Appendix B. Resilience attributes

In FoPIA-SURE-Farm I (Paas et al., 2019) the list with original resilience attributes as proposed by Cabell & Oelofse (2012) was extended by splitting up original attributes (italic in Table B1) and adding new resilience attributes and explanations (bold in Table B1) based on the research focus and the resilience research framework of SURE-Farm (Meuwissen et al. 2019). For the sake of workability during the FoPIA-SURE-Farm I and II workshops, only 13 attributes were selected to be evaluated in the workshops (in green). These covered all processes and resilience principles (see last columns), and some overlap was assumed with the other 9 resilience attributes. The other 9 (in red) were also considered when assessing the contribution of strategies to resilience attributes, as this research-based assessment aimed to assess the most important resilience attributes, and hence starting with a full list was appropriate.

Table B1 . List of resilience attributes (based on Cabell & Oelofse (2012) and Meuwissen et al. (2019)). Italic font indicates that these attributes are split up with reference to the original attribute in Cabell & Oelofse (2012). Bold font indicates that attributes and information are added based on Meuwissen et al. (2019). Green font indicates that these attributes are selected to be evaluated during the FoPIA-SURE-Farm I workshops. Source: Paas et al. (2019). See also Meuwissen et al. (2022) for shorter explanations.

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| **Resilience attribute** | **Definition** | **Implications** | **Characteristics** | **Related to SURE-Farm process** | **Related to general resilience principles** |
| Reasonably profitable | Persons and organizations in the farming system are able to make a livelihood and save money without relying on subsidies or secondary employment | Being reasonably profitable allows participants in the system to invest in the future; this adds buffering capacity, flexibility, and builds wealth that can be tapped into following release | Farmers and farm workers earn a livable wage; agriculture sector does not rely on distortionary subsidies | Agricultural production | System reserves |
| Coupled with local and natural capital **(production)** | The system functions as much as possible within the means of the bioregionally available natural resource base and ecosystem services | Responsible use of local resources encourages a system to live within its means; this creates an agroecosystem that recycles waste, relies on healthy soil, and conserves water | Builds or maintains soil fertility, recharges water resources, little need to import nutrients or export waste | Agricultural production | System reserves |
| *Functional diversity* | *Functional diversity is the variety of (ecosystem) services that components provide to the system* | *Diversity buffers against perturbations (insurance) and provides seeds of renewal following disturbance* | *Diversity of inputs, outputs, income sources, markets, etc.* | *Risk management* | *Diversity* |
| *Response diversity* | *Response diversity is the range of responses of these components to environmental change* | *Diversity buffers against perturbations (insurance) and provides seeds of renewal following disturbance* | ***Diversity of risk management strategies****, e.g. different pest controls,* ***weather insurance, flexible payment arrangements*** | *Risk management* | *Diversity* |
| Exposed to disturbance | The system is exposed to discrete, low-level events that cause disruptions without pushing the system beyond a critical threshold | Such frequent, small-scale disturbances can increase system resilience and adaptability in the long term by promoting natural selection and novel configurations during the phase of renewal; described as “creative destruction” | Pest management that allows a certain controlled amount of invasion followed by selection of plants that fared well and exhibit signs of resistance | Risk management | Openness |
| Spatial and temporal heterogeneity **(farm types)** | Patchiness across the landscape and changes through time | Like diversity, spatial heterogeneity provides seeds of renewal following disturbance | **Diverse farm types with regard to economic size, intensity, orientation and degree of specialisation.** | **Farm demographics, risk management** | **Modularity, diversity** |
| *Optimally redundant* ***(farms)*** | *Critical components and relationships within the system are duplicated in case of failure* | *Also called response diversity; redundancy may decrease a system’s efficiency, but it gives the system multiple back-ups, increases buffering capacity, and provides seeds of renewal following disturbance* | ***Farmers stop without endangering continuation of the farming system and new farmers can enter the farming system easily*** | ***Farm demographics; risk management*** | ***Modularity*** |
| **Supports rural life** | **The activities in the farming system attract and maintain a healthy and adequate workforce, including young, intermediate and older people** | **A healthy workforce that includes multiple generations will ensure continuation of activities and facilities in the area, and the timely transfer of knowledge** | **A balanced population with young, intermediate and older people; Enough facilities in the nearby area to maintain an adequate standard of life** | **Farm demographics** | **System reserves** |
| Socially self-organized | The social components of the agroecosystem are able to form their own configuration based on their needs and desires | Systems that exhibit greater level of self-organization need fewer feedbacks introduced by managers and have greater intrinsic adaptive capacity | Farmers are able to organize themselves into networks and institutions such as co-ops, farmer’s markets, community sustainability associations, and advisory networks | Governance | Tightness of feedbacks |
| Appropriately connected **with actors outside the farming system** | **The social components of the agroecosystem are able to form ties with actors outside their farming system** | **In case self-organization fails, signals can be send to actors that indirectly influence the farming system** | **Farmers and other actors in the farming system are able to reach out to policy makers, suppliers and markets that operate at the national level** | Governance | Tightness of feedbacks |
| Coupled with local and natural capital **(legislation)** | **Regulations are developed to let** the system function as much as possible within the means of the bio-regionally available natural resource base and ecosystem services | Responsible use of local resources encourages a system to live within its means; this creates an agroecosystem that recycles waste, relies on healthy soil, and conserves water | **Norms, legislation and regulatory framework adapted to the local conditions** | **Governance, agricultural production** | **System reserves** |
| **Infrastructure for innovation** | **Existing infrastructure facilitates diffusion of knowledge and adoption of cutting-edge technologies (e.g. digital)** | **Through timely adoption of new knowledge and technologies, a farming system can better navigate in a changing environment.** | **Infrastructure that allows new ways of agricultural production and improved information flows e.g. allowing track and trace of agricultural products throughout the value chain** | **Governance, agricultural production** | **Openness, system reserves** |
| **Diverse policies** | **Policies stimulate all three capacities of resilience, i.e. robustness, adaptability, transformability** | **Policies addressing all three resilience capacities avoid situations in which farming systems are permanently locked in a robust but unsustainable situation. Or situations in which adapting and transforming systems are increasingly vulnerable** | **Policies that create a stable and safe environment in which experimentation and structural change for more sustainable agriculture is supported** | **Governance** | **Diversity** |
| Ecologically self-regulated | Ecological components self-regulate via stabilizing feedback mechanisms that send information back to the controlling elements | A greater degree of ecological self-regulation can reduce the amount of external inputs required to maintain a system, such as nutrients, water, and energy | Farms maintain plant cover and incorporate more perennials, provide habitat for predators and parasitoids, use ecosystem engineers, and align production with local ecological parameters | Agricultural production | Tightness of feedbacks |
| *Optimally redundant* ***(crops)*** | *Critical components and relationships within the system are duplicated in case of failure* | *Also called response diversity; redundancy may decrease a system’s efficiency, but it gives the system multiple back-ups, increases buffering capacity, and provides seeds of renewal following disturbance* | *Planting multiple varieties per crop rather than one, keeping equipment for various crops* | *Risk management* | *Modularity* |
| *Optimally redundant* ***(nutrients & water)*** | *Critical components and relationships within the system are duplicated in case of failure* | *Also called response diversity; redundancy may decrease a system’s efficiency, but it gives the system multiple back-ups, increases buffering capacity, and provides seeds of renewal following disturbance* | *Getting nutrients and water from multiple sources.* | *Risk management* | *Modularity* |
| Spatial and temporal heterogeneity **(land use)** | Patchiness across the landscape and changes through time | Like diversity, spatial heterogeneity provides seeds of renewal following disturbance; through time, it allows patches to recover and restore nutrients | Diverse land use on the farm and across the landscape, mosaic pattern of managed and unmanaged land, diverse cultivation practices, crop rotations | Risk management | *Modularity, diversity* |
| *Optimally redundant* ***(labour)*** | *Critical components and relationships within the system are duplicated in case of failure* | *Also called response diversity; redundancy may decrease a system’s efficiency, but it gives the system multiple back-ups, increases buffering capacity, and provides seeds of renewal following disturbance* | ***Labour comes from multiple sources*** | ***Risk management; Farm demographics*** | ***Modularity*** |
| Globally autonomous and locally interdependent | The farming system has relative autonomy from exogenous control and influences and inhibits a high level of cooperation between individuals and institutions at the more local level | A system cannot be entirely autonomous but it can strive to be less vulnerable to forces that are outside its control; local interdependence can facilitate this by encouraging collaboration and cooperation rather than competition. | Less reliance on commodity markets and reduced external inputs; more sales to local markets, reliance on local resources; existence of farmer co-ops, close relationships between producer and consumer, and shared resources such as equipment | Governance, risk management | Openness |
| Reflective and shared learning | Individuals and institutions learn from past experiences and present experimentation to anticipate change and create desirable futures | The more people and institutions can learn from the past and from each other, and share that knowledge, the more capable the system is of adaptation and transformation, in other words, more resilient | Extension and advisory services for farmers; collaboration between universities, research centers, and farmers; cooperation and knowledge sharing between farmers; record keeping; baseline knowledge about the state of the agroecosystem | Governance | Openness |
| Honours legacy | The current configuration and future trajectories of systems are influenced and informed by past conditions and experiences | Also known as path dependency, this relates to the biological and cultural memory embodied in a system and its components | Maintenance of old varieties and engagement of elders, incorporation of traditional cultivation techniques with modern knowledge | Governance | System reserves |
| Builds human capital | The farming system takes advantage of and builds resources that can be mobilized through social relationships and membership in social networks | Human capital includes: constructed (economic activity, technology, infrastructure), cultural (individual skills and abilities), and social capital (social organizations, norms, formal and informal networks) | Investment in infrastructure and institutions for the education of children and adults, support for social events in farming communities, programs for preservation of local knowledge | Governance | System reserves |