display server, i18n translation tool.

The app source code and some technical documentation can be accessed here. We kindly ask you to consider this material as confidential, as we have not yet publicly released the app open source.

Additional integrated services and webhooks include:

1. Twilio: platform to send SMS from the app (for user invitation and notification).
2. Email backend (Django): send email from the app (for user invitation and notification).
3. COMSOL Multiphysics: software used to create the DT models. DTs and compiled into I/O executable files that can be run without the need of a COMSOL licence.
4. UbiBot, Ecozen, and Figorr: three technology providers offering hygrothermal (temperature and relative humidity) sensors that are placed inside of cold rooms to monitor room conditions in real-time. They provide an API connection, which has been integrated in the Coldtivate app to read the temperature data from it. The room temperature cannot be modified from the app as the connection is read-only.

3. Submission of quotation and evaluation criteria

Quotations should be submitted in English before the deadline specified below.

Please include the following information:

- Consultant’s Organisation:
  - a) Briefly describe your background / the background of your consulting firm / organisation, and,
    - b) Provide a brief description or profile of the key team personnel that would be working in the project and the sub consultant(s) that your consulting firm proposes to engage for this assignment. Describe their role.
- Consultant’s Experience: Provide work samples and past experiences of yours / the firm in similar or related projects, where possible.
- Comments and suggestions to this Request for Quotation: Present and justify any modifications to the RfQ your consulting firm would like to propose, if there are any, to perform the assignment better and more effectively (e.g. deleting some activity
that you find unnecessary, adding others or proposing a different phasing of the activities). Such suggestions should be concise and incorporated in your Proposal.

- Description of Approach, Methodology, Work Plan and budget overview: It is suggested that you include the following sections: a) technical approach or methodology, b) work plan and c) the budget allocated to the latter. Please provide a time and budget estimate for each of the features listed in section 2.2.2 separately. We also welcome a min-max estimate if needed.

Questions and clarifications:

You can send your questions to Roberta Evangelista, roberta.evangelista@energy-base.org.

Please send quotes via email to:
Roberta Evangelista, roberta.evangelista@energy-base.org.

Deadline for submission: EoB CET 18th April, 2024.

Quotes will be evaluated and selected based on the principle of best value for money. This includes quality/suitability as well as price criteria.

1. Quality and suitability of the proposal including:
   ● Demonstrated understanding of the objectives and scope.
   ● Suitability and quality of the approach on the proposed scope of work.
   ● Relevance of company experience.
2. Price (the cost of additional suggested activities will be considered separately)

BASE may consider other value for money sub-criteria in the evaluation of proposals.

Further information:

The software development team is expected to collect necessary information from the BASE and Empa team and clarify the work structure and work plan for the development of the app during the kick-off meeting and execution phase.

It is encouraged that the software development team suggests additional activities deemed necessary to reach the objectives.

The proposal must include the time frame of the implementation of the different activities.

All elements should be developed in consultation with the project team (led by BASE) and should be aligned with other project activities mentioned above.
4. Appendix

Below we present a list of FAQs, ordered by theme.

Operational Aspects

1. Project Timeline and Milestones: What are the expected project's current timeline and major milestones? Are there any immediate deadlines?

The main milestones for the further development of the Coldtivate app are:
- By May 2024: Translation of app content in 3 additional languages
- By June 2024: Improvement of app backend structure and resource optimization
- By July 2024: Integration of ‘consumer’ user type
- By October 2024: Improvement of UI/UX experience, rewriting of app frontend
- By November 2024: Expansion of Coldtivate’s Knowledge Hub
- By January 2025: Translation of app content in 1-2 additional languages
- By March 2025: Release of app code open-source (including testing suite and documentation)
- Throughout the project timeline: corrective and predictive maintenance

We are open to discuss the order of some milestones in alignment with project objectives and within the overall project timeline of 1 year. As the app already has 500+ registered users, aspects such as minimising downtimes, data migration to new database structure, and user feedback collection throughout the development cycle are of utmost importance.

2. User Feedback: Is there user feedback on the current version of the app? What are the key areas of user satisfaction and dissatisfaction?

We regularly collect user feedback with virtual and in-person meetings, as well as emails and user surveys. Key areas of user satisfaction are:
   i) intuitive user experience,
   ii) clear app design,
   iii) good usage of visual aids for less literate users.

Key areas of dissatisfaction are:
   i) slow response times in completing some operations (especially in areas with low internet connectivity),
   ii) at times faulty login process (users get logged out and are unable to access - partially linked to resource depletion,
   iii) inability to receive SMS for password reset and notification of users without smartphones (Nigeria)
3. Analytics and Metrics: What analytics or KPIs are currently being tracked? Can you provide access to these reports?
The key metrics we monitor are:
   i) Number of app downloads
   ii) Number of registered users and cooling units
   iii) Number of operations (check-ins, check-outs) and quantities stored
   iv) Number of filled in user surveys
We usually generate weekly reports for the companies we are piloting with, and can confidentially share this information.

Strategic Aspects

1. Vision and Objectives: What is the strategic vision for the app? What are the short-term and long-term objectives?
The short-term vision (1-1.5y) for Coldtivate is to continue the piloting phase with cooling companies and farmers. The codebase and data will be managed by BASE and Empa in cooperation with the software development team. By integrating the ‘consumer’ user type, we are planning to integrate a small transaction fee (around 3.5%) on crop purchase to support some of the app hosting and maintenance costs. The long-term vision is to release the app as open-source code, so that multiple versions of Coldtivate can be developed independently of BASE / Empa. We are also actively exploring with interested organisations about the opportunities for them to take over the maintenance and development of the application.
While, as two not-for-profit organisations, BASE and Empa do not focus on commercialising the app, we are interested in developing an app that is tailored to the end user needs and strive to create a solution that is economically viable for cooling companies to integrate and maintain as part of their operations without our direct support.

2. Market and Competitors: Who are the primary competitors? What market needs does the app aim to meet, and how does it differentiate from existing solutions?
While we are aware of existing apps and platforms that cover some aspects of the cold chain and crop commercialisations (e.g. Ecozen AI to manage cold room temperature, Olam Direct and Foodlocker Limited for crop marketing), Coldtivate has been welcomed by cooling companies as a unique tool that serves as a one-stop solution to efficiently manage cold rooms. The integration of digital fruit twins (that predict the remaining shelf-life of each crate in storage for 26 different types of fruits and vegetables) is a unique selling point of Coldtivate, which, coupled with the digital management of the inventory, enables the traceability of the produce across the cold chain. We are not aware of any existing solution that encompasses all these different aspects.
3. **Future Roadmap:** What features or improvements are planned for future releases? How flexible is this roadmap?

As part of the Your VCCA initiative, we are currently exploring how to further support smallholder farmers in accessing affordable cooling solutions, as well as ensuring that cooling companies are able to scale their operations. As such, we are interested in continuously integrating the feedback of these users in the application. We routinely collect open points for improvements and hope to be able to include some of the priority items as part of the development cycle.

4. **Cultural Fit:** Can you describe the working style, communication preferences, and expectations from your team?

BASE / Empa form a dynamic team of individuals of different backgrounds (researchers, engineers, data scientists, climate finance specialists), driven by the prospect of contributing to reduce postharvest losses and improve farmers’ livelihood with the Your VCCA project and beyond. We have a lean communication style (via Slack, emails, virtual meets) and try to develop Coldtivate with the needs of the end users at the centre. As a result, we regularly take a step back from the day-to-day development plan to understand and prioritise user feedback, as well as brainstorming on how to support the users in the adoption of Coldtivate. We value working relationships that are based on open communication, transparency, attention to detail, and a shared understanding of the project mission.

5. **Budget Allocation:** How has the budget been allocated across different areas of the project, such as development, design, marketing, and maintenance? Are there specific areas where the budget has exceeded or undershot expectations?

As the availability of budget is project-dependent and thus not easily adjustable, we try to compensate for unexpected overload by re-prioritising pending features. While some ‘flagship’ features are agreed with the project donors and are not negotiable, we have so far been able to reduce the complexity of other tasks to remain within the agreed budget and time expectations.

6. **Cost Management:** What cost management practices are in place? Are there preferred vendors or contractors? How are costs tracked and reported?

To ensure the project remains within the envisioned budget, we track expenditure linked to app hosting and third-party services (Microsoft Azure, Twilio). BASE has access to not-for-profit discounts / credits and attempts to minimise costs associated with software whenever possible. To track the app development work, we ask the software development team to keep track of working hours invested in the development of batches of features and regularly check that this
matches expectations. In case of overtime, we are open to re-discuss how to simplify the implementation of consequent features.

Technical aspects

**1. Codebase Access and Documentation:** Can you provide access to the current codebase for both iOS and Android apps? Is there comprehensive documentation available for the codebase, APIs, and third-party services integration?

The current codebase is hosted on Gitlab and the code can be shared for review. The same code (frontend and backend) is used for the app, which is available at app.coldtivate.org, on iOS, and on Android. Apart from the main code block, there are the following external modules:

- Machine Learning Market Forecast model for India (ML4market India)
- Machine Learning Market Forecast model for Nigeria (ML4market Nigeria)
- Impact Dashboard
- Farmers Dashboard
- App Impact Monitoring module (to export app impact data in excels)

All these components have been primarily developed by BASE / Empa and are properly documented. The rest of the codebase (which is entirely developed by the software company without active hands-on participation of BASE / Empa) is documented (in code), but lacks a testing suite. We also have some technical documentation which can be easily shared, but it is rather high-level and not fully up-to-date.

**2. Version Control History:** Can we review the version control history to understand the development progression, including any branches, commits, and merges? This will help us assess the project’s technical debt and development practices.

Yes, all history is documented on GitLab / GitHub.

**3. Collaboration Tools:** What project management and collaboration tools have been used? Are there ongoing discussions, tickets, or documentation that we should review?

We have been using Jira to keep track of tickets and work done, weekly meetings to prioritise and discuss tickets, and Confluence to keep track of meeting notes. We can grant access to the Jira board if of interest, and share some more details on the next tasks we are planning to integrate, for which tickets are not yet available.

**4. External Dependencies:** Are there external dependencies, such as third-party libraries, APIs, or services, that are crucial to the app’s functionality? What are the terms of use or licensing for these dependencies?
Apart from the external modules developed by BASE / Empa, the Coldtivate app is connecting to 3 APIs to fetch temperature sensor data (Ecozen, UbiBot, Figorr). These integrations have been developed in close collaboration with the aforementioned companies and are adds-on rather than components that are crucial for app’s functionality. The app also integrates .exe files developed in COMSOL Multiphysics, a software for physics-based simulations that has been used by Empa to develop physics-based models of fruits and vegetables ageing coupled with real-time temperature data (Digital Twin models). The integration of the .exe files is possible without COMSOL licence. Finally, the app uses Twilio as a software to send SMS to users without smartphones. Given the existing feedback of some Nigerian users being unable to receive this SMS, we are interested in exploring the option of adding an additional service with higher delivery rate to Nigerian phones.

5. Previous Development Team: Will you provide contact information for the previous development team members? Their insights could be invaluable for understanding the context behind certain architectural decisions or unresolved issues.

The app has been developed by two sets of developers. We are confident that we can provide direct contacts of the software company that has been implementing the most recent part of the code.

6. Development Environment: What development, testing, and deployment environments are in use? Are there any specific CI/CD pipelines set up?

We usually develop across three environments: a local environment (internal to the development team), a testing environment (accessible at apptest.coldtivate.org and as Android beta releases / iOS TestFlight), and the production environment. Both test and production environments (including databases) are hosted on Microsoft Azure. There is no automated CI/CD pipeline in place, and testing is rather sparse and confined to isolated modules. Implementing a proper testing suite and integrating it as part of a standardised CI/CD pipeline for deployment is one of the tasks we are planning to implement to make the code ready for open-source publication. The BASE / Empa team usually supports the developers with User Acceptance Testing after multiple rounds of reviews internal to the software company.

7. App State and Performance: What is the current state of the app in terms of functionality, scalability, and performance? Are there any known issues or technical debts?

In the past months, we have been focusing on troubleshooting the app and making it more stable. Despite these efforts, we are aware of the current issues:

- Resource overload: CPU / memory are sometimes at capacity due to suboptimal implementation of the Digital Twin (DT) models. The DT models are currently
implemented as part of the main app code, but it should be evaluated whether having them as an external service would be beneficial
- Long query times due to nested structure of the existing database
- Difficulties for users in low connectivity regions to access parts of the app. We would like to focus on making the app as lightweight as possible to allow these users to access the app more easily.
- App frontend sometimes fails to refresh and remains stuck in the wrong screen despite the implementation of loading screens.

Our primary goal at this stage is to refactor the app to ensure high performance (including minimising downtime, resource overload, and non-responsiveness) and scalability (as we expect a 10x increase in the number of users in the upcoming year), and this is why we welcome suggestions on how to refactor / rewrite current codebase to reach this goal.

8. Compliance and Security: Have any security measures or compliance standards (e.g., GDPR, HIPAA) been implemented? How is user data handled and protected?

Users signing up on Coldtivate agree to its Privacy Policy and EULA, and COMSOL Terms of Use. User data is hosted on Microsoft Azure to which only BASE, Empa, and the software team have direct access. Data is protected with standard Microsoft Firewall and network security rules. Each cooling company is able to download utilisation data for their own cold rooms (and cold room users), but have no visibility on other companies’ operations.