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Evaluation Method for Biomass-harvest Logistics

Biomass harvest logistics is gaining in importance due the increasing amounts to be handled, e.g. for growing dairy cow herds or for biogas plants. The objective and the task of farm economics are on one hand the accounting of harvest activity work. On the other hand it should identify optimization potentials by creating transparency and by ensuring overall vertical and horizontal comparability. This paper shows exemplarily the method starting at the interpretation-orientated data collection and ending at selected comparable key figures.

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Keywords

Biomass, harvest logistics, operating figures, process comparison

Biomass harvest logistics is not limited to biomass transport. It includes the three process elements harvest, transport, and storage, as well as their interaction. Currently, the classic optimization of harvest logistics is mainly pursuing economic and process-technological goals (cost minimization and maximization of process output). As an implicit result of increasing fuel prices, ecological optimization is becoming useful for economic reasons alone (minimization of fuel consumption).

In this wide field, the present contribution concentrates on the description of a comprehensible method for the calculation of easily understandable key figures with the goal of allowing the entire work chain and individual machines involved to be evaluated both horizontally and vertically. The special focus of this contribution is on data collection.

Data collection

The raw data which are necessary for the calculation of key figures are largely generated during harvesting work. Therefore, the danger exists that overly intensive data collection may excessively impair actual harvest work or that the necessary minimum data depth and quality are not reached due to incomplete data collection. The objective to be striven for is evaluation-oriented data collection. In principle, the six information sources shown in *Table 1* are used for this purpose.

In the long run, it is conceivable to automate the collection of a large part of the information listed in *Table 1* as far as possible without additional manual input and to document it after information processing in a quality which is needed immediately for the calculation of key figures. In the short and medium run, however, manual collection will continue to play a more important role. This kind of data collection will be described in more detail below.

Weighing of incoming biomass

Incoming biomass is weighed by a vehicle weighing machine in kilograms of fresh weight [kg] and documented in weight notes. As standard, a weight note contains information about the transport vehicle (license plate), the time of weighing, the empty and full weight, as well as the kind of biomass. A weight note is created for every vehicle which arrives at the store. For accounting or more detailed evaluation, the weight note should additionally contain information about the field of origin of the crops and the farmer who cultivates it. The empty weight of a transport unit can be measured in the form of samples.

Fuel consumption

Fuel consumption is measured in litres [l] by a meter at the fuel station and documented in a fuel note. This fuel note contains the fuelling date, the identification number of the

Table 1: Source of information to determine the key figures

Informationsquelle source of information	**Einheit** unit	**Erfassung** data entry	**Dokumentation** documentation
Frischmasse-Lagereingang incoming biomass (fresh)	[t], ([t FM])	Fuhrwerkswaage vehicle weighing machine	Wiegeschein weight note
Kraftstoffeinsatz required fuel	[l]	Zäpfsäule filling pump	Tankliste fuel note
Maschineneinsatz machine usage	[h], ([Mh])	Betriebsstundenzähler engine hour meter	Tankliste fuel note
Arbeitskräfteeinsatz worker usage	[h], ([Akh])	Arbeitskraft worker	Formblatt form
Trockenmasseanteile percentage fresh weight	[%]	Schnellbestimmung, Labor laboratory	Protokoll, Wiegeschein lab report
Kontoumsätze account turnover	[€], [$]	Kreditinstitut credit institution	Kontoauszug abstract of account

Abgrenzung: Erntemaßnahme (Gesamt) scope: harvest logistics (total)		Frischmasse fresh weight [t]	Trockenmasse* dry weight [t]
	Total	8.252	2.599
Kraftstoff fuel usage [l]	16.270	1,97	6,26
Frischmasse fresh weight [t]	8.252	1,00	3,18
Trockenmasse dry weight [t]	2.599	0,315	1,00
Maschineneinsatz machine usage [h]	776	0,09	0,30
Arbeitskräfteeinsatz worker usage [h]	795	0,10	0,31
Umsatz turnover [€], [$]	-48.120	-5,83	-18,51

Table 2: Key figure matrix "cost unit"

* erfasster Trockenmasseanteil / recorded percentage of dry weight: 31,5 %

fuelled machine (vehicle license plate), and the dispensed quantity of fuel. The machine begins and ends its daily work with a full fuel tank. This applies to all machines used for storage, transport, and the harvest.

Machinery use

Machinery use is measured in hours [h] by the engine hour meter of the machine used and documented on the fuel note every time after fuelling is completed. Experience shows that the mentioned fuel note is also used for documentation, which is extended to include information about the reading of the engine hour meter. In machines with an odometer (e.g. trucks), the number of driven kilometers is noted as well. Every time the machine is fuelled, the reading of the engine hour meter is noted on the fuel note.

Use of manpower

Manpower use is measured by the workers themselves in hours [h] and documented in a form.

Percentage of dry matter

The load-specific percentage of dry matter is measured in [%] using a rapid analysis scale or a drying chamber and documented on the weighing note which belongs to the individual load. At several points, samples are taken directly after the end of the unloading process because renewed mixing of the vehicle load must be expected to occur here.

Account turnover

Account turnover as quasi cash-outlay cost is registered by the bank and documented in an abstract of account or by exporting account management software. Account turnover is mainly used for statistical cost accounting on the basis of real monetary transactions.

Key figures

The mere absolute values can be used as key figures without additional calculations, even though their meaningfulness is restricted. If a harvesting measure repeats itself under otherwise virtually identical conditions (e.g. grass harvest on the same field using identical storage, transport, and harvesting machines), for example, different measures can be compared directly. The development of key figure matrices, however, provides a better comparison. Below, two matrices are presented as examples.

Key figure matrix with reference to a cost unit

The term "resource use" generally stands for the number and quantity of all machines, workers, operating inputs, etc. used for the harvesting measure. From an economic viewpoint, the cost unit is the harvested, transported, and stored tonne of fresh weight (or dry weight). All quantities used are referred to the cost unit in the form of a matrix (*Table 2*). The rows of the matrix list the registered individual quantities used, while the columns contain the desired cost units. The matrix can be extended as desired.

Table 2 contains real figures of maize logistics from the year 2007 except for the turnover. During this harvest measure, fuel consumption for the harvest as well as transport and storage added up to 1.97 litres per tonne of fresh weight or a converted 6.26 litres per tonne of dry weight. If the negative turnover (=payments) in the amount of [€] [$] –48,120 is considered in a second example, this maize harvest provided a liquidity result of [€] [$] –5.83 per tonne of fresh weight.

Table 2 gives an overview of the key figures of the entire harvesting measure. Depending on the depth of data collection, this method also allows individual process elements (harvest, transport, storage) or at a more detailed level, even individual machines of harvest logistics to be shown and evaluated separately by using the same method.

Key figure matrix of process output and efficiency

The inversion of the resource use matrix provides the matrix of process output and efficiency. In the present example, *Table 3* is restricted to machinery use and fuel consumption, which are additionally broken down into the process elements harvest, transport, and storage. The values are taken from the harvest chain, which is identical with the one shown in *Table 2*.

The "machinery use" column allows for an exemplary discussion of process output. In terms of fresh weight, the process element "harvest" (the harvesting machine) reaches a process output of almost 87 tonnes per working hour, whereas only 17.6 tonnes are handled in the process element "transport" within one working hour of a vehicle. The present ratio of these two key process output figures (1:4.9) shows the ratio between individual process chain links in figures. Due to the larger output, a harvesting machine had to be served by almost five transport units.

The column "fuel consumption" from *Table 3* allows process efficiency to be discussed. The entire fuel consumption of 16,270 litres, which has already been mentioned in *Table 2*, is broken down into process elements. Altogether, one litre of fuel enabled 0.51 tonnes of fresh weight to be harvested, transported, and stored. In terms of fresh weight, 1.06 tonnes were able to be harvested, and it was possible to transport 1.82 t and to store 2.07 t using one litre of fuel. These efficiency key figures in particular facilitate the direct comparison of individual machines (e.g. transport vehicle 1 vs. transport vehicle 2) as well as the comparison of different measures.

Conclusions

In harvesting logistics like in other fields, the quality of the data base determines the quality of the key figures calculated on this basis. Currently, the data collection needed for calculation is largely carried out manually and requires conscious behaviour during the harvesting measure. The two key figure matrices which show the use of resources as well as process output and efficiency only indicate the various possibilities of evaluation. From the viewpoint of the author, the future challenge, whose goal is fully automated data collection and evaluation, not only consists in sensor technology, but largely also in on-farm or web-based information management due to the various sources of information.

Table 3: Key figure matrix "process performance and efficiency"

Abgrenzung: Erntemaßnahme (Gesamt und Prozesskettenglieder) scope: harvest logistics (total and process chain links)		Maschineneinsatz machine usage [h]				Kraftstoffeinsatz fuel usage [l]			
		Total total	Ernte harvest	Transport transport	Einlagerung storage	**Total total**	Ernte harvest	Transport transport	Einlagerung storage
Total		**776**	95	468	213	**16.270**	7.750	4.540	3.980
Frischmasse fresh weight	[t] 8.252	**10,6**	86,9	17,6	38,7	**0,51**	1,06	1,82	2,07
Trockenmasse* dry weight	[t] 2.599	**3,3**	27,4	5,6	12,2	**0,16**	0,34	0,57	0,65

* erfasster Trockenmasseanteil / recorded percentage of dry weight: 31,5 [%]