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SmartCommUnity

DELIVERABLE 3.4.1 | **Component for data analysis**

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Abstract

This **Deliverable 3.4.1** presents the component for **Data Analysis**, which is a software solution in the form of a **WordPress plugin** that merges various metrics and features into a single dashboard. It can analyze users' sentiment, create charts, and compile forum data for export, among many other capabilities. Our **community managers** can track user registrations, comment activity, and server parameters. The plugin also supports GamiPress for points-based leaderboards and monitors recent content performance. An optional short code allows the dashboard to be **displayed beyond the admin area**, making it suitable for different presentation needs.

Introduction

Handling large amounts of information requires careful organization and processing. Our **Data Analysis Component (DAC)** applies statistical methods and machine learning to turn raw data into structured and helpful material in the context of Smart Villages [4]. The goal is **to support Community Managers (CMs)** with findings of interest that could guide practical steps.

In the context of this work, we have developed a **WordPress plugin** [7] offering a community insight dashboard to do that. Key functionalities include **chart generation** (via QuickChart.io), **sentiment analysis**, **forum CSV export**, **server environment** details, **gamification metrics** [1, 2], WordPress **database overview**, and **content performance** analytics.

The aim of the DAC is to serve CMs who need **a single interface** to monitor all details. To do that, our DAC provides an **all-in-one panel** for CMs who handle online discussions and content-driven communities. It integrates data related to posts, comments, forum topics, user registrations, and other key areas, enabling a unified method of community monitoring.

Other aspects such as sentiment analysis, chart rendering, and optional gamification details complete the DAC which also **allows measuring participation and engagement**. The CSV export function, paired with an overview of server settings and database status, keeps relevant

information within **easy reach for ongoing analysis**, both internally (project stakeholders) and externally (people from academia researching Smart Villages and Communities).

Each section of the DAC is designed to **reduce the time spent** switching between tools or manually collecting data. Instead of relying on separate plugins, our DAC consolidates key indicators in one place. The major goal is to provide **immediate access** to **relevant information** while maintaining compatibility with different hosting environments and WordPress setups.

Our design choices have been guided by our operational needs: user tracking, content monitoring, infrastructure checks, and periodic reviews. With a focus on performance, usability, and maintainability, our DAC should help assess what is happening on our site **smart-alps.eu** at a given moment and **react accordingly**.

The rest of this document is organized as follows: Section 2 presents the **Analysis** that has guided the development of the DAC. Section 3 explains the core **Functionality** of the DAC as well as the implementation history and limitations. Section 4 details our plans for long-term **Sustainability** of the DAC. Finally, we conclude with the major remarks and possible future actions.

Analysis

Our DAC is designed to give CMs a unified way to track **community engagement** [3] and system performance. It collects data from key sources such as posts, comments, users, and settings, and summarizes it through visual, low-overhead charts. The following sections detail the **core requirements**, covering data monitoring features, sentiment analysis, export options, integration methods, and internal architecture.

Motivation

The DAC has been created to **simplify daily site operations** for those managing WordPress platforms like **smart-alps.eu**. Many typical tasks such as checking user activity, reviewing content, or verifying server status require switching between tools or gathering information

manually. That setup is inefficient and often leads to **delays or oversights**. The **DAC replaces scattered tools** with one dashboard that shows essential data using static charts and standard tables, which keeps load times low and **avoids unnecessary browser dependencies**. It includes features for content tracking, sentiment tagging, export options, and system checks. All presented in a form that fits naturally within the WordPress admin area. The aim is to provide a tool that **helps CMs understand** what is happening and respond without extra effort.

Requirements

The following are the requirements that have guided the building of this component:

Requirement 1: The component should be designed to give WordPress stakeholders **a clear view of what is happening** across their platform. It should collect data from posts, comments, users, and system settings, and present it through **visual summaries** that are **easy to interpret**. These visual elements should be delivered as image charts, which reduces browser load and removes the need for JavaScript-based libraries.

Requirement 2: The component should include **tools to monitor** user activity across hours of the day, and **participation trends**. It should add a basic method for analyzing sentiment in forum topics, giving a rough signal of how users express themselves. This can help **moderators notice shifts in tone** or **identify threads** that may need attention. It should also track individual users' activity, such as posting frequency, comment volume, and recognition through likes.

Requirement 3: The component should be able to **analyze forum topics** and export them in CSV format, optionally including sentiment scores. This should make it easier to **analyze trends** offline or **use the data in other systems**. It should also include **system-related metrics** like disk usage, PHP/MySQL versions, and current memory load, giving admins a broader picture of performance without needing to install separate diagnostics tools.

Requirement 4: The **main dashboard** should appear in the WordPress admin sidebar. All display elements should use standard tables and images, and chart sections should be wrapped in **visual containers for readability**.

Requirement 5: The component should use **WordPress hooks and native APIs** to remain compatible with common setups. It could also be extended to support more advanced analytics, REST API endpoints, or other plugin integrations if needed. The plugin should serve as a **general-purpose monitoring tool** that balances **practicality** with **flexibility**.

Target Audience

The DAC is oriented to be used by CMs to **monitor activity** on the platform **efficiently**. The DAC collects information from posts, comments, user sign-ups, and server settings, presenting it through charts and tables. This setup should help CM **identify trends**, **detect changes** in participation, and **keep track** of key events without switching between multiple plugins or exporting data manually. The sentiment scores attached to **recent discussions** should serve as an **early signal for moderation** or **follow-up**.

The DAC also supports **sharing** and **reporting tasks**. CMs can export data in CSV format and display parts of the dashboard on public pages using a short code. If gamification is active, the tool provides rankings based on user activity. These features make it easier to **measure participation** and report on **user engagement**. The DAC also should show technical details such as system performance, making it easier to assess the state of the platform.

The Data Analysis Component

The DAC component is structured as a **modular WordPress plugin**, designed for easy integration and extensibility. It registers custom admin menu entries, hooks into WordPress actions to collect and process data, and provides short codes for frontend display when needed.

Introduction

Figure 1 shows us how the DAC provides a clear **visual overview** of **forum activity**, enabling CMs to monitor **discussion topics over time**. The interface supports interactive charts that reflect **key**

metrics such as topic volume, author distribution, and sentiment trends. This helps **identify emerging themes**, **shifts in engagement**, or **areas that may require moderation**.

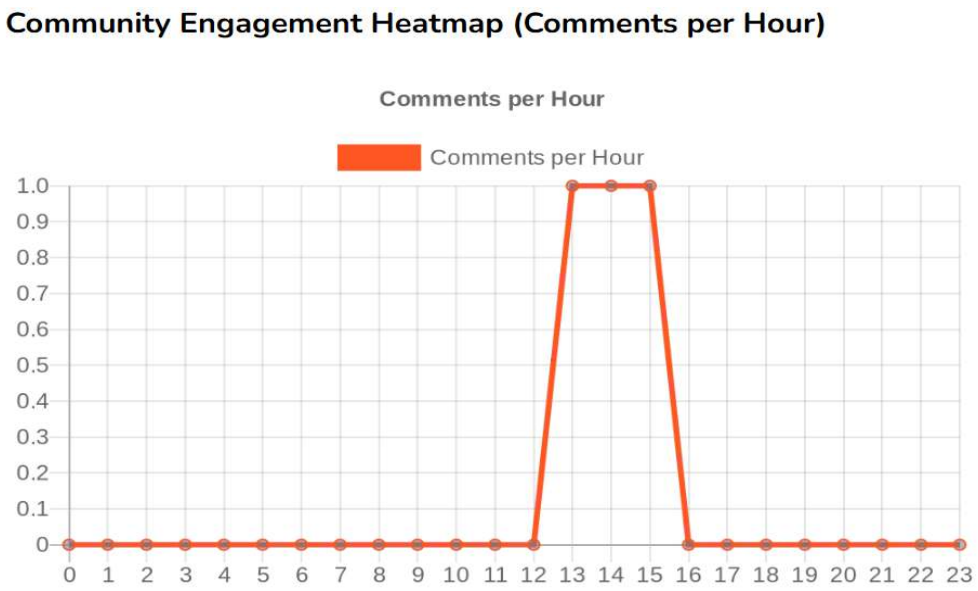

Figure 1. *Example of community engagement using our DAC*

Figure 2 shows an example of a plot illustrating the evolution of the **topic created by date**, including the trends, peaks, and fluctuations in topic activity over the observed period.

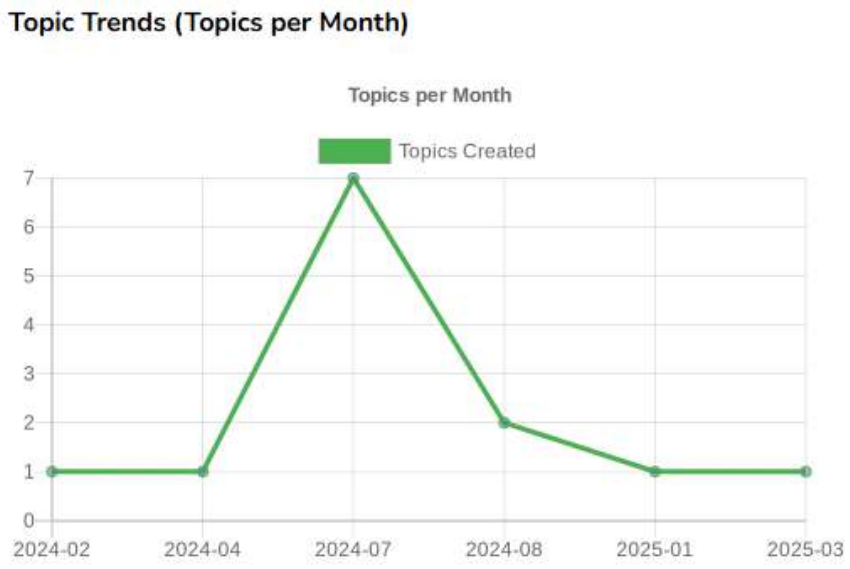

Figure 2. *Evolution of the topic created by date*

Figure 3 shows us the monthly analysis of **user registrations**. This is interesting because it shows trends in platform adoption and seasonal activity, revealing periods of peak interest and potential engagement opportunities. The number of registrations **has increased significantly** since the first stable version of the smart platform was released.

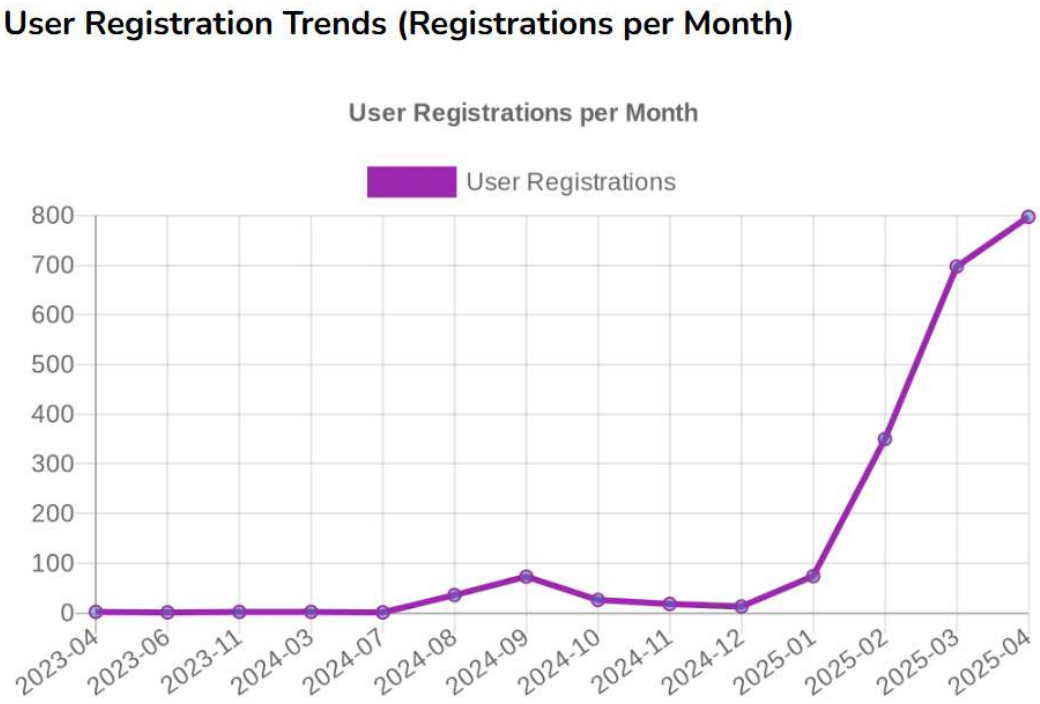

***Figure 3**. Analysis of user registrations by month*

Figure 4 shows the general view through which the DAC offers access to **key metrics and configuration options** through a **unified interface**. From this screen, CMs can navigate between different **reporting sections**, **adjust filters**, and **trigger data exports**. The layout is optimized for clarity and ease of use.

At the same time, **Figures 5** and **6** also show other aspects of the DAC, particularly, the **engagement-related metrics** and environment**-related information.** In our opinion, this is interesting for our CMs because it provides additional context on how users interact with the platform and the conditions under which usage occurs.

Last 5 Forum Topics

Title	Date	Author
Getting to Valence was easy	2025-03-19 10:42:13	Jorge Martinez-Gil
Municipal Communication Platforms	2025-01-09 12:34:28	Jure Trilar
How can governance get smarter in regards of public participation?	2024-08-07 11:05:31	Lucas
Sharing Ideas on Social and Local Cohesion	2024-08-05 12:38:32	Jorge Martinez-Gil
What role does sustainability play in the concept of smart living?	2024-07-29 16:56:09	Lucas

Sentiment Analysis of Forum Topics

Title	Date	Sentiment Score
Getting to Valence was easy	2025-03-19 10:42:13	0
Municipal Communication Platforms	2025-01-09 12:34:28	0
How can governance get smarter in regards of public participation?	2024-08-07 11:05:31	0
Sharing Ideas on Social and Local Cohesion	2024-08-05 12:38:32	0
What role does sustainability play in the concept of smart living?	2024-07-29 16:56:09	0
How important do you believe sustainability is in the context of a smart economy	2024-07-29 16:49:36	0
How do you see data analytics contributing to the effectiveness of a smart eco?	2024-07-29 15:50:30	0
What role do you think technological innovation plays in a smart economy?	2024-07-29 15:18:29	0
Sustainable Transportation	2024-07-29 09:53:23	0
Best Software for Smart Governance?	2024-07-25 16:17:16	0

Feedback Sentiment Summary (Last 20 Topics)

Total Topics Analyzed	Positive	Negative	Neutral
13	1	0	12

Top Community Contributors

User	Topics Created
Lucas	6
Jorge Martinez-Gil	5
Noémie Lechat	1
Jure Trilar	1

Figure 4. *General view of some metrics monitored by the DAC*

Engagement Leaderboard

User	Engagement Score
Jorge Martinez-Gil	12
Lucas	10
Noémie Lechat	2
Jure Trilar	2
Annalisa	1

Recent Comments

Comment	Author	Date
These are great news. Many thanks for sharing with us.	Jorge Martinez-Gil	2025-04-10 14:57:27
Very interesting. Many thanks for sharing!!	Jorge Martinez-Gil	2025-03-27 13:17:03
E' stato davvero un momento molto bello in cui si...	Annalisa	2024-12-19 15:44:20

Latest Registered Users

Username	Email	Registered Date
alexandracleme	evseqf@recreationalmarijuanashop.com	2025-04-15 12:16:43
jillmcquillen	brianchery@mailmenot.io	2025-04-15 11:18:38
margaritakibbl	fsdfeasd8fsad1@cheaptrave.space	2025-04-15 09:53:17
tamimilam84885	luigipitre7719@anonmails.de	2025-04-15 09:34:30
julianndaigle2	mollysteward@qiott.com	2025-04-15 08:53:28

Recent Blog Posts

Title	Date	Author
19-20 March 5th SmartCommunity project Meeting in the Rhone Valley	2025-03-24 13:23:10	Jure Trilar
SMART LAB opened in the test area in Cogorno (IT)	2025-03-07 13:20:24	Jure Trilar
Newsletter#2	2025-02-26 13:19:15	Jure Trilar
Lighthouse Test Area in the Autonomous Region of Valle d'Aosta	2025-01-31 13:18:26	Jure Trilar
Join the Smart Alps Network!	2025-01-31 13:17:25	Jure Trilar

Figure 4. *Example of engagement-related metrics*

Server Environment Information

WordPress Version	PHP Version	MySQL Version	Current Theme	Memory Limit	Max Execution Time
6.7.2	7.4.33	10.6.21-MariaDB-cll-lve-log	Cirkle	256M	60

Performance Metrics

Average Page Load Time	Current Memory Usage	Peak Memory Usage
Not available	61 MB	88 MB

Cirkle Theme Information

Theme Name	Version	Author	Description
Cirkle	1.2.5	RadiusTheme	Cirkle is one of the latest and unique responsive community WordPress Theme.

Disk Space Usage

Total Space	Free Space	Usage
700 GB	178 GB	74.63%

Figure 5. *Example of environment-related information*

Functionality

All the functionalities that our DAC can carry out are summarized below.

- **Site Overview**: Including posts, pages, topics, comments, users.
- **Word Cloud Chart**: Constructs bar chart from the top 20 words used in recent comments.
- **Engagement Heatmap**: Shows the distribution of comments per hour (line chart).
- **Topic Trends**: Shows topics created per month.
- **User Registration Trends**: Registrations per month.
- **Top 5 Active Topics**: Based on comment counts.
- **Active Users**: Topics posted in the last 30 days.
- **Last 5 Forum Topics**: To monitor the latest trends
- **Sentiment Analysis**: Score for the last 10 forum topics.
- **Feedback Sentiment Summary** (positive, negative, neutral distribution).
- **Top Community Contributors** (by topic count).
- **Engagement Leaderboard:** To identify local heroes.
- **Recent Comments:** To better understand the latest trends in the platform.
- **Latest Registered Users:** To assess legit activity.
- **Recent Blog Posts:** To monitor the latest trends.
- **Gamification Leaderboard:** To see the rewards of the community members.
- **Latest Users Logins:** To assess legit activity.
- **Content Performance**: Top engaged posts by comment count.
- **Gamification Leaderboard** (requires GamiPress plugin).
- **User Engagement Overview**: Summarizes topics + comments per user to form an "engagement score."
- **Server Environment**: Displays WP version, PHP version, MySQL version, current theme, memory limits, etc.
- **Performance Metrics:** To be able to assess user experience.
- **Cirkle Theme Information**: If the theme named "cirkle" is installed.
- **Disk Space Usage:** To be aware of usage limits.

Dependencies

It is necessary to have these dependencies installed to run our component:

- **WordPress Version**: Recommended 5.0 or higher (due to newer WordPress functions)
- **PHP Version:** 7.0+ recommended (basic JSON support and performance).
- **QuickChart.io**: External service for rendering static charts. No library installations are required; the plugin constructs image URLs.
- **GamiPress (optional):** If installed and active, the plugin can display a leaderboard.
- **MySQL:** The plugin uses $wpdb queries that require WordPress database structure.

Installation and Usage

Our DAC can be installed by completing the following steps:

1. **Download/Clone** the plugin folder into `wp-content/plugins/`.
2. **Activate** from the WordPress admin ("Plugins" page).
3. **Verify** that you have a custom post type `topic` in your admin sidebar.
4. **Access the Dashboard** via "Community Dashboard" in the sidebar.
    - Alternatively, **use the Shortcode** `[ccd_dashboard]` in a page or post to display the same data to authorized users (or the public if no other access constraints exist).
5. **Export CSV**: A button is provided on the dashboard to export forum topics. Only users with `manage_options` capability can do so.

Admin Interface

Figure 3 shows an example of charts plotted within the DAC. The interface uses WordPress-native components to **maintain consistency** and **reduce the learning curve** for administrators. All visualizations are rendered client-side using **lightweight libraries** to ensure responsiveness.

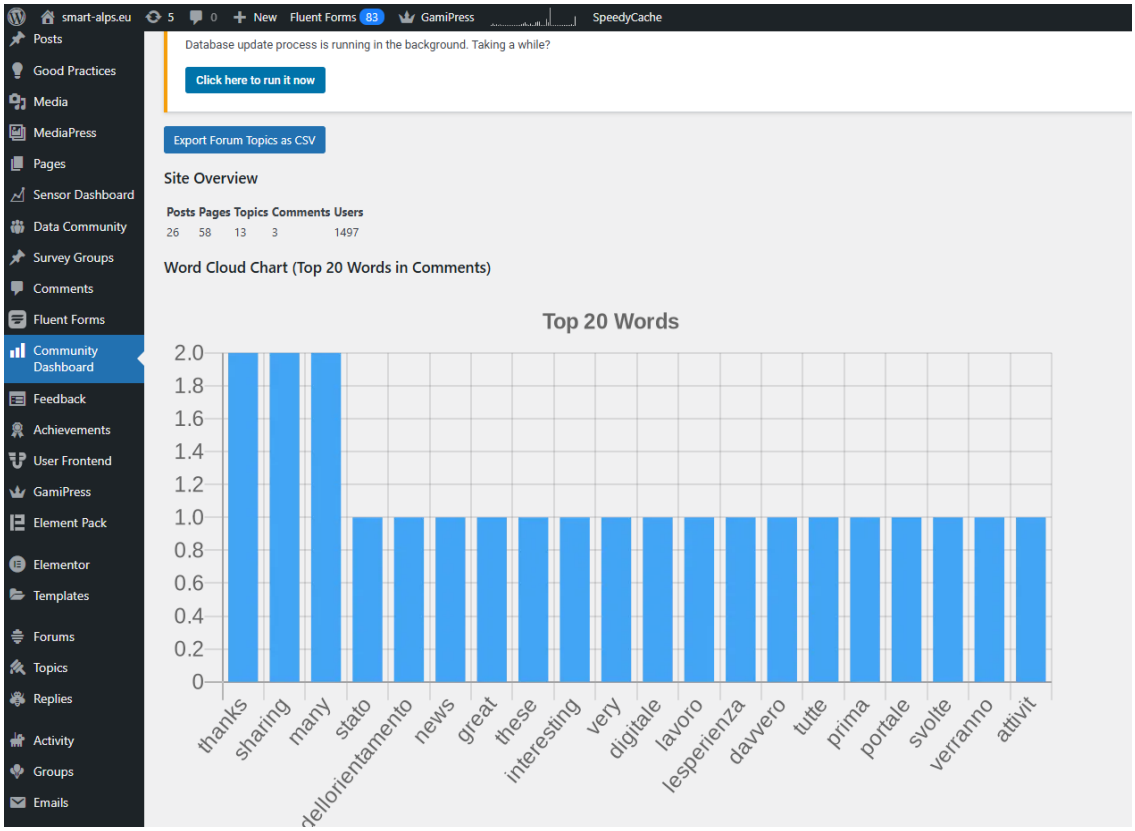

Figure 6. *Admin interface of our DAC*

Known Limitations

Some of the limitations of our DAC can be summarized as follows:

- **Real-time updates are not supported** (refresh required). This decision **prioritizes stability** and avoids introducing frequent background queries or websocket-based listeners, which can introduce scaling issues or resource contention in shared hosting.
- Charts **rely on external QuickChart.io** that it is a lightweight library; if offline, fallbacks are not rendered.
- **Sentiment analysis uses a basic keyword match**—no context awareness. The approach **avoids dependency on third-party NLP services** but limits nuance. A future improvement could involve adding part-of-speech filters to improve precision.

Security Considerations

The plugin follows WordPress **security practices**, including **nonce verification** for export actions, **role-based access control**), and **output sanitization** via built-in escaping functions. User input is validated and sanitized, **minimizing potential injection vectors**. These measures are in place to ensure reliable behavior across installations **without introducing unnecessary risk**.

Technical Specifications

Our DAC component is structured as a **standard WordPress extension** [5], organized into clearly separated functions. Each major feature is handled through its own section of the component's codebase to support **clarity** and **maintainability**. This structure allows **selective reuse of individual features** in other contexts, such as custom dashboards or integrations with third-party tools.

Architecture Overview

The key components of our architecture are the following:

- **Startup and Hooks**
  Initialization is handled through **WordPress action hooks** [6]. These include registering the custom post type (`topic`), adding admin menus, and setting up login tracking. Activation and deactivation routines take care of rewriting rules and cleanup.
- **Admin Interface**
  The main dashboard appears in the **WordPress admin sidebar**. It is rendered with `ccd_render_dashboard_page()`, which outputs each block in sequence. All display elements use **standard HTML tables and images**, and chart sections are wrapped in visual containers for readability.

- **Data Queries**

  Statistics are retrieved using direct **SQL queries** via the **$wpdb** object and WordPress-provided functions. These include counts of posts, comments, users, and category totals. Queries are limited and scoped to **avoid performance issues**.

- **Chart Integration**

  All charts are generated using static images from **QuickChart.io**. A JSON configuration object defines each chart, which is then converted into a URL and displayed with an image tag. This **avoids extra client-side processing** or dependencies.

- **Sentiment Analysis**

  Sentiment is analyzed through a **word-matching algorithm**. A fixed list of positive and negative terms calculates a numeric score. The function is self-contained and does not rely on external APIs.

- **Gamification Support**

  If GamiPress is active, the plugin **collects point totals** for each user and ranks them. This feature is optional and does not interfere with other plugin behavior if the dependency is missing.

- **CSV Export**

  The export feature gathers forum topic data and sends it as a **downloadable CSV file**. User permissions are checked, and security is handled with nonces. The exported data includes titles, dates, authors, and sentiment scores.

- **Frontend Display**

  A short code is available for **embedding the dashboard** into **any public page**. It reuses the same logic used in the admin area, with minimal changes. This is relevant for CMs that wish to expose engagement metrics to the broader community or stakeholders, without requiring backend access.

- **Code Structure**

  Functions are written to return values where possible. This allows reuse in other views or extensions. Constants, hooks, and helper functions are used to **separate logic from presentation**.

Supporting Software and Licenses

The technical specification is as follows:

- **Tags:** community, analytics, dashboard, gamification, engagement, user activity
- **Requires at least:** Wordpress 5.8
- **Tested up to:** Wordpress 6.5
- **Stable tag:** 3.6
- **License:** GPLv2 or later
- **License URI:** https://www.gnu.org/licenses/gpl-2.0.html

Description: It is implemented in the form of a WordPress plugin providing community analytics including chart images, forum insights, user activity, sentiment analysis, CSV export, server data, and GamiPress stats.

Changelog

The changelog of the component has been the following:

v1.6

- Added **disk space usage** section.
- Display of latest **user login timestamps**.
- **Performance metrics**: memory usage and page load placeholder.
- **Category insights** section added.
- **General cleanup** and **layout consistency.**

v1.5

- Introduced **engagement leaderboard** based on topics, comments, and likes.
- **Likes given/received** counters via user meta.
- **GamiPress integration** with top 5 leaderboard.

v1.4

- **Sentiment analysis** summary added for the last 20 topics (positive/neutral/negative).
- Recent comments, latest registered users, and recent blog posts **sections added**.
- **Top Community Contributors** block showing most active topic creators.

v1.3

- Added **shortcode** `[ccd_dashboard]` for **frontend display**.
- Access control using WordPress capabilities for exports and admin sections.

v1.2

- **CSV export** of forum topics including sentiment scores.
- **Nonce-based** protection for export actions.

v1.1

- **Sentiment analysis** based on keyword frequency.
- **Topic sentiment table** for recent forum topics.

v1.0

- Initial release of the **DAC component**.
- Inclusion of **first sections**: site overview, comment heatmap, word frequency chart, topic and registration trends.
- **Top 5 active topics** and active users (30-day window).
- **Server environment** and **Cirkle theme details.**

Sustainability

To guarantee sustainability once that t**he project might be finished**, the component is built using standard WordPress APIs and follows **best practices for plugin development** to ensure **compatibility with future WordPress versions**. Dependence on **external services is optional** and loosely coupled, **reducing risk** if those services become unavailable.

Furthermore, the **codebase is modular**, making it maintainable and extensible as community needs evolve. **Clear documentation** and **adherence to open-source conventions** also allow for broader **community contributions** and **easier onboarding of new developers**. Regular updates and a focus on minimal reliance on niche libraries help ensure long-term usability and **low technical debt**.

Short-Term Sustainability

To further support its sustainability soon after the project is finished, the plugin **avoids hardcoded configurations** and instead **offers a settings panel for administrators** to adjust key parameters without modifying the source code. This flexibility enables adaptation to **different hosting environments** and **community scales**. **Error handling** and fallback mechanisms are built in to ensure **graceful degradation** if certain **data sources become unavailable**.

The DAC is also compatible with common caching and security plugins, **reducing maintenance overhead** and integration conflicts. These design choices aim to keep the component stable, adaptable, and usable over extended periods without requiring constant refactoring.

Long-Term Sustainability

In order to guarantee **sustainability in the long term**, our DAC will be integrated with the **SmartAlps Network (**https://smart-alps.eu/smartalps-network/**)** which is an initiative designed to **connect Alpine communities across Europe**, enabling them to collaborate on various topics such as mobility, agriculture, housing, and economic development. This platform

aims to keep offering tools like an interactive guide, gamification approaches, and a catalogue of good practices to assist communities in their smart transition.

The rationale behind facilitating discussions and sharing innovative solutions is to create smarter, more sustainable, and resilient rural areas in the **Alpine region** [8]. This **network will remain active after the project is finished**, and will keep receiving support, so the plugin will keep playing a role after the SmartCommUnity project.

Supporting Open Data: Data Export

Export functionality is particularly useful for stakeholders that wish to conduct **periodic offline audits**, **generate internal reports**, or **combine dashboard outputs** with other datasets. It can also be used for **research purposes**. The CSV format ensures portability and compatibility with standard data analysis tools. Our DAC is explicitly **prepared for exporting data**. To get the data dump, it is necessary to access via this URL:

```
/wp-admin/admin.php?page=community-dashboard&ccd_export=csv&ccd_export_nonce={nonce}
```

Generates a file: **forum_topics.csv** with the following fields:

- **Topic ID**
- **Title**
- **Author**
- **Date**
- **Sentiment Score**

The export operation preserves the current filtering set in the dashboard, ensuring consistency between the on-screen view and the exported file. All timestamps are stored in UTC and follow ISO 8601 format to facilitate integration and comparison across systems.

Conclusions

In this **Deliverable 3.4.1**, we have presented **our DAC** as a suitable component for **analyzing all the data generated** through the **Smart Platform**, and how it groups relevant site data into **a single administrative tool**. We have also seen how our DAC can combine different kinds of content such as posts, comments, topics, user registrations, and server parameter metrics with chart-based summaries and export capabilities. This **reduces the need to switch between plugins or perform manual data checks**.

Our component can collect information already present in the WordPress environment and present it to CMs in a way that **supports regular reviews**. Whether checking user registrations, identifying active topics, or scanning for sentiment trends, our component can provide access **without requiring additional configuration**.

Other features include such aspects as gamification rankings and public display through short codes, so the information is available for everybody. Export functions that allow offline analysis or record-keeping. System information, including PHP, MySQL, and WordPress versions, helps **detect configuration issues early**.

The design focuses on **usability** and **long-term compatibility**. The DAC works with **standard APIs** and **avoids dependencies** that could cause maintenance problems. It is suited for sites where **CMs need practical tools to monitor activity** and **site health without too much overhead.**

The DAC has been tested across **different configurations** and several volumes to confirm consistent behavior and **acceptable performance**. It is currently in use to monitor **our Smart Platform**, where it supports **day-to-day monitoring** and reporting needs with minimal overhead required.

Possible Future Improvements

While our DAC already offers a **wide range of monitoring and reporting tools**, several **improvements** could expand its **usefulness and reach**. These additions would support **broader accessibility, make the data more portable**, and allow for more **fine-grained analysis** of community behavior. Below are **some ideas** that could be taken into consideration in further developments of the platform.

Accessibility Features

Implement **keyboard navigation** and **WCAG 2.1 compliance** for broader usability across different user needs and **assistive technologies**. This includes ensuring logical tab order, visible focus indicators, sufficient color contrast, and proper use of semantic HTML elements. This would also **improve compatibility** with screen readers and voice-control tools.

REST API Exposure

Make all the **data available via a REST API** to support headless WordPress setups or integration into external systems and dashboards. This would allow developers to build **custom front ends** or connect to external data pipelines, business intelligence tools, and automated workflows more easily.

User Segmentation

Add **filtering options** to analyze data by **user roles**, **geographic regions**, **activity levels**, or other dimensions. This would **help CMs better understand different audience segments** and tailor engagement strategies accordingly. Filters could be combined to create **more targeted views**, such as identifying highly active contributors within a specific region or tracking new user engagement by role.

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